# Application of reflected light microscopy for non-invasive wood identification of marquetry furniture and small wood carvings



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# APPLICATION OF REFLECTED LIGHT MICROSCOPY FOR NON-INVASIVE WOOD IDENTIFICATION OF MARQUETRY FURNITURE AND SMALL WOOD CARVINGS

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**ABSTRACT**

Wood identification is a basic information that should interest any wooden artefact. This typically involves invasive sampling, but sometimes sampling is unattainable either because of the object typology or because it is difficult to obtain authorizations.

In the present study reflected light microscopy potential as a non-invasive identification tool for wooden cultural artefacts is assessed on a number of marquetry furniture and small wood carvings.

In more than one half of the 13 examined cases accurate wood identification was possible, while the remaining cases yielded information of diagnostic value, making it possible to exclude several potential candidate species. In a number of cases the use of optical filters improved the visibility of character states. Shape and orientation of surfaces influenced the visibility of microscopic characters.

The study confirms that reflected light microscopy is a valuable tool for non-invasive wood identification. In many cases it is able to support accurate identification, in others it can anyway provide important information, useful to help decision about supposed species, or to limit the invasiveness of possible further analysis by addressing them on specific features.

Keywords: **reflected light microscopy / IAWA list / Savoia Royal House / non-invasive wood identification / antiques**

## 1. Research aims

The purpose of this work is to non-invasively identify woods used in some antique marquetry furniture and small carvings through the use of reflected light microscopy. Limits and potential of reflected light microscopy as a non-invasive identification tool, i.e. without any prior preparation of observed surfaces, are hence discussed, together with the role of retrieved information for objects' interpretation.

## 2. Introduction

The knowledge of the timber(s) used in a wooden object or work of art belonging to the cultural heritage is a basic information for any study, conservation or restoration activity. Its importance can vary from one kind of artifact to another, but it is always an essential information. The role of the knowledge of the woods used in an object of art, in the specific case ancient furniture, is finely pointed out in [1], where the author states "… furniture-making is essentially a

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manufacturing activity, although it may also involve artistic expression, and, like all manufacturing processes, it therefore begins with raw materials" and more precisely "knowledge of the woods used in furniture-making is not just a question of connoisseurship; it is a fundamental requirement for understanding any piece of furniture". Just to mention few other examples, without this knowledge it is impossible for instance to infer the mechanical strength of the timber elements in a wooden structure [2], while in the archeological studies, all the physical and chemical measured parameters are compared to those of the sound wood of the same timber in order to determine the amount of the decay [3].

The question therefore is: how can we identify wood on an antique? Rarely identification through macroscopic features can be reliable; in most cases microscopic analysis is necessary. Limits of microscopic wood identification have been examined by many authors, both considering the technique itself [4], and in relation with specific problems associated with valuable cultural artefacts [5] and [6]. The Italian standard UNI 11118 [7] describes criteria and limits of species identification on wooden artefacts of historical, artistic and archaeological interest. This document states that the identification process is a step-by-step path, which starts from the macroscopic observation and deepens until a satisfactory level of taxon can be reached. Because of the above mentioned limits, even microscopic analysis can disappoint expectations.

The same standard also indicates that sampling is always subject to an official permission from the artefact's curator, who is the sole to have authority on the subject. Such authorization can be difficult to obtain when artistic objects, such as statues and panel paintings, are involved, even if sampling is always targeted on hidden places, like the back of the artifacts, or non-decorated parts [8]. On the other hand, sampling can be sometimes impracticable, like on pieces of art where the decorated or artistic functions are given by the wood surface itself. This is the case of marquetry or preciously decorated furniture.

Therefore non-invasive wood identification can be highly preferred, when not unavoidable.

Reflected light microscopy (RLM) potential as a non-invasive identification tool for wooden cultural artefacts has been discussed in a recent paper [9]. Here we test the technique and methodology on historical objects made available by the "*Centre of Conservation and Restoring of La Venaria Reale*" near Turin, Italy.

