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A multi-disciplinary study of woodcrafts and plant remains that reveals the history of Pontevedra’s harbour (northwest Iberia) between the 13th and 19th centuries AD

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Abstract:	Waterlogged woodcrafts and other plant remains were recovered at 65 Arcebispo Malvar Street (Pontevedra, Spain) from contexts from the 13th to 19th centuries AD, although most of the artefacts were concentrated in accumulations of organic remains dating to the 15th century AD. The site is located close to the harbour (Peirao da Ponte) and the wooden dock (A Prancha), and it is in an area closely associated with trade and fishing activities. Plant-based crafts and other organic remains were classified into five groups: timbers, containers, personal items, fishing implements, and miscellaneous artefacts. The great majority of items are related to timber building or even shipbuilding, including planks, beams, posts, stakes, pegs, trenails and wedges. Other objects, such as a plate/lid, a basket, a cup, stave-built containers, and combs, provide information about day-to-day life, trade, fishing activities, etc. The timber assemblage offers a unique opportunity to expand our knowledge about wood-working techniques and the selection of raw materials from the Middle Ages onwards, complementing the information already known from written sources. In addition, the identification of an oar made of Fagus sylvatica verifies the written evidence of their importation from other areas of the Iberian Peninsula, while the identification of a cup made from a coconut shell suggests the arrival of objects from tropical areas.
Additional Information:	
Question	**Response**
Author Comments:	
Response to Reviewers:	Manuscript Number - ENV383 – Environmental Archaeology The manuscript was modified to address the minor revisions suggested by Reviewer 1 and 2. The modifications of the original manuscript are listed as follows: Key-words: The Key-words have been modified following the suggestions made by Reviewer 1 and 2: Waterlogged wood; Pitch; Chaîne-opératoire; Medieval and Post-

	Medieval period; Iberia. We excluded “wood conversion” and “wood anatomy” because of the limit of 5 key-words. Chronology: Reviewer 1 and 2 raised questions about chronologies. Firstly, we have rewritten one of the related sentences. Secondly, it was specified in the Material and Methods section that the chronological adscription of the contexts has been made only using the archaeological materials, namely pottery. No radiocarbon dates are available from this site. In all the objects analysed no large series of tree-rings were preserved, and the number of tree-rings was not enough for dendrochronological and dendro-provenience analysis. Words replaced: All the suggestions made by Rev. 2 regarding the use of specific terms, have been accepted: “manufactures” has been replaced by “artefacts” or “objects”; “collections of documents” by “the study of written sources”; “determination” by “identification”; among others. We have replaced Middle Age by Medieval and Post-Medieval period; and we have suppressed “Post-Medieval period”, “harbour” and added “Iberia”. Pegs and trenails: Reviewer 2 asked about the differences between pegs and trenails, which is explained in the revised manuscript where we provide a definition of both terms to avoid confusion. Replying the questions made by Reviewer #1, the diameter of trenails ranged from more than 1cm to 2.5cm; whilst pegs presented higher diameters ranging between 3.5 to 3.8. The morphology of the trenails was only recorded in one case because the plank was fractured, the trenail presented a quadrangular section and a pointed edge. When the trenails were preserved in situ we could not register their morphology. We have not identified the presence of “épîte” associated to the trenails. Function of planks: Questions raised by Reviewer 1 about the function of plant, and the possibility of distinguishing between building and shipbuilding planks, or event distinguishing parts or types of ships was not possible with the assemblage available. We suppose that several planks were related to shipbuilding but in all the cases were recovered from tertiary contexts, probably abandoned or stored for a later use. Salix/Populus: Salix and Populus could only be distinguished on the basis of their ray anatomy (Schweingruber 1990): Populus presents homogeneous rays, rarely with square marginal cells, and Salix heterogeneous rays with one to two rows of square and upright marginal cells. When square ray cells are present in Populus or when the marginal upright cells are absent, it is difficult to distinguish between these two genera. The samples analysed at Arcebispo Malvar presented heterogeneous rays, and this is the reason of identifying this wood as Salix/Populus. Combs: The paragraphs discussing the presence of combs, and their classification and interpretation, have been rewritten, to enrich the discussion. We also added references such as Vaz et al. 2016 and Mille 1993 and 2008. Figures: Figure 3 was improved the colour scales have been deleted and only one black scale of 5 cm has been added, the order of the images has changed, and the caption was modified. Figure 4 has been modified replacing solid by pattern fills. Figure 5. In the caption “Cocos nucifera drupe” was replaced by by “Cocos nucifera shell”. Figure 7: In the caption “pericarp of Corylus avellana” was replaced by “hazelnut shell”. The drawing of the hazelnut shell has been rotated to the left. Other misprints have been corrected in the captions of figures and tables. References: All the missing references and misprints have been corrected, including those listed by Reviewer #1: Bernard et al 2013, Brisbane and Hather 2007 ; Cappers et al 2006 ; Armas Castro 1992 ; Coles and Coles 1986 ; Coles et al 1978 ; Comey 2003; Dietrich 1994; Durand 2002; Ferreira 1987 ; Hausman 1920; Ingold 2007; Jacomet 2006; Lopez 2006; Morgan 1988; Pillonel 2007 ; Rast Eicher 2016 ; Sands 1997; Solórzano 2009 ; Tegel et al 2016 ; Shackley 1981; Vermeeren 2001; Zutter 2000; Deforce 2017; Earwood 1991; Hurcombe 2014; Ottaway and Rogers 2002; Schweingruber 1990 and 2007; Wood 2005. The alphabetical order of the references has been checked and corrected. The reference Mille et al. 2014 has been added. We have also added the new references Sartal Lorenzo 2016, Del Río et al. 2016, Kolchin and Chernetsov 1989, Mato and César 2017, Mille 1993, 2008, Mooney 2016, Vaz et al. 2016. Cites including “et al.” throughout the text has been formatted as italics as indicated by Reviewer #1. English version: Clíodhna Ní Lionáin with a PhD in Archaeology and native speaker of English has reviewed the English version of the text. Finally, we would like to express our willingness to exchange ideas about wooden elements of shipwrecks, as suggested by Reviewer 1.

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A multi-disciplinary study of woodcrafts and plant remains that reveals the history of Pontevedra's harbour (northwest Iberia) between the 13th and 19th centuries AD

Waterlogged woodcrafts and other plant remains were recovered at 65 Arcebispo Malvar Street (Pontevedra, Spain) from contexts from the 13th to 19th centuries AD, although most of the artefacts were concentrated in accumulations of organic remains dating to the 15th century AD. The site is located close to the harbour (Peirao da Ponte) and the wooden dock (A Prancha), and it is in an area closely associated with trade and fishing activities. Plant-based crafts and other organic remains were classified into five groups: timbers, containers, personal items, fishing implements, and miscellaneous artefacts. The great majority of items are related to timber building or even shipbuilding, including planks, beams, posts, stakes, pegs, trenails and wedges. Other objects, such as a plate/lid, a basket, a cup, stave-built containers, and combs, provide information about day-to-day life, trade, fishing activities, etc. The timber assemblage offers a unique opportunity to expand our knowledge about wood-working techniques and the selection of raw materials from the Middle Ages onwards, complementing the information already known from written sources. In addition, the identification of an oar made of *Fagus sylvatica* verifies the written evidence of their importation from other areas of the Iberian Peninsula, while the identification of a cup made from a coconut shell suggests the arrival of objects from tropical areas.

Keywords: Waterlogged wood; Pitch; *Chaîne-opératoire*; Medieval and Post-Medieval period; Iberia

Introduction

Medieval and Post-Medieval societies used plant materials for multiple purposes including food, fodder for livestock, fuel, building structures and crafting a wide range of objects, including those for personal use, tools, weaponry and means of transport such as boats or carts. Wood was the main raw material selected for crafting (Le Goff 1988). There is an increasing body of research focused on wooden artefacts and wood-crafting from Early Medieval to Post-Medieval archaeological contexts throughout Europe (e.g.

Cywa 2017, Lange *et al*. 2017, Mooney 2016, Tegel *et al*. 2016, Allen 2014, Mille *et al*. 2014, Bernard et al. 2013, Brisbane and Hather 2007, Wood 2005 Comey 2003, Ottaway and Rogers 2002, Durand 2002, Zutter 2000, Dietrich 1994, Earwood 1993, 1991, Kolchin and Chernetsov 1989). However, the archaeobotanical study of Medieval and Post-Medieval contexts in northwest Iberia (Porto *et al*. 2016, Teira *et al*. 2012, Martín-Seijo 2010) is a relatively underdeveloped area of research, despite the availability of large plant assemblages ‒including artefacts‒ that have been recovered recently (Fig. 1). Most of the assemblages have been preserved by waterlogging. Wet timbers and craft woods have been recovered from harbours, riverbanks, ditches or wells (e.g. Mato and César 2017; Porto *et al*. 2016; Del Río *et al*. 2016). Mineral preservation of wood—when wooden artefacts were in close association with bronze or iron objects such as tools and weapons—is also relatively frequent. Burning is a less common cause of preservation of wooden crafts during the Medieval and Post-Medieval periods (Teira *et al*. 2012).

This paper presents the archaeobotanical, technological and biographical analysis of wooden crafts and other plant remains recovered from Pontevedra's harbour, which provides an interesting assemblage to study the day-to-day life of this urban area, as well as Medieval and Post-Medieval perishable materiality, wood-working and shipbuilding.

INSERT FIGURE 1 ABOUT HERE

Plant manufactures recovered from Arcebispo Malvar Street (Pontevedra, Spain) are closely linked to Pontevedra's harbour, which was one of Castile's Atlantic seaports (Solórzano 2009). Research of this port has been focused mostly on urban networks and maritime history, with an emphasis on mercantile activities through the study of written sources (e.g. Juega 2012, Ferreira 1987, Armas Castro 1992). Archaeological and archaeobotanical studies are less common, despite the fact that these contexts –which are closely linked to activities such as trade and fishing– are capable of long-term preservation of waterlogged organic remains. During the excavation, woodcrafts and other plant remains were recovered from the Lérez river bank, and were probably linked to activities taking place in the environs. The study of these remains aims to: 1) shed light on the materiality of day-to-day life, 2) obtain archaeological evidence of fishing, trade and mercantile activities that took place in port areas; 3) obtain data related to wood-working and timber building techniques; 4) highlight the value of archaeobotany in providing relevant information on the links established between a commercial urban context and its woodland surrounding; and 5) contribute to addressing the archaeobotanical research gap identified in the study of Medieval and Post-Medieval contexts of northwest Iberia.

Wooden artefacts, which included modified objects, tools, used objects and structures, revealed raw material and technological choices, technological know-how, use, re-use, maintenance, recycle, discard, etc. (Hurcombe 2009, 2014). The identification of raw material is only the first step in studying wooden artefacts. Raw materials and crafts are closely linked, and the study of material culture is engaged with the materiality of artefacts (Ingold 2000). Materials could be differently understood and perceived between individuals, between societies and through time (Ingold 2007). Wood is a living material and the choice of the tree or shrub species and the part of the plant used could affect every stage of production and even artefact use (Bintley and Shapland 2013). The current authors' theoretical approach incorporates the concepts of the *chaîne-opératoire* (Lemmonier 2004, Dobres 1999, Creswell 1983) and object biography (Joy 2009, Gosden and Marshall 1999).

Material and methods

Site

The last archaeological investigation in this area took place at 65 Arcebispo Malvar Street (Pontevedra, Spain) between 2014 and 2016. This developer-funder excavation revealed a complex archaeological site with successive occupations, ranging from Roman times to the 19th century (Sartal Lorenzo 2016). It is near, and closely related to, Pontevedra's harbour, which was placed at a natural shelter at the mouth of the Lérez river, a location with defensive advantages and protected from the wind. Pontevedra had both a fishermen's wharf in A Moureira, and a commercial seaport –Peirao da Ponte– located inside the town (Solórzano 2009). The latter was founded by Fernando II in 1169 but given to the bishop of Santiago de Compostela in 1180. Ships arriving into Pontevedra were docked and anchored at the bridge itself, and following merchant exchange they left the bridge and anchored randomly at another place in the river. The bridge was used as a dock, and to load and unload goods. The Prancha, a wooden structure for mooring smaller boats that carried salt and fish, was built nearby.

INSERT TABLE 1 ABOUT HERE

Archaeobotanical samples have been dated on the basis of artefact typology. For samples from the Middle Ages, the chronology is based mainly on the features of the ceramic assemblages, such as Saintonge wares, and coins. For the Post-Medieval period, chronologies were established using ceramic types (e.g. Columbia plain ware, Columbia plain gunmetal ware, Isabella Polychrome ware and Yayal Blue on White ware), kaolin tobacco pipes, coins and a bronze medal with the inscription *Paulus Papa III* dated to the 16th century. In addition, the stratigraphic relationships between structures and deposits provided *post quem* and *ante quem* chronologies. At 65 Arcebispo Malvar Street, Middle Age contexts –dated from 12th to 14th centuries AD– correspond to predominantly silt and sandy deposits containing waterlogged organic remains such as wood, fruits, seeds or leather (Sartal Lorenzo 2016). Contexts dated to between the 15th and 17th century included a length of the 16th century city wall, as well as silt and mud deposits that contained woodcrafts (Table 1). Contexts that were dated to the Post-Medieval period include natural deposits of silt and mud that also preserved organic remains by waterlogging. These layers were covered by deposits that were dated to the 19th century. The preliminary chronological assessment based on the study of the material culture associated with the samples indicates that the oldest wooden artefacts were recovered from contexts dating to the 13th-14th centuries, whilst the most recent artefacts were dated to the 18th-19th centuries (Table 1).

INSERT FIGURE 2 ABOUT HERE

Wooden manufactures were mainly recovered from contexts ranging from the 15th to 16th century: SU1506 (*n*=84), SU1207 (*n* =8) and SU1264 (*n* =11) (Fig. 2). The SU1506 deposit is an accumulation of organic remains that contained different kinds of wooden crafts (beams, posts, planks, staves, stakes and pegs), which was dated to the 15th century; whilst SU1207 and SU1264 correspond to a ditch where wood crafts had been vertically positioned and fixed with stone wedges. Finally, SU1440 is a deposit within a posthole in which the post was preserved. The other wood remains were recovered from layers of a probable natural origin related to fluvial deposition processes (Table 1).