The guiding principle in artefact selection was to go back over the production of the cabinet-makers who alternated at the service of the Royal House of Savoia in Piedmont through the 18$^{th}$ and 19$^{th}$ Century. Following this path, the paper takes its cues from a range of different manufacturing typologies to present the results obtained through non-invasive RLM and discuss their reliability and diagnostic value.

## 3. Materials and methods

### 3.1 Microscopes

Three different reflected light microscopes were alternatively used depending on artefacts dimensions: for the smallest objects or parts an Olympus BX51 optical microscope fitted with an Olympus TH4-200 reflected light source, a polarizing filter (Pf), an Olympus U-MNB2 narrow-band blue filter (Bf) and an Olympus DP71 digital color camera; for medium sized objects an Olympus SZX10 stereomicroscope fitted with an Olympus KL1500 LCD light source and a ColorView I digital color camera; bigger objects which could not fit under any of the previous instruments where observed with a Scalar DG-3 portable digital microscope equipped with 25x-200x par focal zoom lens. As regards fixed instruments, a digitized image analysis system (analySIS®, Olympus) was used for microphotography and quantitative anatomy.

3.2 Identification

All pieces were observed rigorously as they are, avoiding any kind of alteration of their surfaces. Each visible feature was recorded and documented through photographs, some examples of which are presented in the paper. Because of the reduced features visibility entailed in the observation of non-prepared surfaces (i.e. neither oriented nor surfaced), absence of specific features was not used for identification.

Terminology and survey principles generally followed the IAWA list of microscopic features for hardwood identification [10] and the IAWA list of microscopic features for softwood identification [11]. Some exceptions, pointed out in the text, have been occasionally made as regards survey principles in order to adapt to surfaces availability. Some character states not detailed in the IAWA list were recorded too. Non-anatomical features were occasionally considered since they have been proved useful in wood identification [12], yet keeping in mind that some of them, such as color, can be easily modified by time, light or human manipulation, which are all common agents on ancient artefacts.

[13], [14], [15], [16], [17], [18], [19] and [20] were adopted as references for identification, while [1], [21] and [22] were consulted for the botanical identity of common names. Reference information about employed woods, when available, were used for the sole purpose of results comparison and discussion.

3.3 Artefacts

*Secretary chest of drawers with shelves, Decorative arts museum of the "Pietro Accorsi" Foundation, Turin* – Pietro Piffetti (1701-1777).

This art piece is almost the twin of the one conserved at the Quirinale Palace (official residence of the President of the Italian Republic). By tradition the main veneer (*Fig. 1,a*) was supposed to be "rosewood". Unfortunately, the botanical identity of this vernacular name can't be retrieved, since it has been widely used over the centuries for woods belonging to several different taxa [1]. A little loose veneer card, which had to be rearranged by restorers, was observed on both sides by means of the Olympus BX51.

*Centre table, Palazzina di Caccia di Stupinigi* – Giovanni Galletti (XVIII cent.).

The main veneer (*Fig. 2*) consists of a composition of transverse sections and wood burls, a quite original pattern for this type of objects. In an ancient document reported by [23] it was attributed to "busso", an Italian vernacular name for boxwood (*Buxus sempervirens*) [21]. Observations aimed to verify this assumption were performed on the drawers in both sides of the table by means of the Scalar DG-3.

*Table, Palazzina di Caccia di Stupinigi* – Giovanni Galletti (speculation).

Two veneers (*Fig. 3,a and b*) lacking any documental information were observed by means of the Scalar DG-3.

*Carlo X table, Reggia di Valcasotto, Garessio* – Gabriele Capello (1806-1877, speculation).

Any documental information about the species used is lacking. Based on general historical knowledge, the light-colored veneer (*Fig. 4, a*) was supposed to be "citronnier" or "satinwood", to which species from different genera can be referred, mainly: *Chloroxylon*, *Morus*, *Pericopsis*, *Zanthoxylum* [1], [22] and [24]. The dark inlay (*Fig. 4,b*) was supposed to be "purpleheart", i.e., *Peltogyne* sp. [1] and [22]. Both were analyzed by means of the Scalar DG-3.

*Military trophy, Palazzo Madama, Turin* – Giuseppe Maria Bonzanigo (1745-1820).

Bonzanigo, apart from being a great cabinet-maker, is worldwide recognized as one of the most prominent wood carvers, especially regarding miniature. This work of art is an example of his outstanding skills and, being made up of several small pieces, constitutes an exceptional chance for study. Vernacular names of some timbers used in this art piece can be found in an ancient document mentioned in [25]. The author states to have collected these information directly from the artist, but does not specify any correspondence to single pieces.

Some pieces (*Fig. 5 to 10*), representative of different typologies inside the artifact, were analyzed. Thanks to their limited dimensions, they could be observed with the Olympus BX51, but the Olympus SZX10 was sometimes used too.

## 4. Results and discussion

For a better comprehension results are displayed in Table 1; hereinafter identification results are discussed.

Both tropical (*Dalbergia*, *Pterocarpus*) and Italian indigenous (*Buxus*, *Laburnum*, *Taxus*) genera were identified on furniture, while in one case and identification could not be provided.

*Dalbergia* comprises approx. 250 species [26] distributed from the tropical to subtropical regions of the World [16] and [27], some of which can be numbered among the most wanted woods for valuable furniture [1] and [24]. Although only around 10-15 species are of economic importance [28], separation of some of them is nowadays a challenge [29]. Several species of the genus have been traded (and still they are) under the name "rosewood" [1], the supposed attribution for this veneer. Noteworthy is the better visibility of most features, really small ones such as intervessel pits dimension and vesturing included, on the shellac finished side of the veneer card rather than the non-finished one; thus confirming the positive effect of shellac on anatomical features visibility pointed out in [9]. The *Pterocarpus* genus includes extremely valuable timbers too, which have been extensively used in marquetry furniture [1] and [24]. The identification does not confirm the initial assumption (*Peltogyne*). *Laburnum anagyroides*, golden chain, has been often employed in marquetry as a substitute for more expensive exotic ones, such as mahogany [1] and [24]. *Buxus* and *Taxus* identifications are not certain. As for the first, although observed features are in agreement with documented information, no sufficient anatomical information were detected to confirm the genus. In particular, perforation plate type evidence is needed, because *Buxus* has exclusively scalariform perforations. The difficulty met in identifying this feature is not surprising if we look at its comparatively low Feature Recognition Index on non-finished surfaces pointed out in [9]. Moreover, it must be noted that the indistinctness of numerous individual character states is due to the extremely fine texture and grain of the wood, which is in agreement with an identity of *Buxus* wood, also very fine-grained. As regards the second, more clear evidence of helical thickenings should be needed for confirmation. Yew wood, mostly known for its use in longbows manufacturing since medieval times in England [1], was frequently used in marquetry in order to emulate exotic ones [24]. In the case of the Carlo X table "veneer a", observed features were not sufficient to make an accurate identification, but still allowed to exclude any of the genera commonly known as "citronnier" or "satinwood".

All the woods identified on the military trophy sculptures belong to Italian indigenous genera. Half of them are not mentioned in [25]: *Tilia*, *Ilex* and the Rosaceae group (*Pyrus* / *Malus* / *Sorbus*); while *Aesculus*, *Buxus* and *Populus* can be retrieved in the document with their correspondent vernacular names, respectively "Castagno d'India" (literally "Indian chestnut"), "bosso" and "pioppo maschio".

The wood of holly (*Ilex*) is reported to be valued as a carving material especially because of its color resemblance to ivory and fine texture [24]. At this regard, noteworthy is the presence in the centre of the trophy of a similar portrait made of ivory representing the king Vittorio Emanuele I, to whom the object was donated [30]. This could suggest an interesting artistic choice, nowadays hidden by discoloration of the wood. *Aesculus* and *Poplar* woods too are traditionally widely used for carving [24]. *Buxus* and *Tilia* identifications are not certain. In the first case, evidence of intact scalariform perforation plates is needed for further confirmation. Because of wood discoloration this piece shows no more any evident color contrast with its support (piece 8,a) made of *Aesculus*, which instead was probably the original intention of the artist. The use of boxwood for carving, especially for small refined objects, can be traced back to ancient times [24]. In the second case, evidence of axial parenchyma pattern would be useful for further confirmation. Lime wood is amongst the preferred timbers all over Europe for carving [24]. Finally, on the basis of observed features further discrimination was not possible amongst the three genera *Pyrus*, *Sorbus*, *Malus* belonging to the Rosaceae group, all woods highly valued for refined carving and turning [24].