Sampling

Systematic sampling was performed during the archaeological excavation. Samples were gathered by hand-picking, and bulk and column samples were obtained for different analytical purposes as well. Plant-based objects and other organic remains were collected individually by hand-picking. After recovery, they were stored in rigid containers preserving their humidity and avoiding contact with light and elevated temperatures. In spite of these efforts, the original morphology of several items was modified by fragmentation or desiccation. Conservation treatments were avoided to preserve the cellular structure of wood (Cartwright 2015).

Wood Analysis

A total of 121 artefacts of waterlogged wood were analysed. Samples for identifying each item were taken with a razor blade and were observed on an Olympus CX40 transmitted-light microscope (Crivellaro and Schweingruber 2013; Akkemik and Yaman 2012; Gale and Cutler 2000; Hather 2000; Schweingruber 1993). Dendrological attributes were registered simultaneously with taxonomic identification to characterize the kind of wood resources used as raw material: (1) the part of the plant (i.e. trunk, twig, root, etc.) was recorded when anatomical and morphological characteristics allowed for such identification (Schweingruber *et al.* 2008); (2) the maturity of the wood was established by distinguishing between heartwood and sapwood, and by the presence or absence of inclusions such as tyloses or gum deposits (Schweingruber *et al.* 2008); (3) the calibre of the wood was qualitatively evaluated through annual ring curvature –i.e. weak, moderate, strong and indeterminate– (Marguerie and Hunot 2007); (4) the number of annual rings was counted when both bark and pith were present (Morgan 1988). The occurrence of biodeterioration was recorded when tunnels resulting from wood-boring insects or woodworm degradation were observed and/or white filaments (fungal hyphae) were present in cross sections of vessels (Marguerie and Hunot 2007).

In order to obtain information related to wood-working and technological know-how, and to reconstruct the different stages of the *chaîne-opératoire*, complementary data was recorded (Martín-Seijo 2013; Brunning and Watson 2010; Pillonel 2007; Brunning 2007; Morris 2000; Sands 1997; Earwood 1993; Crone and Barber, 1981): (1) raw material supply –as defined by taxonomic identification and dendrological attributes–; (2) the preparation of raw material including transport and conversion process from the original support to the manufactured object – cutting off branches, removing bark, rough-hewing and splitting the trunk or branch, etc.-; (3) product preparation –storage, drying, shaping, polishing, etc.– and (4) final product. To record the conversion process, codes were used to classify the different types of extraction from the original support (Martín-Seijo, 2013), combining various previously published schemes (Pillonel, 2007; Vermeeren, 2001; Coles and Coles, 1986; Crone and Barber, 1981; Shackley, 1981; Coles *et al.*, 1978). Other attributes were recorded in relation to object biography such as those related to their use, re-use, recycling, abandonment and post-depositional alterations.

Seed analysis

Two of the plant-based manufactures were crafted from the woody parts of a nut –pericarp– and a drupe –endocarp. Identification was carried out using an Olympus SZX7 stereoscopic microscope for comparing these botanical remains with carpological atlases (Neef et al. 2012; Cappers *et al*. 2006; Jacomet, 2006).

Fibre identification

The identification of plant or animal fibres combined the use of transmitted-light microscope Olympus CX40 with Scanning Electron Microscope ZEISS EVO LS 15 to observe the surface and medulla characteristics following the method described by Rast-Eicher (2016). Atlases of plant and animal fibres were used for comparison (Hausman 1920; Rast-Eicher 2016).

Py-GC-MS and THM-GC-MS

The bunch of fibres from deposit SU 1489 was analysed by pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) and thermally assisted hydrolysis and methylation (THM-GC-MS). Conventional Py-GC-MS was performed with a Pyroprobe 5000 (CDS Analytical) coupled to a 6890N GC and 5975B MSD (Agilent Technologies).

The samples were embedded in glass wool-containing fire-polished quartz tubes and pyrolyzed at 650 °C for 20 seconds (heating rate 10 °C/ms). The pyrolysis-GC interface, GC inlet, and GC-MS interface were set at 325 °C. The GC was equipped with a (non-polar) HP-5MS 5% phenyl, 95% dimethylpolysiloxane column (length 30 m; internal diameter 0.25 mm; film thickness 0.25 μm). Helium was used as carrier gas (constant gas flow, 1 ml/min). The GC oven was heated from 50 to 325 °C at 20 °C/min. The ion source of the MS operated in electron impact mode (70 eV) at 230 °C and the quadrupole detector was held at 150 °C, measuring fragments in the *m*/*z* 50–500 range. The instrumentation and analytical parameters used for Py-GC-MS were also applied for THM-GC-MS. For THM-GC-MS, an aliquot of 25 % tetramethylammonium hydroxide (aqueous TMAH from Sigma-Aldrich) was added prior to analysis.

Results

To present the results of this multi-disciplinary study the objects have been organised by group (timbers, containers, personal items, fishing implements, and miscellaneous artefacts), by functional interpretation (e.g. plank, post, plate, basket, comb, etc.), and by date (Table 2). All of the analysed artefacts were end-products, and no evidence of woodworking or manufacture debris was identified in the wooden assemblage.

INSERT TABLE 2 ABOUT HERE

Timbers

Within the group of timbers, all the crafted wood, which could be related to building, shipbuilding or furniture, were considered (Fig. 3). This diverse assemblage was classified as follows: (1) planks: longitudinal and thin pieces of wood with rectangular or quadrangular sections; (2) beams: thick and long pieces of wood with rectangular or quadrangular sections; (3) posts: thick and long pieces with circular or semi-circular sections and pointed ends; (4) stakes: stick pointed at one end; (5) pegs: pointed wooden pieces used to pin down objects or to fit into or close holes; (6) trenails: small wooden pins with a pointed tip used to fasten two pieces of wood and (7) wedges: pieces of wood which are driven within two objects to secure or separate them. Most of the analysed crafts belongs to this group: planks (*n*= 46), trenails (*n* =30), posts (*n* = 12), beams (*n* = 6), stakes (*n* = 4), pegs (*n* = 3) and a wedge (*n* = 1).

INSERT FIGURE 3 AND TABLE 3 ABOUT HERE

Planks dating from the 15th to 16th centuries AD were made from *Castanea sativa* (*n* = 30) and *Quercus* sp. deciduous (*n* = 16) and beams dating to the 15th century AD were made of *Quercus* sp. deciduous (*n* =6) (Table 2 and 3). *Quercus* sp. deciduous (*n* = 7) was also the preferred wood for crafting posts, followed by *Castanea sativa* (*n* = 2), *Alnus* sp. (*n* =1), *Betula* sp. (*n* =1) and *Salix/Populus* (*n* =1). Trunks were used for crafting planks, beams and posts (Table 4). In planks, weak to moderate tree-rings predominate in the studied objects, whereas moderate to strong curvatures were relatively frequent in beams and posts. These differences regarding tree-ring curvature of artefacts could be related to the calibre of the original support, which was probably bigger in the case of planks, and to the use of inner splits of heartwood for beams and planks, although sapwood was present occasionally in the outer parts of the pieces. This favoured the presence of biological action - 67% of beams, 39% of planks and 25% of posts were affected by xylophagous insects (Table 4). Trenails associated with planks and beams were identified, most of which were made of *Quercus* sp. deciduous (*n* =25) wood, but *Castanea sativa* (*n* =2) and *Fraxinus* sp. (*n* =1) was also identified; in two cases the state of preservation of the pieces of wood prevented taxonomic identification (Table 3). Stakes were recovered only from contexts dating to the 15th century AD, and were crafted from *Quercus* sp. deciduous (*n* =3) and *Castanea sativa* (*n* =1) (Table 2 and 3). The only wedge identified was made from *Castanea sativa* (*n* =1) (Table 3).

INSERT TABLE 4 ABOUT HERE

Primary conversion predominates in posts, stakes, pegs and wedges (Table 5), which was associated to the use of roundwood in posts (*n* =7), pegs (*n* =2), stakes (*n* =1) and wedges (*n* =1). Furthermore, three half-sections have been identified in posts, one quarter radial in a peg and two radially split sections in one plank and one indeterminate manufacture. In the case of posts, the whole trunk, probably with the bark, was used (where bark was not identified it is unknown whether this is related to preservation issues) or by radial splitting of the stem and removal of lateral branches (Fig. 4, Table 6). When both bark and pith were preserved, the maximum diameter was measured, ranging from 6.2 to 18 cm and between 10 to 16 annual rings. In all the cases the season of plant death was autumn-winter (Table 6). The original support was only shaped in the proximal part to obtain a sharp point using metal tools with sharp cutting edges, probably axes.

INSERT FIGURE 4 AND TABLE 5 AND 6 ABOUT HERE

Planks, beams and trenails were mostly shaped through radial secondary conversion and tangential conversion (Table 5). Planks were shaped through tangential conversion, both by rift and quarter sawn, and beams combined radial secondary conversion with tangential conversion (Fig. 4). In both cases, trenails preserved in their original position were identified ranging from 1 to 9 depending on the piece, and sometimes only the holes were identified. Tools related with these holes could be bow-drills, augers or spoon bits.

Containers

Four types of functional items were examined in this group: a plate or a lid, stave-built containers, a basket and a cup, all of which were made of wood, except for the cup which was made from an endocarp of *Cocos nucifera*. The artefact classified as plate or lid was recovered from a context dated to the 13^{th} to 14^{th} centuries AD. Though fragmented, its original form is almost completely preserved, and evidence of charring was identified in a reduced area near the edge (Fig. 5). This wooden object was made of a *Castanea sativa* trunk (Table 3), obtained by radial primary conversion and shaped by lathe-turning, although its polished surface prevented the identification of tool-marks or lathe-attachment scars, which could give information regarding the production process –tools, techniques, etc. This double-sided circular plate or lid is flat on the top side and heavily ribbed on the bottom. The sunken centre could indicate that it corresponds to a small bowl or a means to fit the object to a container. It contains a curved bottom or knob as well. There are few references to objects with a similar shape (Evan-Thomas 1973: 159; Pugsley 2005: 10).

The basket was recovered from a context dated to the 14th to 15th centuries AD. This composite artefact was made of wooden strips that were intertwined in single intervals, as described for simple 1/1 interval plaiting, i.e. one element per set (Adovasio 2010). The weave of the artefact was intact when initially recovered, but this aspect was lost during the storage and cleaning process (Fig. 6). The strips were made of *Quercus* sp. deciduous from twigs with moderate-strong curvatures and they were obtained by tangential conversion. Fragments of *Vitis vinifera* leaves and fish scales were adhered to the surface of the wooden strips (Fig. 6).

The staves were recovered from contexts dating to the 15th century AD and all the pieces examined were made of *Castanea sativa* by tangential conversion of the trunks -with conversion code N- (Fig. 6). Buckets and casks are the main types of stave-built containers (Earwood 1993), and in this case the size and morphology of the pieces probably correspond to the latter type.

Finally, the most recent vessel recovered at Arcebispo Malvar Street was a fragmented cup recovered from a context dating to the 16th-17th centuries AD and made from a *Cocos nucifera* shell, which was half-sectioned (Fig. 5).

INSERT FIGURE 6 ABOUT HERE

Personal items

The personal items have been classified as a bead and three hair combs (Fig. 7). The bead was recovered from a context dated to the 15th century AD. It was made from a hazelnut shell and has a biconical perforation, which was achieved by abrasion. This object could be part of an ornament or a toy. The combs were recovered from contexts dated to the 16th to 17th centuries AD (Table 2). They were all made from *Buxus sempervirens* wood (Table 3). Their original morphology -complete width and length- has been modified by old and recent fractures, and in one case almost all the fine teeth were lost (Fig. 7). The three combs present a H morphology: double-sided combs with coarse and thin teeth in each side, a transverse piece or central bar and a lentoid section (Pugsley 2003). The bad state of preservation impeded the description of the terminal styles and prevented identification of decoration in the transverse piece.

INSERT FIGURE 7 ABOUT HERE

Fishing implements

An oar made of *Fagus sylvatica* from a context dated to the 17th-18th centuries AD was classified as a fishing implement. This wooden piece was obtained from a tangential conversion of a mature trunk, with weak tree-ring curvature. The piece has a polygonal section with a pointed, but broken edge, and its complete morphology remains unknown.

Miscellaneous artefacts

Two woodcrafts and a fibre bundle were classified as miscellaneous artefacts. A wooden object of indeterminate function, dated to the 13th century AD, was made of *Quercus* sp. deciduous trunk (Table 3). This broken wooden object has a rectangular shape and rounded corners, is curved longitudinally, and has a rectangular perforation in the upper part. The final woodcraft included in this group is a pointed object made of *Ilex aquifolium*, which was dated to the 16th-17th centuries (Table 3).

The fibre bundle was recovered from a context dated to 16th-17th centuries AD. The fibres were classified as animal in origin by the presence of scars, and their length, surface and medullar morphology are very similar to *Equus* sp. fibres (Fig. 8). The molecular fingerprint of the sample as obtained by Py-GC-MS can be subdivided in several regions. Among the low molecular weight products that elute in the first 10 minutes of the chromatrograms, C_1-C_2 alkylbenzenes, nitrogen-containing products (pyrrole, pyridine, benzyl nitrile, indole, methylindole, benzene propanitrile, diketodipyrrole, Cyclo (Pro-Val) and several unidentified N-products (e.g. *m*/*z* 80/123, *m*/*z* 54/125, *m*/*z* 56/111, *m*/*z* 55/124/166 and *m*/*z* 100) and phenols (phenol and C_1-C_2 alkylphenols) prevail (Fig. 9a). These products originate from a proteinaceous biopolymer, most likely α-keratins. The samples of modern human hair and the unidentified hair sample produced the same series of compounds and in very similar relative proportions, indicative of good preservation of the protein. Modern human hair also produced fatty acids, not detected in the archaeological sample (Fig. 9a). The archaeological sample produced intense peaks for several diterpenoid products not detected in modern human hair, such as methyldehydroabietate and about a dozen of similar products (Fig. 9b). These compounds reflect a resinous substance and are produced by thermoevaporation rather than pyrolytic cleavage, which probably explain the bias towards resins (compared to keratin) in terms of peak intensities. Due to the thermal modification by analytical pyrolysis, unaltered coniferous resin cannot be reliably distinguished from distilled resinous materials such as pitch. Nevertheless, the large peaks of fully aromatized diterpene derivatives with *m*/*z* fragments of retene (*m*/*z* 219 and 234) and methylretenes (*m*/*z* 233 and 248), which are less abundant in modern diterpene resin pyrolyzates analyzed under the same conditions (Traoré *et al*. 2016), might point towards tar pitch materials. The predominance of abietane diterpenes and lack of pimarene resins suggests that the conifer belonged to the Pinaceae family (*Pinus, Abies, Larix*), not Cupressaceae (Colombini and Modugno 2009).

INSERT FIGURE 8 AND 9 ABOUT HERE

The THM-GC-MS chromatogram also shows two distinct regions. Small peaks of unidentified compounds with base *m*/*z* 181 and M^+ of 196 or 210 may represent bibenzyl like compounds from recombination of two aromatic moieties but also from methylated 1,3,5-trihydroxybenzenes in tannin (Nierop *et al*., 2005), or perhaps unknown products of keratin (not shown). However, the largest peaks correspond to the diterpenic products that were also identified by Py-GC-MS, albeit in different relative proportions caused mainly by enhanced visibility of diterpenic acid due to methylation of carboxylic groups to methyl esters (Challinor 2001) (Fig. 9b). These results confirm the presence of a coniferous resin source.

Discussion

While the wooden artefacts recovered at 65 Arcebispo Malvar Street belonged to a broad chronological range (13^{th}-18^{th}/19^{th} centuries), the majority were recovered from contexts dating to the 15^{th}-16^{th} centuries AD (Table 1). The archaeological contexts in which they were found included intentional accumulations of wooden artefacts (SU1506), ditches and post-holes (SU1207, 1264, 1440 and 1493) where woodcrafts remain *in situ*, and contexts related to riverine deposition. Where intentional accumulations were identified, the wooden crafts were spread horizontally and placed under large stones. Written sources, such as the municipal ordinances, reveal that carpenters sometimes submerged wood for warping using stones from the bridge (Solórzano 2009: 92), and in the current study the existence of timber storage practices by submersion could not be discounted. The presence of wooden objects within features provides direct information about timber structures built in this area between 14th to 16th centuries AD, involving the use of posts, planks and trenails. The artefacts recovered from fluvial deposits could be related to chance loss, deliberate deposition or conscious acts of discard, among other possibilities.

Building and shipbuilding

Since the Middle Ages, there has been a strong demand for timber in the city of Pontevedra, for constructing dwellings, shipbuilding and crafting (Armas Castro 1992). The trunks were transported to the city by carts or by floating upstream from the Lérez river. Upon arrival, they were sawn and split into strips, boards and planks, and sold in the city market at prices that were established by the city council. Timber met the demand of specialised crafters, such as barrel makers, and it was one of the goods exported to the Lisbon and Seville shipyards; the documentary references describe shipments of chestnut planks (Armas Castro 1992: 193). Taxa identified for crafting planks, posts, beams, stakes, pegs, trenails and wedges at 65 Arcebispo Malvar Street indicate the existence of a strong selection of raw materials, which is also referenced in the written sources that describe the exclusive use of oak and chestnut wood (Armas Castro 1992). Archaeological evidence attested the predominance of *Castanea sativa* wood for crafting planks during 15th to 16th centuries AD, followed by *Quercus* sp. deciduous, while beams dated to the 15th century AD were all made of *Quercus* (Table 2 and 3). Planks were obtained from trunks probably by sawing or splitting using tangential conversion by rift and quarter sawn (Table 5, Fig. 4). Beams were obtained from the original support through radial secondary conversion (Table 5). All the planks and beams had a previous use and they could have been stored for later exploitation or were abandoned in this area. Most of the beams contained holes of trenails and sometimes trenails were preserved *in situ*. A high percentage was affected by the action of xylophagous insects (Table 4). Diverse kinds of planks were mixed in the beam assemblages, including planks of furniture, door planks, planks related to shipbuilding (Fig. 3). Regarding wood-working techniques, there is evidence of the use of trenails and pegs to fasten the wooden pieces, and no metal nails were identified. The trenails were made of *Quercus* sp. deciduous wood, and sporadically of *Castanea sativa* or *Fraxinus* sp. (Table 3).

In the case of posts, which were probably linked to harbour activities, the preferred wood for crafting was *Quercus* sp. deciduous, although other species such as *Castanea sativa*, *Alnus* sp., *Betula* sp. and *Salix/Populus* were occasionally selected (Table 3). Trunks for posts were felled during autumn-winter and were obtained from young and small diameter trees (Table 6). The investment of labour in their shaping may be considered low (Fig. 3 and 4, Table 6), contrasting with the careful shaping of the planks: the stem was used entirely or radially split, the bark was not removed in all the cases and lateral branches were cut; only the lower part of trunk was sharpened using an axe to facilitate driving them into the ground. There was no evidence of charring of the lower part of the posts in the assemblage in order to improve preservation and avoid rotting in wet conditions.

The preference for *Quercus* sp. deciduous and *Castanea* wood for building and/or shipbuilding –the distinction of the original use of planks is difficult– could be related to the relative abundance of these hardwoods in the local woodlands. In addition to their availability, the preference for *Quercus* and *Castanea* wood was probably related to their morphological and physical attributes. Mature specimens of both genera provide high quantities of durable wood suitable for sawing or splitting. In the case of wood selected for posts, *Quercus* wood was long considered excellent for use in foundations, and *Quercus, Castanea* and *Alnus* are very durable in wet and boggy conditions (Abella 2003, Ulrich 2007). Although *Betula* and *Salix/Populus* are poor for building, as both are soft and light woods that rapidly rotten under conditions that favoured putrefaction (Abella 2003), their use could be related to their presence in the riverine forests that probably grew along the riverbanks. The sporadic use of *Fraxinus* for crafting trenails could be associated with the use of production debris (Abella 2003).

In relation to shipbuilding techniques, it is worthwhile to mention the identification of caulking material. The animal hair bunch presented morphological and surface attributes that indicated that it was probably horse hair. Its molecular fingerprint suggested the presence of products originated from a proteinaceous biopolymer, most likely α-keratins together with diterpenoid products such as methyldehydroabietate. These compounds reflect a resinous substance possibly manipulated to pitch. The predominance of abietane diterpenes and lack of pimarene resins suggests that the conifer belonged to the Pinaceae family not Cupressaceae. The use of mixtures of hair and pitch as caulking or luting materials in shipbuilding has been attested previously. Pitch is a black or dark brown resinous substance obtained from the distillation of wood tar or turpentine used for caulking the seams of ships, protecting wood from moisture, etc. Combined results clearly confirm the likelihood of the presence of a keratin or keratin-like biopolymer, probably from hair, and the co-existence of a coniferous resin-derived material. The presence of these materials in the sample is not surprising, because of the known use of mixtures of hair and pitch as caulking or luting (sealant) materials in shipbuilding (Nayling and Jones 2014).

Vessel turning, barrel and basket making

The plate (or lid), staves and strips attested activities related to vessel turning, barrel and basket making. The plate, which was recovered from a context dated to the 13th-14th centuries AD, was obtained from a tangential split of a *Castanea* trunk and then turned (Table 5, Fig. 5). The absence of tool-marks or lathe-turning scars restricts the information about the production process for this artefact. Its shape suggests that it probably had a combined function for consumption of liquid as well as solid food. Alternatively, it could be a lid to fit in a recipient. Small areas of the piece showed evidence of fire, probably related to its use. The preferred wood for crafting vessels or cups in this area was *Alnus* (Porto et al. 2016), because its wood is tasteless, whereas the presence of tannins in *Castanea* wood provides a specific taste and odour to the recipient.

The simple plaited basket was crafted using *Quercus* twigs, although this kind of artefact could also be made using *Castanea* or *Salix* strips, as is referred to in ethnographic studies (Fontales 2005). These baskets of plaited strips were used for carrying a wide range of products, including fish. This use could be reliably assigned to the basket recovered at Arcebispo Malvar because fish was usually carried over a layer of leaves, and the wooden strips were covered by *Vitis* leaves and fish scales (Fig. 6).

The wooden barrels were made of *Quercus* staves, which is also described in the written sources. These artefacts present a standardised production reflected in the homogeneous morphology and type of conversion (Fig. 6), which could be related to the existence of specialised barrel-making artisans. The written sources describe how during the 15th century barrel-makers were differentiated from carpenters and since 1518 they were grouped as “ofiçiaes do dito ofiçio de tonelería”. They were place at the Tonearia Street near Santa Clara’s door where the wine came into the city of Pontevedra from the Ribeiro region. They had a seasonal activity ranging from September to December, a period coincident with winemaking and fishing sardine for producing “sardina arencada”

(Armas Castro 1992). Until the 15th century, the local woodlands provided enough timber for barrel-making, but since the 16th century onwards, the cutting of trees for barrel production was forbidden in order to secure the timber supply for shipbuilding (Armas Castro 1992). The most common stave-built container was the “pipa” -which in Pontevedra has a volume equivalent to 497 litres- and was used for trading fish and wine. During the 15th century AD, Pontevedra’s harbour was an important wine trade centre that supplied the local market and also different destinations along the Atlantic sea-lane reaching the North Atlantic Sea. The city was also a focus of the fishing and conserving activity of the Rías Baixas (Armas Castro 1992).

Trade

Three plant-based crafts could be related to trade and commercial sea lanes: the oar, the comb assemblage and the cup made from a coconut shell. The piece of *Fagus sylvatica* wood was identified as an oar made from the heartwood of trunk with weak tree-ring curvature (Table 3). It has a polygonal section, with a pointed edge and it is broken in the other side so that the complete shape of the oar remains unknown. The identification of this object as an oar was possible with the aid of the written sources. There are references about wood of *Fagus sylvatica* as the most appreciated for crafting oars. Beech is not a common tree in northwest of Iberia, growing only in the eastern mountain areas of Galicia. The oars were probably supplied by merchants from Santander (Cantabria), who sold it throughout the Cantabrian Coast, reaching as far as the Atlantic Seaports. In the case of Pontevedra, the written documentation attested the demand of oars in the city during the 16th century in relation to the sardine fishing (Armas Castro 1992).

The cup and combs, recovered from contexts dated to the 16th and 17th centuries, were broken and incomplete, and this, added to their recovery from a riverine deposit could indicate that they were deliberately discarded. The three double-sided combs could be interpreted as toilet combs, used by both women and men (Mille 2008, Mille *et al*. 2014). Since Antiquity, combs present standardised morphologies and production processes (Pugsley 2003), and even for the Middle Ages and the Post-Medieval period combs have been proposed as accurate chronological markers (Mille 2008). The morphology of the combs recovered at Arcebispo Malver is very similar to the sub-type D1 described by Mille (2008), which can be dated from the 14th to the beginning of the 16th century AD. In the Middle Ages, boxwood was the preferred wood for comb-making, as attested by archaeological artefacts (Pugsley 2003, Morris 2000) and textual references (Mille 1993), because this genus provides wood with an unparalleled hardness, mechanical strength and fine-grain in Europe (Mille 2008). *Buxus* grows naturally in northwest Iberia, though it is scarce and found only in restricted areas (López 2002). The inexistence or scarcity of this *genus* in the local woodlands, added to the complex *chaîne-opératoire* required for producing the combs—the wood has to be worked (sawing, polishing) while it is green and by means of a standardised procedure—could link these objects to trade and commercial contacts, which are attested since Antiquity (Vaz *et al*. 2016, Derks and Vos 2010) and during Middle Ages (Mille 2008) throughout Europe.

The cup made from a coconut shell could be also related to trade or to commercial lanes of Pontevedra's harbour. *Cocos nucifera* is a palm that grows in tropical areas of Africa, America and Asia. This object probably arrived in Pontevedra as a manufactured item in relation to the commercial lanes or as a day-to-day object inside a ship.

Conclusion

This study showed the relevance of integrating plant-based materials in the interpretation of archaeological contexts, and above all the importance of a multi-disciplinary approach in verifying written sources, as well as providing data not recorded in documentary sources. The plant assemblage of the Peirao da Ponte comprised a wide variety of objects, including construction and shipbuilding timber, personal objects, baskets or stave-built containers among others. These objects show the short list of species used in wooden construction and shipbuilding and the presence of imported plant-based objects from other areas of the Iberian Peninsula and even from tropical areas. This assemblage also provided clues about the timber and wood supply of a dynamic commercial area such as the city of Pontevedra.

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Table 1. Date, stratigraphic unit of provenance (SU), number of artefacts (N) and remarkable observations.

Table 2. Number of manufactures organised by group, functional interpretation and date.

Table 3. Taxa identification and functional interpretation of woodcrafts.

Table 4. Timber: dendrological attributes and complementary data (W: weak, M: moderate, S: strong, Ind.: indeterminate).

Table 5. Timber: conversion of wood and artefact section (Ind.: indeterminate).

Table 6. Timber: dendrological attributes of posts.

Figure 1. Map of northwest Iberia showing the location of Arcebispo Malvar Street. Other sites from which plant-based crafts -that were preserved by waterlogging, mineralisation or carbonisation- have been recovered and dated to Medieval and Post-Medieval Periods are also shown.

Figure 2. Photographs of a) SU1506 which concentrates most of the woodcrafts and b) SU1264 with stakes recovered within a ditch.

Figure 3. Timbers: in the upper part of the image two posts, one stake, two types of planks, one peg and one wedge; in the lower part a carved plank. Scale: 5cm.

Figure 4. Conversion code of planks, beams and posts (Radial Conversion. Primary conversion: A to G; Secondary conversion: K to M; Alternative conversion: U; Tangential conversion: N to P).

Figure 5. Plate made of a *Castanea sativa* trunk (a) and a cup crafted from a *Cocos nucifera* shell (b) (Drawn by Xurxo Constela Doce).

Figure 6. Basket: a) woven wooden strips after cleaning in laboratory; b) tree-rings in one of the *Quercus* sp. deciduous strips; c) *Vitis vinifera* leaf and d) fish scale adhered to the surface of the strips.

Figure 7. The wooden combs made of *Buxus sempervirens*, the bead made of a hazelnut shell and the pointed object made of *Ilex aquifolium* (drawn by Xurxo Constela Doce).

Figure 8. Fibre bundle: a) bundle of fibres; b) and c) scales on the fibre surface; and d) medulla.

Figure 9. Example chromatograms. A) Retention time region between 0 and 10 minutes, from Py-GC-MS. Red line: archaeological sample AM.65.14/8869. Grey line modern animal (human) hair. These products correspond to a proteinaceous biopolymer, probably keratin. B) retention time region from 10 to 15 minutes, showing the presence of fatty acids in the sample of modern hair (grey line) and a series of diterpene resin-derived compounds from the archaeological sampleAM (red line: Py-GC-MS, blue line: THM-GC-MS) but not the modern hair.

A multi-disciplinary study of woodcrafts and plant remains that reveals the history of Pontevedra's harbour (northwest Iberia) between the 13th and 19th centuries AD

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A multi-disciplinary study of woodcrafts and plant remains that reveals the history of Pontevedra's harbour (northwest Iberia) between the 13th and 19th centuries AD

Waterlogged woodcrafts and other plant remains were recovered at 65 Arcebispo Malvar Street (Pontevedra, Spain) from contexts from the 13th to 19th centuries AD, although most of the artefacts were concentrated in accumulations of organic remains dating to the 15th century AD. The site is located close to the harbour (Peirao da Ponte) and the wooden dock (A Prancha), and it is in an area closely associated with trade and fishing activities. Plant-based crafts and other organic remains were classified into five groups: timbers, containers, personal items, fishing implements, and miscellaneous artefacts. The great majority of items are related to timber building or even shipbuilding, including planks, beams, posts, stakes, pegs, trenails and wedges. Other objects, such as a plate/lid, a basket, a cup, stave-built containers, and combs, provide information about day-to-day life, trade, fishing activities, etc. The timber assemblage offers a unique opportunity to expand our knowledge about wood-working techniques and the selection of raw materials from the Middle Ages onwards, complementing the information already known from written sources. In addition, the identification of an oar made of *Fagus sylvatica* verifies the written evidence of their importation from other areas of the Iberian Peninsula, while the identification of a cup made from a coconut shell suggests the arrival of objects from tropical areas.

Keywords: Waterlogged wood; Pitch; *Chaîne-opératoire*; Medieval and Post-Medieval period; Iberia

Introduction

Medieval and Post-Medieval societies used plant materials for multiple purposes including food, fodder for livestock, fuel, building structures and crafting a wide range of objects, including those for personal use, tools, weaponry and means of transport such as boats or carts. Wood was the main raw material selected for crafting (Le Goff 1988). There is an increasing body of research focused on wooden artefacts and wood-crafting from Early Medieval to Post-Medieval archaeological contexts throughout Europe (e.g.

Cywa 2017, Lange *et al*. 2017, Mooney 2016, Tegel *et al*. 2016, Allen 2014, Mille *et al*. 2014, Bernard et al. 2013, Brisbane and Hather 2007, Wood 2005 Comey 2003, Ottaway and Rogers 2002, Durand 2002, Zutter 2000, Dietrich 1994, Earwood 1993, 1991, Kolchin and Chernetsov 1989). However, the archaeobotanical study of Medieval and Post-Medieval contexts in northwest Iberia (Porto *et al*. 2016, Teira *et al*. 2012, Martín-Seijo 2010) is a relatively underdeveloped area of research, despite the availability of large plant assemblages –including artefacts– that have been recovered recently (Fig. 1). Most of the assemblages have been preserved by waterlogging. Wet timbers and craft woods have been recovered from harbours, riverbanks, ditches or wells (e.g. Mato and César 2017; Porto *et al*. 2016; Del Río *et al*. 2016). Mineral preservation of wood—when wooden artefacts were in close association with bronze or iron objects such as tools and weapons—is also relatively frequent. Burning is a less common cause of preservation of wooden crafts during the Medieval and Post-Medieval periods (Teira *et al*. 2012).

This paper presents the archaeobotanical, technological and biographical analysis of wooden crafts and other plant remains recovered from Pontevedra's harbour, which provides an interesting assemblage to study the day-to-day life of this urban area, as well as Medieval and Post-Medieval perishable materiality, wood-working and shipbuilding.

INSERT FIGURE 1 ABOUT HERE

Plant manufactures recovered from Arcebispo Malvar Street (Pontevedra, Spain) are closely linked to Pontevedra's harbour, which was one of Castile's Atlantic seaports (Solórzano 2009). Research of this port has been focused mostly on urban networks and maritime history, with an emphasis on mercantile activities through the study of written sources (e.g. Juega 2012, Ferreira 1987, Armas Castro 1992). Archaeological and archaeobotanical studies are less common, despite the fact that these contexts –which are closely linked to activities such as trade and fishing– are capable of long-term preservation of waterlogged organic remains. During the excavation, woodcrafts and other plant remains were recovered from the Lérez river bank, and were probably linked to activities taking place in the environs. The study of these remains aims to: 1) shed light on the materiality of day-to-day life, 2) obtain archaeological evidence of fishing, trade and mercantile activities that took place in port areas; 3) obtain data related to wood-working and timber building techniques; 4) highlight the value of archaeobotany in providing relevant information on the links established between a commercial urban context and its woodland surrounding; and 5) contribute to addressing the archaeobotanical research gap identified in the study of Medieval and Post-Medieval contexts of northwest Iberia.

Wooden artefacts, which included modified objects, tools, used objects and structures, revealed raw material and technological choices, technological know-how, use, re-use, maintenance, recycle, discard, etc. (Hurcombe 2009, 2014). The identification of raw material is only the first step in studying wooden artefacts. Raw materials and crafts are closely linked, and the study of material culture is engaged with the materiality of artefacts (Ingold 2000). Materials could be differently understood and perceived between individuals, between societies and through time (Ingold 2007). Wood is a living material and the choice of the tree or shrub species and the part of the plant used could affect every stage of production and even artefact use (Bintley and Shapland 2013). The current authors' theoretical approach incorporates the concepts of the *chaîne-opératoire* (Lemmonier 2004, Dobres 1999, Creswell 1983) and object biography (Joy 2009, Gosden and Marshall 1999).

Material and methods

Site

The last archaeological investigation in this area took place at 65 Arcebispo Malvar Street (Pontevedra, Spain) between 2014 and 2016. This developer-funder excavation revealed a complex archaeological site with successive occupations, ranging from Roman times to the 19th century (Sartal Lorenzo 2016). It is near, and closely related to, Pontevedra's harbour, which was placed at a natural shelter at the mouth of the Lérez river, a location with defensive advantages and protected from the wind. Pontevedra had both a fishermen's wharf in A Moureira, and a commercial seaport –Peirao da Ponte– located inside the town (Solórzano 2009). The latter was founded by Fernando II in 1169 but given to the bishop of Santiago de Compostela in 1180. Ships arriving into Pontevedra were docked and anchored at the bridge itself, and following merchant exchange they left the bridge and anchored randomly at another place in the river. The bridge was used as a dock, and to load and unload goods. The Prancha, a wooden structure for mooring smaller boats that carried salt and fish, was built nearby.

INSERT TABLE 1 ABOUT HERE

Archaeobotanical samples have been dated on the basis of artefact typology. For samples from the Middle Ages, the chronology is based mainly on the features of the ceramic assemblages, such as Saintonge wares, and coins. For the Post-Medieval period, chronologies were established using ceramic types (e.g. Columbia plain ware, Columbia plain gunmetal ware, Isabella Polychrome ware and Yayal Blue on White ware), kaolin tobacco pipes, coins and a bronze medal with the inscription *Paulus Papa III* dated to the 16th century. In addition, the stratigraphic relationships between structures and deposits provided *post quem* and *ante quem* chronologies. At 65 Arcebispo Malvar Street, Middle Age contexts –dated from 12th to 14th centuries AD– correspond to predominantly silt and sandy deposits containing waterlogged organic remains such as wood, fruits, seeds or leather (Sartal Lorenzo 2016). Contexts dated to between the 15th and 17th century included a length of the 16th century city wall, as well as silt and mud deposits that contained woodcrafts (Table 1). Contexts that were dated to the Post-Medieval period include natural deposits of silt and mud that also preserved organic remains by waterlogging. These layers were covered by deposits that were dated to the 19th century. The preliminary chronological assessment based on the study of the material culture associated with the samples indicates that the oldest wooden artefacts were recovered from contexts dating to the 13th-14th centuries, whilst the most recent artefacts were dated to the 18th-19th centuries (Table 1).

INSERT FIGURE 2 ABOUT HERE

Wooden manufactures were mainly recovered from contexts ranging from the 15th to 16th century: SU1506 (*n*=84), SU1207 (*n* =8) and SU1264 (*n* =11) (Fig. 2). The SU1506 deposit is an accumulation of organic remains that contained different kinds of wooden crafts (beams, posts, planks, staves, stakes and pegs), which was dated to the 15th century; whilst SU1207 and SU1264 correspond to a ditch where wood crafts had been vertically positioned and fixed with stone wedges. Finally, SU1440 is a deposit within a posthole in which the post was preserved. The other wood remains were recovered from layers of a probable natural origin related to fluvial deposition processes (Table 1).

Sampling

Systematic sampling was performed during the archaeological excavation. Samples were gathered by hand-picking, and bulk and column samples were obtained for different analytical purposes as well. Plant-based objects and other organic remains were collected individually by hand-picking. After recovery, they were stored in rigid containers preserving their humidity and avoiding contact with light and elevated temperatures. In spite of these efforts, the original morphology of several items was modified by fragmentation or desiccation. Conservation treatments were avoided to preserve the cellular structure of wood (Cartwright 2015).

Wood Analysis

A total of 121 artefacts of waterlogged wood were analysed. Samples for identifying each item were taken with a razor blade and were observed on an Olympus CX40 transmitted-light microscope (Crivellaro and Schweingruber 2013; Akkemik and Yaman 2012; Gale and Cutler 2000; Hather 2000; Schweingruber 1993). Dendrological attributes were registered simultaneously with taxonomic identification to characterize the kind of wood resources used as raw material: (1) the part of the plant (i.e. trunk, twig, root, etc.) was recorded when anatomical and morphological characteristics allowed for such identification (Schweingruber *et al.* 2008); (2) the maturity of the wood was established by distinguishing between heartwood and sapwood, and by the presence or absence of inclusions such as tyloses or gum deposits (Schweingruber *et al.* 2008); (3) the calibre of the wood was qualitatively evaluated through annual ring curvature –i.e. weak, moderate, strong and indeterminate– (Marguerie and Hunot 2007); (4) the number of annual rings was counted when both bark and pith were present (Morgan 1988). The occurrence of biodeterioration was recorded when tunnels resulting from wood-boring insects or woodworm degradation were observed and/or white filaments (fungal hyphae) were present in cross sections of vessels (Marguerie and Hunot 2007).

In order to obtain information related to wood-working and technological know-how, and to reconstruct the different stages of the *chaîne-opératoire*, complementary data was recorded (Martín-Seijo 2013; Brunning and Watson 2010; Pillonel 2007; Brunning 2007; Morris 2000; Sands 1997; Earwood 1993; Crone and Barber, 1981): (1) raw material supply –as defined by taxonomic identification and dendrological attributes–; (2) the preparation of raw material including transport and conversion process from the original support to the manufactured object – cutting off branches, removing bark, rough-hewing and splitting the trunk or branch, etc.-; (3) product preparation –storage, drying, shaping, polishing, etc.– and (4) final product. To record the conversion process, codes were used to classify the different types of extraction from the original support (Martín-Seijo, 2013), combining various previously published schemes (Pillonel, 2007; Vermeeren, 2001; Coles and Coles, 1986; Crone and Barber, 1981; Shackley, 1981; Coles *et al.*, 1978). Other attributes were recorded in relation to object biography such as those related to their use, re-use, recycling, abandonment and post-depositional alterations.

Seed analysis

Two of the plant-based manufactures were crafted from the woody parts of a nut –pericarp– and a drupe –endocarp. Identification was carried out using an Olympus SZX7 stereoscopic microscope for comparing these botanical remains with carpological atlases (Neef et al. 2012; Cappers *et al*. 2006; Jacomet, 2006).

Fibre identification

The identification of plant or animal fibres combined the use of transmitted-light microscope Olympus CX40 with Scanning Electron Microscope ZEISS EVO LS 15 to observe the surface and medulla characteristics following the method described by Rast-Eicher (2016). Atlases of plant and animal fibres were used for comparison (Hausman 1920; Rast-Eicher 2016).

Py-GC-MS and THM-GC-MS

The bunch of fibres from deposit SU 1489 was analysed by pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) and thermally assisted hydrolysis and methylation (THM-GC-MS). Conventional Py-GC-MS was performed with a Pyroprobe 5000 (CDS Analytical) coupled to a 6890N GC and 5975B MSD (Agilent Technologies).

The samples were embedded in glass wool-containing fire-polished quartz tubes and pyrolyzed at 650 °C for 20 seconds (heating rate 10 °C/ms). The pyrolysis-GC interface, GC inlet, and GC-MS interface were set at 325 °C. The GC was equipped with a (non-polar) HP-5MS 5% phenyl, 95% dimethylpolysiloxane column (length 30 m; internal diameter 0.25 mm; film thickness 0.25 μm). Helium was used as carrier gas (constant gas flow, 1 ml/min). The GC oven was heated from 50 to 325 °C at 20 °C/min. The ion source of the MS operated in electron impact mode (70 eV) at 230 °C and the quadrupole detector was held at 150 °C, measuring fragments in the *m*/*z* 50–500 range. The instrumentation and analytical parameters used for Py-GC-MS were also applied for THM-GC-MS. For THM-GC-MS, an aliquot of 25 % tetramethylammonium hydroxide (aqueous TMAH from Sigma-Aldrich) was added prior to analysis.

Results

To present the results of this multi-disciplinary study the objects have been organised by group (timbers, containers, personal items, fishing implements, and miscellaneous artefacts), by functional interpretation (e.g. plank, post, plate, basket, comb, etc.), and by date (Table 2). All of the analysed artefacts were end-products, and no evidence of woodworking or manufacture debris was identified in the wooden assemblage.

INSERT TABLE 2 ABOUT HERE

Timbers

Within the group of timbers, all the crafted wood, which could be related to building, shipbuilding or furniture, were considered (Fig. 3). This diverse assemblage was classified as follows: (1) planks: longitudinal and thin pieces of wood with rectangular or quadrangular sections; (2) beams: thick and long pieces of wood with rectangular or quadrangular sections; (3) posts: thick and long pieces with circular or semi-circular sections and pointed ends; (4) stakes: stick pointed at one end; (5) pegs: pointed wooden pieces used to pin down objects or to fit into or close holes; (6) trenails: small wooden pins with a pointed tip used to fasten two pieces of wood and (7) wedges: pieces of wood which are driven within two objects to secure or separate them. Most of the analysed crafts belongs to this group: planks (*n*= 46), trenails (*n* =30), posts (*n* = 12), beams (*n* = 6), stakes (*n* = 4), pegs (*n* = 3) and a wedge (*n* = 1).

INSERT FIGURE 3 AND TABLE 3 ABOUT HERE

Planks dating from the 15th to 16th centuries AD were made from *Castanea sativa* (*n* = 30) and *Quercus* sp. deciduous (*n* = 16) and beams dating to the 15th century AD were made of *Quercus* sp. deciduous (*n* =6) (Table 2 and 3). *Quercus* sp. deciduous (*n* = 7) was also the preferred wood for crafting posts, followed by *Castanea sativa* (*n* = 2), *Alnus* sp. (*n* =1), *Betula* sp. (*n* =1) and *Salix/Populus* (*n* =1). Trunks were used for crafting planks, beams and posts (Table 4). In planks, weak to moderate tree-rings predominate in the studied objects, whereas moderate to strong curvatures were relatively frequent in beams and posts. These differences regarding tree-ring curvature of artefacts could be related to the calibre of the original support, which was probably bigger in the case of planks, and to the use of inner splits of heartwood for beams and planks, although sapwood was present occasionally in the outer parts of the pieces. This favoured the presence of biological action - 67% of beams, 39% of planks and 25% of posts were affected by xylophagous insects (Table 4). Trenails associated with planks and beams were identified, most of which were made of *Quercus* sp. deciduous (*n* =25) wood, but *Castanea sativa* (*n* =2) and *Fraxinus* sp. (*n* =1) was also identified; in two cases the state of preservation of the pieces of wood prevented taxonomic identification (Table 3). Stakes were recovered only from contexts dating to the 15th century AD, and were crafted from *Quercus* sp. deciduous (*n* =3) and *Castanea sativa* (*n* =1) (Table 2 and 3). The only wedge identified was made from *Castanea sativa* (*n* =1) (Table 3).

INSERT TABLE 4 ABOUT HERE

Primary conversion predominates in posts, stakes, pegs and wedges (Table 5), which was associated to the use of roundwood in posts (*n* =7), pegs (*n* =2), stakes (*n* =1) and wedges (*n* =1). Furthermore, three half-sections have been identified in posts, one quarter radial in a peg and two radially split sections in one plank and one indeterminate manufacture. In the case of posts, the whole trunk, probably with the bark, was used (where bark was not identified it is unknown whether this is related to preservation issues) or by radial splitting of the stem and removal of lateral branches (Fig. 4, Table 6). When both bark and pith were preserved, the maximum diameter was measured, ranging from 6.2 to 18 cm and between 10 to 16 annual rings. In all the cases the season of plant death was autumn-winter (Table 6). The original support was only shaped in the proximal part to obtain a sharp point using metal tools with sharp cutting edges, probably axes.

INSERT FIGURE 4 AND TABLE 5 AND 6 ABOUT HERE

Planks, beams and trenails were mostly shaped through radial secondary conversion and tangential conversion (Table 5). Planks were shaped through tangential conversion, both by rift and quarter sawn, and beams combined radial secondary conversion with tangential conversion (Fig. 4). In both cases, trenails preserved in their original position were identified ranging from 1 to 9 depending on the piece, and sometimes only the holes were identified. Tools related with these holes could be bow-drills, augers or spoon bits.

Containers

Four types of functional items were examined in this group: a plate or a lid, stave-built containers, a basket and a cup, all of which were made of wood, except for the cup which was made from an endocarp of *Cocos nucifera*. The artefact classified as plate or lid was recovered from a context dated to the 13th to 14th centuries AD. Though fragmented, its original form is almost completely preserved, and evidence of charring was identified in a reduced area near the edge (Fig. 5). This wooden object was made of a *Castanea sativa* trunk (Table 3), obtained by radial primary conversion and shaped by lathe-turning, although its polished surface prevented the identification of tool-marks or lathe-attachment scars, which could give information regarding the production process –tools, techniques, etc. This double-sided circular plate or lid is flat on the top side and heavily ribbed on the bottom. The sunken centre could indicate that it corresponds to a small bowl or a means to fit the object to a container. It contains a curved bottom or knob as well. There are few references to objects with a similar shape (Evan-Thomas 1973: 159; Pugsley 2005: 10).

The basket was recovered from a context dated to the 14th to 15th centuries AD. This composite artefact was made of wooden strips that were intertwined in single intervals, as described for simple 1/1 interval plaiting, i.e. one element per set (Adovasio 2010). The weave of the artefact was intact when initially recovered, but this aspect was lost during the storage and cleaning process (Fig. 6). The strips were made of *Quercus* sp. deciduous from twigs with moderate-strong curvatures and they were obtained by tangential conversion. Fragments of *Vitis vinifera* leaves and fish scales were adhered to the surface of the wooden strips (Fig. 6).

The staves were recovered from contexts dating to the 15th century AD and all the pieces examined were made of *Castanea sativa* by tangential conversion of the trunks -with conversion code N- (Fig. 6). Buckets and casks are the main types of stave-built containers (Earwood 1993), and in this case the size and morphology of the pieces probably correspond to the latter type.

Finally, the most recent vessel recovered at Arcebispo Malvar Street was a fragmented cup recovered from a context dating to the 16^{th}-17^{th} centuries AD and made from a *Cocos nucifera* shell, which was half-sectioned (Fig. 5).

INSERT FIGURE 6 ABOUT HERE

Personal items

The personal items have been classified as a bead and three hair combs (Fig. 7). The bead was recovered from a context dated to the 15^{th} century AD. It was made from a hazelnut shell and has a biconical perforation, which was achieved by abrasion. This object could be part of an ornament or a toy. The combs were recovered from contexts dated to the 16^{th} to 17^{th} centuries AD (Table 2). They were all made from *Buxus sempervirens* wood (Table 3). Their original morphology -complete width and length- has been modified by old and recent fractures, and in one case almost all the fine teeth were lost (Fig. 7). The three combs present a H morphology: double-sided combs with coarse and thin teeth in each side, a transverse piece or central bar and a lentoid section (Pugsley 2003). The bad state of preservation impeded the description of the terminal styles and prevented identification of decoration in the transverse piece.

INSERT FIGURE 7 ABOUT HERE

Fishing implements

An oar made of *Fagus sylvatica* from a context dated to the 17^{th}-18^{th} centuries AD was classified as a fishing implement. This wooden piece was obtained from a tangential conversion of a mature trunk, with weak tree-ring curvature. The piece has a polygonal section with a pointed, but broken edge, and its complete morphology remains unknown.

Miscellaneous artefacts

Two woodcrafts and a fibre bundle were classified as miscellaneous artefacts. A wooden object of indeterminate function, dated to the 13th century AD, was made of *Quercus* sp. deciduous trunk (Table 3). This broken wooden object has a rectangular shape and rounded corners, is curved longitudinally, and has a rectangular perforation in the upper part. The final woodcraft included in this group is a pointed object made of *Ilex aquifolium*, which was dated to the 16th-17th centuries (Table 3).

The fibre bundle was recovered from a context dated to 16th-17th centuries AD. The fibres were classified as animal in origin by the presence of scars, and their length, surface and medullar morphology are very similar to *Equus* sp. fibres (Fig. 8). The molecular fingerprint of the sample as obtained by Py-GC-MS can be subdivided in several regions. Among the low molecular weight products that elute in the first 10 minutes of the chromatrograms, C_1-C_2 alkylbenzenes, nitrogen-containing products (pyrrole, pyridine, benzyl nitrile, indole, methylindole, benzene propanitrile, diketodipyrrole, Cyclo (Pro-Val) and several unidentified N-products (e.g. *m*/*z* 80/123, *m*/*z* 54/125, *m*/*z* 56/111, *m*/*z* 55/124/166 and *m*/*z* 100) and phenols (phenol and C_1-C_2 alkylphenols) prevail (Fig. 9a). These products originate from a proteinaceous biopolymer, most likely α-keratins. The samples of modern human hair and the unidentified hair sample produced the same series of compounds and in very similar relative proportions, indicative of good preservation of the protein. Modern human hair also produced fatty acids, not detected in the archaeological sample (Fig. 9a). The archaeological sample produced intense peaks for several diterpenoid products not detected in modern human hair, such as methyldehydroabietate and about a dozen of similar products (Fig. 9b). These compounds reflect a resinous substance and are produced by thermoevaporation rather than pyrolytic cleavage, which probably explain the bias towards resins (compared to keratin) in terms of peak intensities. Due to the thermal modification by analytical pyrolysis, unaltered coniferous resin cannot be reliably distinguished from distilled resinous materials such as pitch. Nevertheless, the large peaks of fully aromatized diterpene derivatives with *m*/*z* fragments of retene (*m*/*z* 219 and 234) and methylretenes (*m*/*z* 233 and 248), which are less abundant in modern diterpene resin pyrolyzates analyzed under the same conditions (Traoré *et al*. 2016), might point towards tar pitch materials. The predominance of abietane diterpenes and lack of pimarene resins suggests that the conifer belonged to the Pinaceae family (*Pinus, Abies, Larix*), not Cupressaceae (Colombini and Modugno 2009).

INSERT FIGURE 8 AND 9 ABOUT HERE

The THM-GC-MS chromatogram also shows two distinct regions. Small peaks of unidentified compounds with base *m*/*z* 181 and M^+ of 196 or 210 may represent bibenzyl like compounds from recombination of two aromatic moieties but also from methylated 1,3,5-trihydroxybenzenes in tannin (Nierop *et al*., 2005), or perhaps unknown products of keratin (not shown). However, the largest peaks correspond to the diterpenic products that were also identified by Py-GC-MS, albeit in different relative proportions caused mainly by enhanced visibility of diterpenic acid due to methylation of carboxylic groups to methyl esters (Challinor 2001) (Fig. 9b). These results confirm the presence of a coniferous resin source.

Discussion

While the wooden artefacts recovered at 65 Arcebispo Malvar Street belonged to a broad chronological range (13th-18th/19th centuries), the majority were recovered from contexts dating to the 15th-16th centuries AD (Table 1). The archaeological contexts in which they were found included intentional accumulations of wooden artefacts (SU1506), ditches and post-holes (SU1207, 1264, 1440 and 1493) where woodcrafts remain *in situ*, and contexts related to riverine deposition. Where intentional accumulations were identified, the wooden crafts were spread horizontally and placed under large stones. Written sources, such as the municipal ordinances, reveal that carpenters sometimes submerged wood for warping using stones from the bridge (Solórzano 2009: 92), and in the current study the existence of timber storage practices by submersion could not be discounted. The presence of wooden objects within features provides direct information about timber structures built in this area between 14th to 16th centuries AD, involving the use of posts, planks and trenails. The artefacts recovered from fluvial deposits could be related to chance loss, deliberate deposition or conscious acts of discard, among other possibilities.

Building and shipbuilding

Since the Middle Ages, there has been a strong demand for timber in the city of Pontevedra, for constructing dwellings, shipbuilding and crafting (Armas Castro 1992). The trunks were transported to the city by carts or by floating upstream from the Lérez river. Upon arrival, they were sawn and split into strips, boards and planks, and sold in the city market at prices that were established by the city council. Timber met the demand of specialised crafters, such as barrel makers, and it was one of the goods exported to the Lisbon and Seville shipyards; the documentary references describe shipments of chestnut planks (Armas Castro 1992: 193). Taxa identified for crafting planks, posts, beams, stakes, pegs, trenails and wedges at 65 Arcebispo Malvar Street indicate the existence of a strong selection of raw materials, which is also referenced in the written sources that describe the exclusive use of oak and chestnut wood (Armas Castro 1992). Archaeological evidence attested the predominance of *Castanea sativa* wood for crafting planks during 15th to 16th centuries AD, followed by *Quercus* sp. deciduous, while beams dated to the 15th century AD were all made of *Quercus* (Table 2 and 3). Planks were obtained from trunks probably by sawing or splitting using tangential conversion by rift and quarter sawn (Table 5, Fig. 4). Beams were obtained from the original support through radial secondary conversion (Table 5). All the planks and beams had a previous use and they could have been stored for later exploitation or were abandoned in this area. Most of the beams contained holes of trenails and sometimes trenails were preserved *in situ*. A high percentage was affected by the action of xylophagous insects (Table 4). Diverse kinds of planks were mixed in the beam assemblages, including planks of furniture, door planks, planks related to shipbuilding (Fig. 3). Regarding wood-working techniques, there is evidence of the use of trenails and pegs to fasten the wooden pieces, and no metal nails were identified. The trenails were made of *Quercus* sp. deciduous wood, and sporadically of *Castanea sativa* or *Fraxinus* sp. (Table 3).

In the case of posts, which were probably linked to harbour activities, the preferred wood for crafting was *Quercus* sp. deciduous, although other species such as *Castanea sativa*, *Alnus* sp., *Betula* sp. and *Salix/Populus* were occasionally selected (Table 3). Trunks for posts were felled during autumn-winter and were obtained from young and small diameter trees (Table 6). The investment of labour in their shaping may be considered low (Fig. 3 and 4, Table 6), contrasting with the careful shaping of the planks: the stem was used entirely or radially split, the bark was not removed in all the cases and lateral branches were cut; only the lower part of trunk was sharpened using an axe to facilitate driving them into the ground. There was no evidence of charring of the lower part of the posts in the assemblage in order to improve preservation and avoid rotting in wet conditions.

The preference for *Quercus* sp. deciduous and *Castanea* wood for building and/or shipbuilding –the distinction of the original use of planks is difficult– could be related to the relative abundance of these hardwoods in the local woodlands. In addition to their availability, the preference for *Quercus* and *Castanea* wood was probably related to their morphological and physical attributes. Mature specimens of both genera provide high quantities of durable wood suitable for sawing or splitting. In the case of wood selected for posts, *Quercus* wood was long considered excellent for use in foundations, and *Quercus, Castanea* and *Alnus* are very durable in wet and boggy conditions (Abella 2003, Ulrich 2007). Although *Betula* and *Salix/Populus* are poor for building, as both are soft and light woods that rapidly rotten under conditions that favoured putrefaction (Abella 2003), their use could be related to their presence in the riverine forests that probably grew along the riverbanks. The sporadic use of *Fraxinus* for crafting trenails could be associated with the use of production debris (Abella 2003).

In relation to shipbuilding techniques, it is worthwhile to mention the identification of caulking material. The animal hair bunch presented morphological and surface attributes that indicated that it was probably horse hair. Its molecular fingerprint suggested the presence of products originated from a proteinaceous biopolymer, most likely α-keratins together with diterpenoid products such as methyldehydroabietate. These compounds reflect a resinous substance possibly manipulated to pitch. The predominance of abietane diterpenes and lack of pimarene resins suggests that the conifer belonged to the Pinaceae family not Cupressaceae. The use of mixtures of hair and pitch as caulking or luting materials in shipbuilding has been attested previously. Pitch is a black or dark brown resinous substance obtained from the distillation of wood tar or turpentine used for caulking the seams of ships, protecting wood from moisture, etc. Combined results clearly confirm the likelihood of the presence of a keratin or keratin-like biopolymer, probably from hair, and the co-existence of a coniferous resin-derived material. The presence of these materials in the sample is not surprising, because of the known use of mixtures of hair and pitch as caulking or luting (sealant) materials in shipbuilding (Nayling and Jones 2014).

Vessel turning, barrel and basket making

The plate (or lid), staves and strips attested activities related to vessel turning, barrel and basket making. The plate, which was recovered from a context dated to the 13th-14th centuries AD, was obtained from a tangential split of a *Castanea* trunk and then turned (Table 5, Fig. 5). The absence of tool-marks or lathe-turning scars restricts the information about the production process for this artefact. Its shape suggests that it probably had a combined function for consumption of liquid as well as solid food. Alternatively, it could be a lid to fit in a recipient. Small areas of the piece showed evidence of fire, probably related to its use. The preferred wood for crafting vessels or cups in this area was *Alnus* (Porto et al. 2016), because its wood is tasteless, whereas the presence of tannins in *Castanea* wood provides a specific taste and odour to the recipient.

The simple plaited basket was crafted using *Quercus* twigs, although this kind of artefact could also be made using *Castanea* or *Salix* strips, as is referred to in ethnographic studies (Fontales 2005). These baskets of plaited strips were used for carrying a wide range of products, including fish. This use could be reliably assigned to the basket recovered at Arcebispo Malvar because fish was usually carried over a layer of leaves, and the wooden strips were covered by *Vitis* leaves and fish scales (Fig. 6).

The wooden barrels were made of *Quercus* staves, which is also described in the written sources. These artefacts present a standardised production reflected in the homogeneous morphology and type of conversion (Fig. 6), which could be related to the existence of specialised barrel-making artisans. The written sources describe how during the 15th century barrel-makers were differentiated from carpenters and since 1518 they were grouped as "ofiçiaes do dito ofiçio de tonelería". They were place at the Tonearia Street near Santa Clara's door where the wine came into the city of Pontevedra from the Ribeiro region. They had a seasonal activity ranging from September to December, a period coincident with winemaking and fishing sardine for producing "sardina arencada"

(Armas Castro 1992). Until the 15th century, the local woodlands provided enough timber for barrel-making, but since the 16th century onwards, the cutting of trees for barrel production was forbidden in order to secure the timber supply for shipbuilding (Armas Castro 1992). The most common stave-built container was the “pipa” -which in Pontevedra has a volume equivalent to 497 litres- and was used for trading fish and wine. During the 15th century AD, Pontevedra’s harbour was an important wine trade centre that supplied the local market and also different destinations along the Atlantic sea-lane reaching the North Atlantic Sea. The city was also a focus of the fishing and conserving activity of the Rías Baixas (Armas Castro 1992).

Trade

Three plant-based crafts could be related to trade and commercial sea lanes: the oar, the comb assemblage and the cup made from a coconut shell. The piece of *Fagus sylvatica* wood was identified as an oar made from the heartwood of trunk with weak tree-ring curvature (Table 3). It has a polygonal section, with a pointed edge and it is broken in the other side so that the complete shape of the oar remains unknown. The identification of this object as an oar was possible with the aid of the written sources. There are references about wood of *Fagus sylvatica* as the most appreciated for crafting oars. Beech is not a common tree in northwest of Iberia, growing only in the eastern mountain areas of Galicia. The oars were probably supplied by merchants from Santander (Cantabria), who sold it throughout the Cantabrian Coast, reaching as far as the Atlantic Seaports. In the case of Pontevedra, the written documentation attested the demand of oars in the city during the 16th century in relation to the sardine fishing (Armas Castro 1992).

The cup and combs, recovered from contexts dated to the 16th and 17th centuries, were broken and incomplete, and this, added to their recovery from a riverine deposit could indicate that they were deliberately discarded. The three double-sided combs could be interpreted as toilet combs, used by both women and men (Mille 2008, Mille *et al*. 2014). Since Antiquity, combs present standardised morphologies and production processes (Pugsley 2003), and even for the Middle Ages and the Post-Medieval period combs have been proposed as accurate chronological markers (Mille 2008). The morphology of the combs recovered at Arcebispo Malver is very similar to the sub-type D1 described by Mille (2008), which can be dated from the 14th to the beginning of the 16th century AD. In the Middle Ages, boxwood was the preferred wood for comb-making, as attested by archaeological artefacts (Pugsley 2003, Morris 2000) and textual references (Mille 1993), because this genus provides wood with an unparalleled hardness, mechanical strength and fine-grain in Europe (Mille 2008). *Buxus* grows naturally in northwest Iberia, though it is scarce and found only in restricted areas (López 2002). The inexistence or scarcity of this *genus* in the local woodlands, added to the complex *chaîne-opératoire* required for producing the combs—the wood has to be worked (sawing, polishing) while it is green and by means of a standardised procedure—could link these objects to trade and commercial contacts, which are attested since Antiquity (Vaz *et al*. 2016, Derks and Vos 2010) and during Middle Ages (Mille 2008) throughout Europe.

The cup made from a coconut shell could be also related to trade or to commercial lanes of Pontevedra's harbour. *Cocos nucifera* is a palm that grows in tropical areas of Africa, America and Asia. This object probably arrived in Pontevedra as a manufactured item in relation to the commercial lanes or as a day-to-day object inside a ship.

Conclusion

This study showed the relevance of integrating plant-based materials in the interpretation of archaeological contexts, and above all the importance of a multi-disciplinary approach in verifying written sources, as well as providing data not recorded in documentary sources. The plant assemblage of the Peirao da Ponte comprised a wide variety of objects, including construction and shipbuilding timber, personal objects, baskets or stave-built containers among others. These objects show the short list of species used in wooden construction and shipbuilding and the presence of imported plant-based objects from other areas of the Iberian Peninsula and even from tropical areas. This assemblage also provided clues about the timber and wood supply of a dynamic commercial area such as the city of Pontevedra.

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Table 1. Date, stratigraphic unit of provenance (SU), number of artefacts (N) and remarkable observations.

Table 2. Number of manufactures organised by group, functional interpretation and date.

Table 3. Taxa identification and functional interpretation of woodcrafts.

Table 4. Timber: dendrological attributes and complementary data (W: weak, M: moderate, S: strong, Ind.: indeterminate).

Table 5. Timber: conversion of wood and artefact section (Ind.: indeterminate).

Table 6. Timber: dendrological attributes of posts.

Figure 1. Map of northwest Iberia showing the location of Arcebispo Malvar Street. Other sites from which plant-based crafts -that were preserved by waterlogging, mineralisation or carbonisation- have been recovered and dated to Medieval and Post-Medieval Periods are also shown.

Figure 2. Photographs of a) SU1506 which concentrates most of the woodcrafts and b) SU1264 with stakes recovered within a ditch.

Figure 3. Timbers: in the upper part of the image two posts, one stake, two types of planks, one peg and one wedge; in the lower part a carved plank. Scale: 5cm.

Figure 4. Conversion code of planks, beams and posts (Radial Conversion. Primary conversion: A to G; Secondary conversion: K to M; Alternative conversion: U; Tangential conversion: N to P).

Figure 5. Plate made of a *Castanea sativa* trunk (a) and a cup crafted from a *Cocos nucifera* shell (b) (Drawn by Xurxo Constela Doce).

Figure 6. Basket: a) woven wooden strips after cleaning in laboratory; b) tree-rings in one of the *Quercus* sp. deciduous strips; c) *Vitis vinifera* leaf and d) fish scale adhered to the surface of the strips.

Figure 7. The wooden combs made of *Buxus sempervirens*, the bead made of a hazelnut shell and the pointed object made of *Ilex aquifolium* (drawn by Xurxo Constela Doce).

Figure 8. Fibre bundle: a) bundle of fibres; b) and c) scales on the fibre surface; and d) medulla.

Figure 9. Example chromatograms. A) Retention time region between 0 and 10 minutes, from Py-GC-MS. Red line: archaeological sample AM.65.14/8869. Grey line modern animal (human) hair. These products correspond to a proteinaceous biopolymer, probably keratin. B) retention time region from 10 to 15 minutes, showing the presence of fatty acids in the sample of modern hair (grey line) and a series of diterpene resin-derived compounds from the archaeological sampleAM (red line: Py-GC-MS, blue line: THM-GC-MS) but not the modern hair.

Manuscript Number - ENV383 – Environmental Archaeology

The manuscript was modified to address the minor revisions suggested by Reviewer 1 and 2. The modifications of the original manuscript are listed as follows:

Key-words: The Key-words have been modified following the suggestions made by Reviewer 1 and 2: Waterlogged wood; Pitch; *Chaîne-opératoire*; Medieval and Post-Medieval period; Iberia. We excluded "wood conversion" and "wood anatomy" because of the limit of 5 key-words.

Chronology: Reviewer 1 and 2 raised questions about chronologies. Firstly, we have rewritten one of the related sentences. Secondly, it was specified in the Material and Methods section that the chronological adscription of the contexts has been made only using the archaeological materials, namely pottery. No radiocarbon dates are available from this site. In all the objects analysed no large series of tree-rings were preserved, and the number of tree-rings was not enough for dendrochronological and dendro-provenience analysis.

Words replaced: All the suggestions made by Rev. 2 regarding the use of specific terms, have been accepted: "manufactures" has been replaced by "artefacts" or "objects"; "collections of documents" by "the study of written sources"; "determination" by "identification"; among others. We have replaced Middle Age by Medieval and Post-Medieval period; and we have suppressed "Post-Medieval period", "harbour" and added "Iberia".

Pegs and trenails: Reviewer 2 asked about the differences between pegs and trenails, which is explained in the revised manuscript where we provide a definition of both terms to avoid confusion. Replying the questions made by Reviewer #1, the diameter of trenails ranged from more than 1cm to 2.5cm; whilst pegs presented higher diameters ranging between 3.5 to 3.8. The morphology of the trenails was only recorded in one case because the plank was fractured, the trenail presented a quadrangular section and a pointed edge. When the trenails were preserved *in situ* we could not register their morphology. We have not identified the presence of "épîte" associated to the trenails.

Function of planks: Questions raised by Reviewer 1 about the function of plant, and the possibility of distinguishing between building and shipbuilding planks, or event distinguishing parts or types of ships was not possible with the assemblage available. We suppose that several planks were related to shipbuilding but in all the cases were recovered from tertiary contexts, probably abandoned or stored for a later use.

***Salix/Populus*:** *Salix* and *Populus* could only be distinguished on the basis of their ray anatomy (Schweingruber 1990): *Populus* presents homogeneous rays, rarely with square marginal cells, and *Salix* heterogeneous rays with one to two rows of square and upright marginal cells. When square ray cells are present in Populus or when the marginal upright cells are absent, it is difficult to distinguish between these two *genera*. The samples analysed at Arcebispo Malvar presented heterogeneous rays, and this is the reason of identifying this wood as *Salix/Populus*.

Combs: The paragraphs discussing the presence of combs, and their classification and interpretation, have been rewritten, to enrich the discussion. We also added references such as Vaz et al. 2016 and Mille 1993 and 2008.

Figures: Figure 3 was improved the colour scales have been deleted and only one black scale of 5 cm has been added, the order of the images has changed, and the caption was modified. Figure 4 has been modified replacing solid by pattern fills. Figure 5. In the caption "Cocos nucifera drupe" was replaced by by "*Cocos nucifera* shell". Figure 7: In the caption "pericarp of *Corylus avellana*" was replaced by "hazelnut shell". The drawing of the hazelnut shell has been rotated to the left. Other misprints have been corrected in the captions of figures and tables.

References: All the missing references and misprints have been corrected, including those listed by Reviewer #1: Bernard et al 2013, Brisbane and Hather 2007 ; Cappers et al 2006 ; Armas Castro 1992 ; Coles and Coles 1986 ; Coles et al 1978 ; Comey 2003; Dietrich 1994; Durand 2002; Ferreira 1987 ; Hausman 1920; Ingold 2007; Jacomet 2006; Lopez 2006; Morgan 1988; Pillonel 2007 ; Rast Eicher 2016 ; Sands 1997; Solórzano 2009 ; Tegel et al 2016 ; Shackley 1981; Vermeeren 2001; Zutter 2000; Deforce 2017; Earwood 1991; Hurcombe 2014; Ottaway and Rogers 2002; Schweingruber 1990 and 2007; Wood 2005. The alphabetical order of the references has been checked and corrected. The reference Mille et al. 2014 has been added.

We have also added the new references Sartal Lorenzo 2016, Del Río et al. 2016, Kolchin and Chernetsov 1989, Mato and César 2017, Mille 1993, 2008, Mooney 2016, Vaz et al. 2016.

Cites including "et al." throughout the text has been formatted as italics as indicated by Reviewer #1.

English version: Clíodhna Ní Lionáin with a PhD in Archaeology and native speaker of English has reviewed the English version of the text.

Finally, we would like to express our willingness to exchange ideas about wooden elements of shipwrecks, as suggested by Reviewer 1.

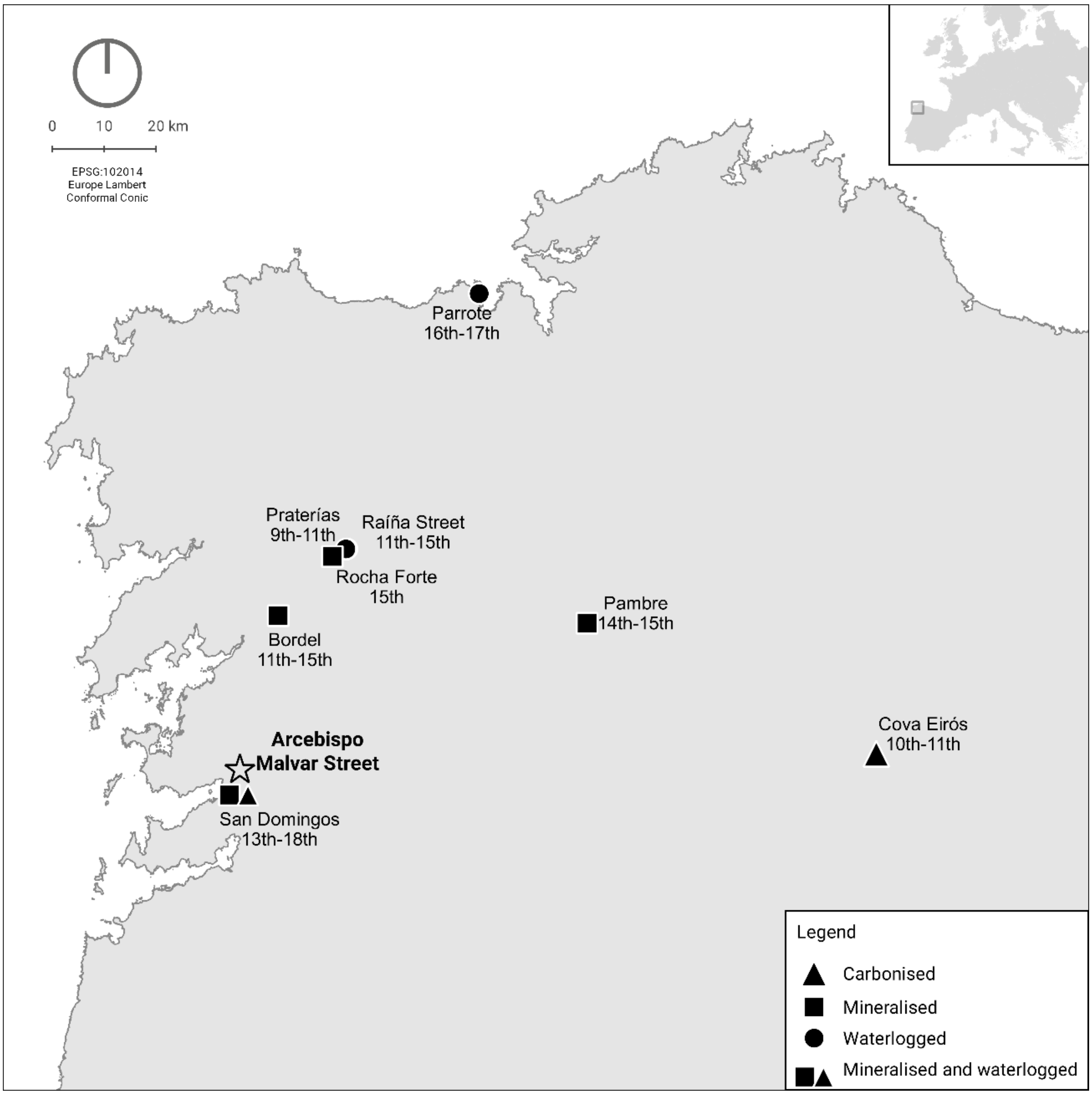


Figure 1. Map of northwest Iberia showing the location of Arcebispo Malvar Street. Other sites from which plant-based crafts -that were preserved by waterlogging, mineralisation or carbonisation- have been recovered and dated to Medieval and Post-Medieval Periods are also shown.

a b

Figure 2. Photographs of a) SU1506 which concentrates most of the woodcrafts and b) SU1264 with stakes recovered within a ditch.

Figure 3. Timbers: in the upper part of the image two posts, one stake, two types of planks, one peg and one wedge; in the lower part a carved plank. Scale: 5cm.

Non-colour figure

Click here to access/download;Non-colour figure;Figure 4.docx

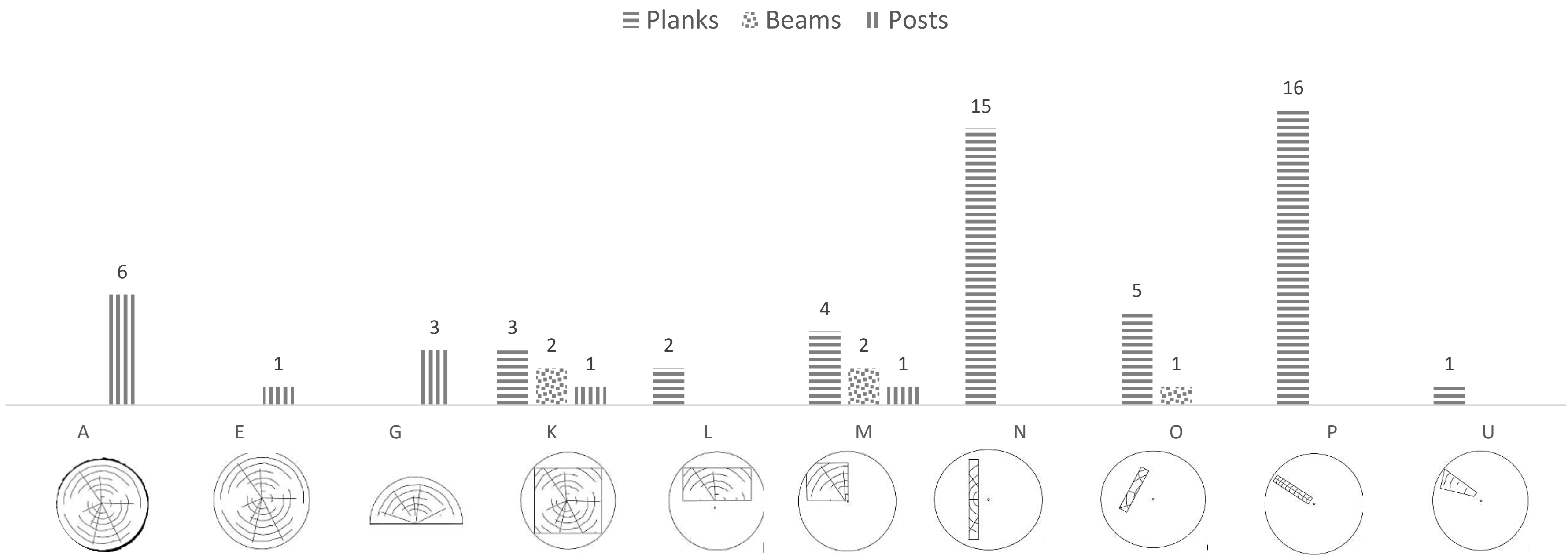
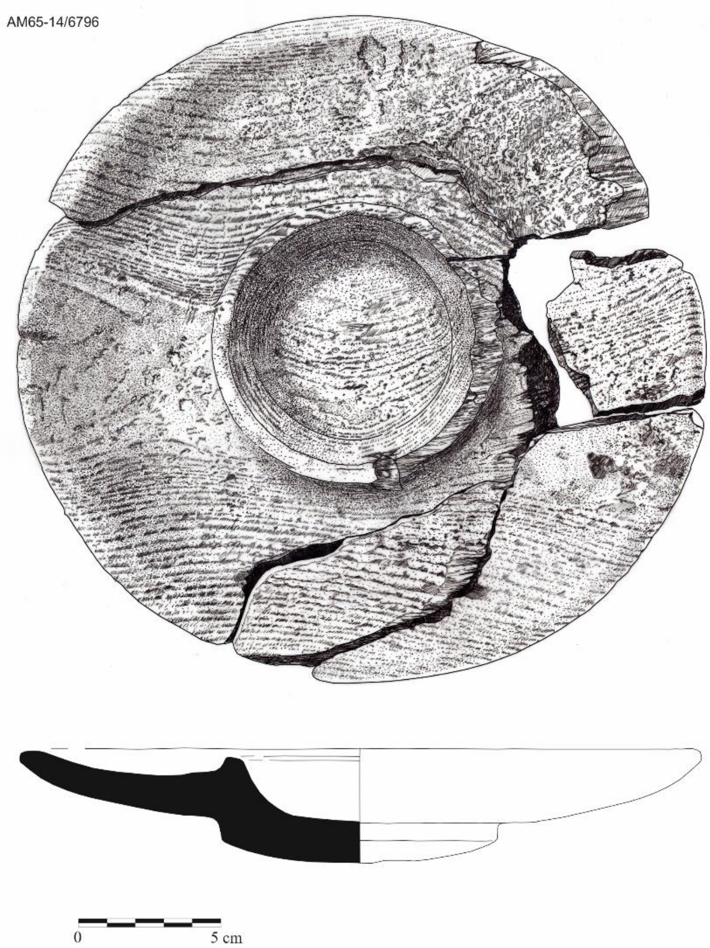
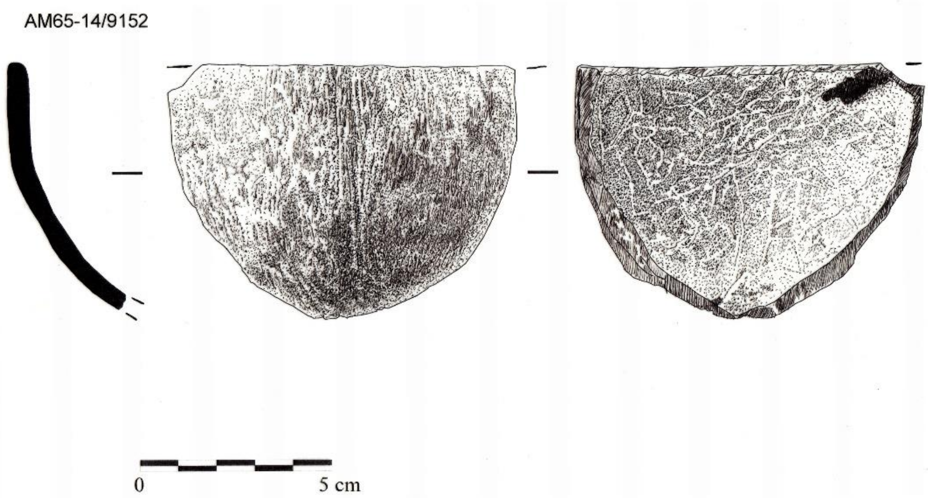


Figure 4. Conversion code of planks, beams and posts (Radial Conversion. Primary conversion: A to G; Secondary conversion: K to M; Alternative conversion: U; Tangential conversion: N to P).

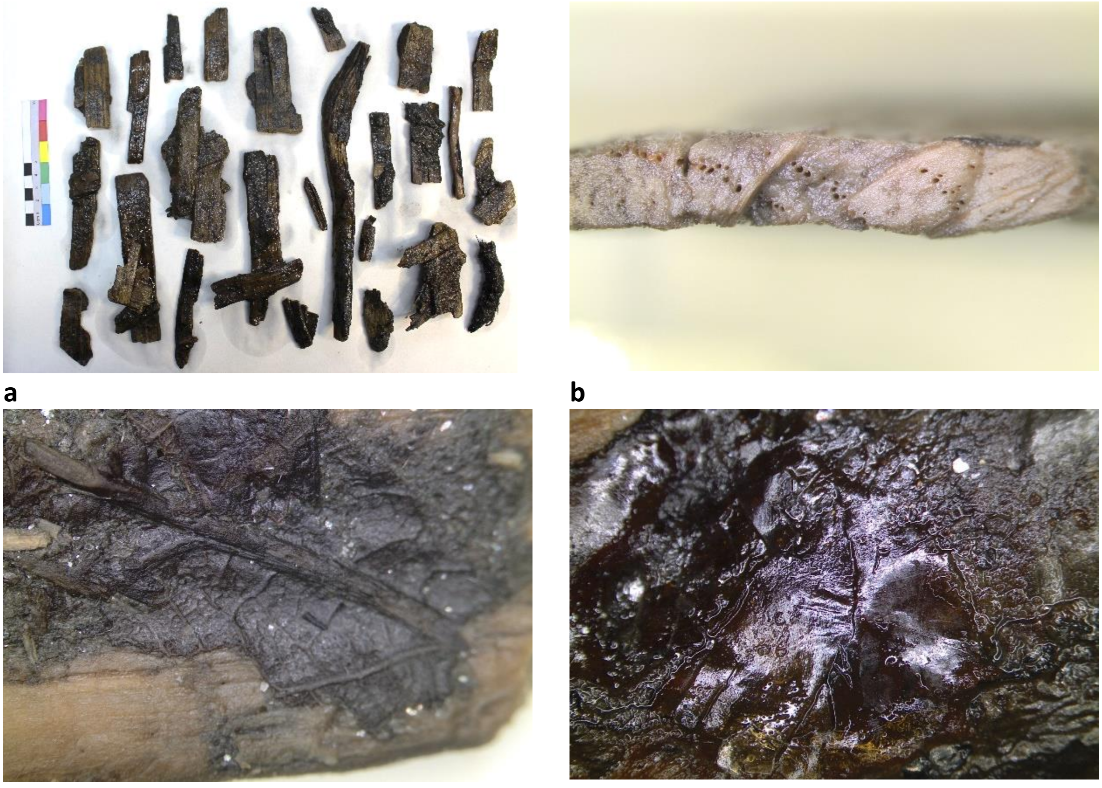


a



b

Figure 5. Plate made of a *Castanea sativa* trunk (a) and a cup crafted from a *Cocos nucifera* shell (b) (Drawn by Xurxo Constela Doce).



a b c d

Figure 6. Basket: a) woven wooden strips after cleaning in laboratory; b) tree-rings in one of the *Quercus* sp. deciduous strips; c) *Vitis vinifera* leaf and d) fish scale adhered to the surface of the strips.

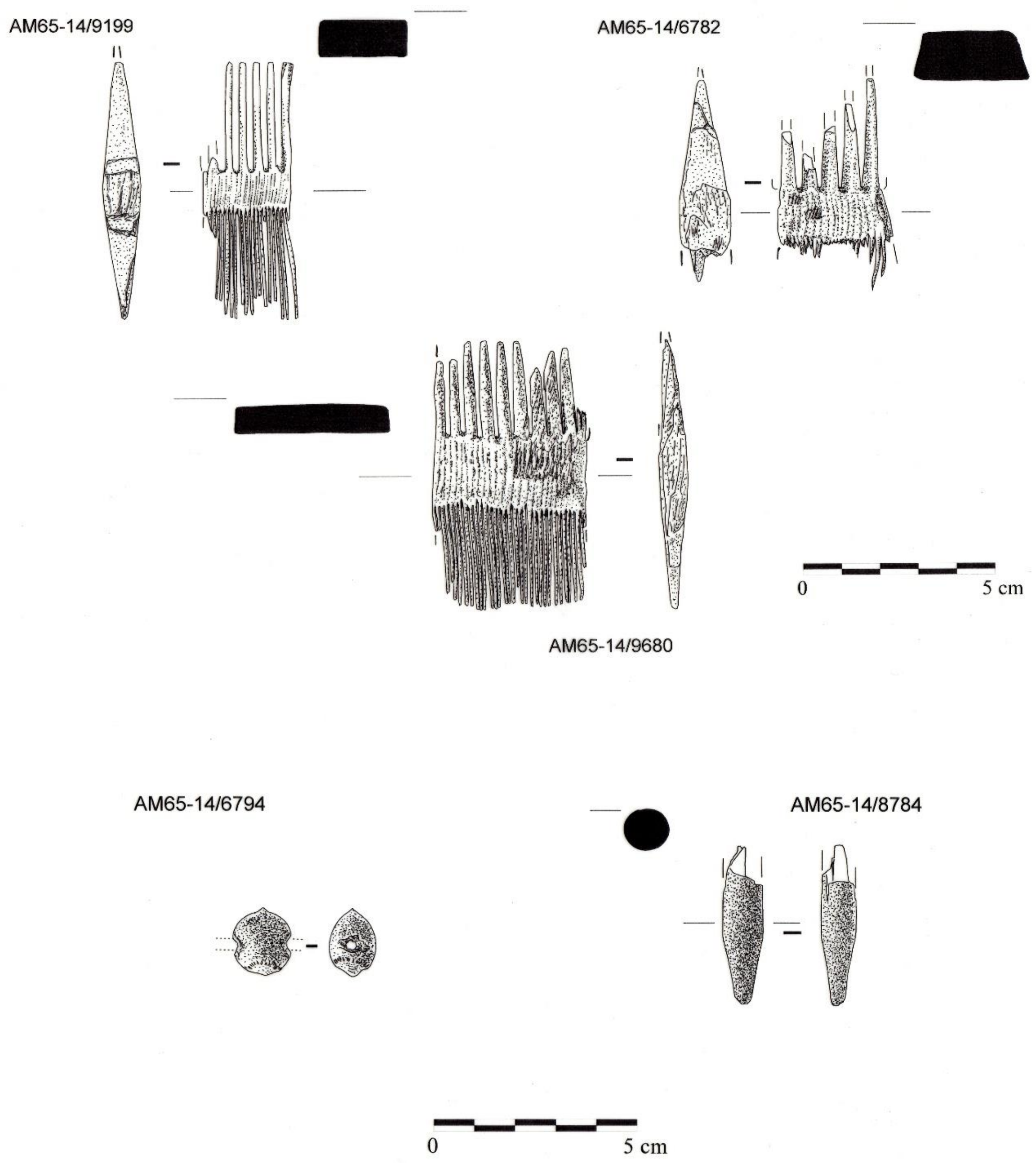


Figure 7. The wooden combs made of *Buxus sempervirens*, the bead made of a hazelnut shell and the pointed object made of *Ilex aquifolium* (drawn by Xurxo Constela Doce).

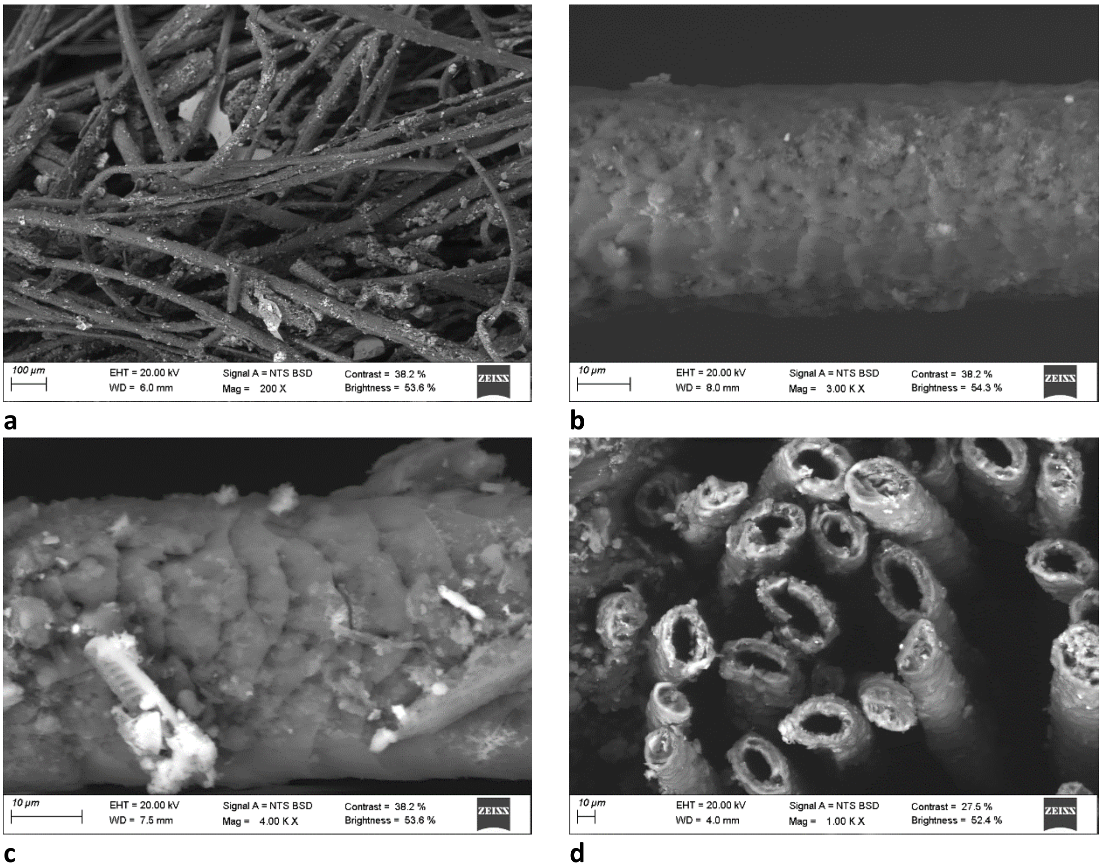


Figure 8. Fibre bundle: a) bundle of fibres; b) and c) scales on the fibre surface; and d) medulla.

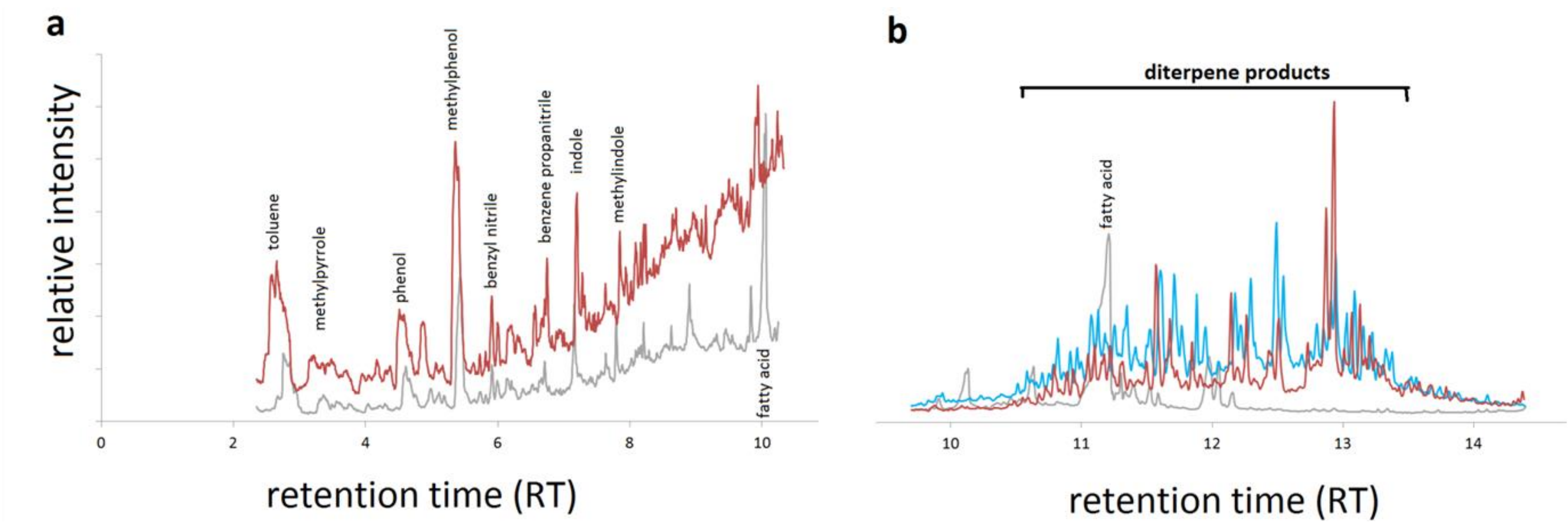


Figure 9. Example chromatograms. A) Retention time region between 0 and 10 minutes, from Py-GC-MS. Red line: archaeological sample AM.65.14/8869. Grey line modern animal (human) hair. These products correspond to a proteinaceous biopolymer, probably keratin. B) retention time region from 10 to 15 minutes, showing the presence of fatty acids in the sample of modern hair (grey line) and a series of diterpene resin-derived compounds from the archaeological sampleAM (red line: Py-GC-MS, blue line: THM-GC-MS) but not the modern hair.

Table 1 Date, stratigraphic unit of provenance (SU), number of artefacts (N) and remarkable observations

Date (centuries AD)	SU	N	Observations
13^{th}	1416	1	Riverine deposition.
13^{th}-14^{th}	1389	1	Riverine deposition.
	1469	2	Deposit inside a cut which could be related to a fluvial origin.
14^{th}-15^{th}	1493	2	Deposit inside a ditch where wooden crafts were preserved in situ.
	1561	1	Riverine deposition.
15^{th}	1490	2	Riverine deposition.
	1506	84	Intentional accumulation of wood remains.
	1392	1	Riverine deposition.
	1394	1	Riverine deposition.
15^{th}-16^{th}	1207	8	Deposit inside a ditch where wooden crafts were preserved in situ.
	1264	11	Deposit inside a ditch where wooden crafts were preserved in situ.
	1464	1	Riverine deposition.
16^{th}-17^{th}	1372	1	Riverine deposition.
	1440	1	Deposit inside a post-hole where wooden craft was preserved in situ.
	1487	1	Riverine deposition.
	1489	1	Riverine deposition.
	1510	1	Riverine deposition.
	1513	1	Riverine deposition.
	1555	1	Riverine deposition.
17^{th}-18^{th}	1341	1	Riverine deposition.
18^{th}-19^{th}	1105	1	Deposit related to an intentional filling.

Table 2 Number of manufactures organised by group, functional interpretation and date.

	Date (centuries AD)								Total
	13th	**13th-14th**	**14th-15th**	**15th**	**15th-16th**	**16th-17th**	**17th-18th**	**18th-19th**	
Timber									
Post			2	3	6	1			12
Peg			2	1					3
Plank				40	6				46
Trenail				22	8				30
Beam				6					6
Stake				4					4
Wedge								1	1
Containers									
Plate		1							1
Basket			1						1
Stave				10					10
Cup						1			1
Personal items									
Comb						3			3
Fishing implements									
Oar							1		1
Miscellaneous artefacts									
Indeterminate	1								1
Fibre bundle						1			1
Pointed object						1			1

Table 3 Taxa identification and functional interpretation of woodcrafts.

	Planks	Beams	Posts	Stakes	Pegs	Trenails	Wedge	Plate	Basket	Staves	Comb	Oar	Pointed object	Indeterminate
Quercus sp. deciduous	16	6	7	3	2	25			1	10				2
Castanea sativa	30		2	1		2	1	1						
Alnus sp.			1											
Salix/Populus			1		1									
Betula sp.			1											
Fraxinus sp.						1								
Buxus sempervirens											3			
Fagus sylvatica												1		
Ilex aquifolium													1	
Non-identifiable						2								

Table 5 Timber: conversion of wood and artefact section (Ind.: indeterminate).

	Total	**Radial conversion**			**Tangential conversion**	**Artefact section**						
		Primary	**Secondary**	**Alternative**		**Ind.**	**Rectangular**	**Quadrangular**	**Circular**	**Semi-circular**	**Triangular**	**Polygonal**
Planks	46	1	6	3	36		40	2				3
Beams	6		6		1		5	1				
Posts	12	10	2					2	7	3		
Stakes	4	3			1				1			3
Pegs	3	3							2		1	
Trenails	30		18		8	4	6	6	18			
Wedges	1	1							1			

Table 4 Timber: dendrological attributes and complementary data (W: weak, M: moderate, S: strong, Ind.: indeterminate).

	Total	Plant part			Tree-ring curvature							Xylophagous' galleries
		Trunk	Twig	Ind.	W	M	S	W-M	M-S	W-M-S	Ind.	
Planks	46	44		2	8	14		12	6		6	18
Beams	6	5		1				1	5			4
Posts	12	12						1	8	3		3
Stakes	4	3	1			1			3			
Pegs	3		3				2		1			
Trenails	30	1		29	2	7					21	
Wedges	1		1				1					

Table 6 Timber: dendrological attributes of posts.

Date centuries (AD)	Taxon	Conversion section	Max. diameter (cm.)	Annual rings	Season of plant death	Lateral branches
14th-15th	*Quercus* sp. deciduous	Rounwood	13.6	11	Latewood	Yes
	Alnus sp.	Rounwood	18.0			Yes
15th	*Betula* sp.	Rounwood	6.2			Yes
15th-16th	*Quercus* sp. deciduous	Rounwood	12.8	10	Latewood	
	Quercus sp. deciduous	Rounwood	11.5	10	Latewood	Yes
16th-17th	*Castanea sativa*	Rounwood	16.0	16	Latewood	