## 5. Conclusions

Conventionally wood anatomical identification is performed through the analysis of each one of the three plans of observation of wood (transverse, longitudinal radial, longitudinal tangential). In most of the examined cases all the three plans were not available simultaneously and at least one of the available ones was not clearly visible because of surfaces size, orientation, evenness or finishing. Of the three, the cross section (very important, especially for hardwoods identification) was the less frequently observable.

Nevertheless, in spite of all these limitations, seven out of the thirteen investigated pieces (*Fig. 1,a; 3,a; 4,b, 6, 8a, 9 and 10*) were identified with the highest accuracy reachable through anatomical analysis. For other six pieces, a hypothesis could be provided together with the detail about lacking features needed for confirmation. In the worst case, Carlo X table, veneer “a”, the exclusion of a previous speculation could be supported anyway.

Amongst the three tested instruments, the optical microscope provided by far the best performances, due to higher magnification and the availability of polarization and filters (which effectiveness was pointed out in [9] too). Stereomicroscopes and portable digital microscopes were helpful for bigger objects, which could not be observed at the optical one, but features visibility was not as good.

Our study confirm that RLM can be considered an effective tool for non-invasive wood identification. In several cases able to support accurate identification, in others it can anyway provide important information, useful to exclude supposed species or to limit the invasiveness of possible further analysis by addressing them on specific features.

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Table 1. Observed surfaces, characters and identification of each observed piece. Surfaces are reported with details about orientation, evenness, extension and finishing; characters with details about IAWA codes in brackets for listed features, filters (if used), surface of survey (if different from survey principles) and magnification to which they have been observed,; when an Italian indigenous genus is identified, local species are suggested in brackets.

| **Artefact** | **Piece** | **Observed surfaces** | **Characters** | **Identification** |
|---|---|---|---|---|
| Secretary chest of drawers with shelves | / | Tangential, not perfectly orientated. Finished with shellac on the front side, with glue traces on the back. All features were detected on the shellac finished side except than "52". | Intervessel pits alternate (22; Bf; 500x); intervessel pits medium (26; Bf; 500x); vestured pits (29; Bf; 500x); mean vessel element length ≤ 350 µm (52; Pf; 100x); eight (5-8) cells per parenchyma strand (93; Bf; 200x; *Fig. 11*); all rays storied (118; Bf; 100x); heartwood basically brown or shades of brown (197); heartwood with streaks (201). | Hardwood: *Dalbergia* sp. |
| Centre table | / | Transverse, radial and tangential. Finished with shellac. | Body ray cells procumbent with one row of upright and/or square marginal cells (106; 100x); body ray cells procumbent with mostly 2-4 rows of upright and/or square marginal cells (107; 100x; *Fig. 12*); heartwood basically yellow or shades of yellow (199). | Hardwood: probably *Buxus* sp. (*Buxus sempervirens*) |
| Table | Veneer "a" | Tangential and radial. Finished with shellac. | Wood ring-porous (3; radial surface; 40x); vessels in tangential bands (6; latewood vessels jagged pattern visible on tangential surface; 40x); fusiform parenchyma cells (90; 100x; *Fig. 13*); larger rays commonly 4- to 10-seriate (98; 100x; *Fig. 13*); body ray cells procumbent with one row of upright and/or square marginal cells (106; 100x); sheath cells (110; 100x); heartwood color darker than sapwood (196). | Hardwood: *Laburnum anagyroides* |
| | Veneer "b" | Tangential and radial. Finished with shellac. | Heartwood color brown or shades of brown (26); growth ring boundaries distinct (40; radial surface; 100x; *Fig. 14*); transition from earlywood to latewood gradual (43; radial surface; 100x; *Fig. 14*); helical thickenings in longitudinal tracheids present (61; 100x; *Fig. 14,* | Softwood: probably *Taxus* sp. (*Taxus baccata*) |

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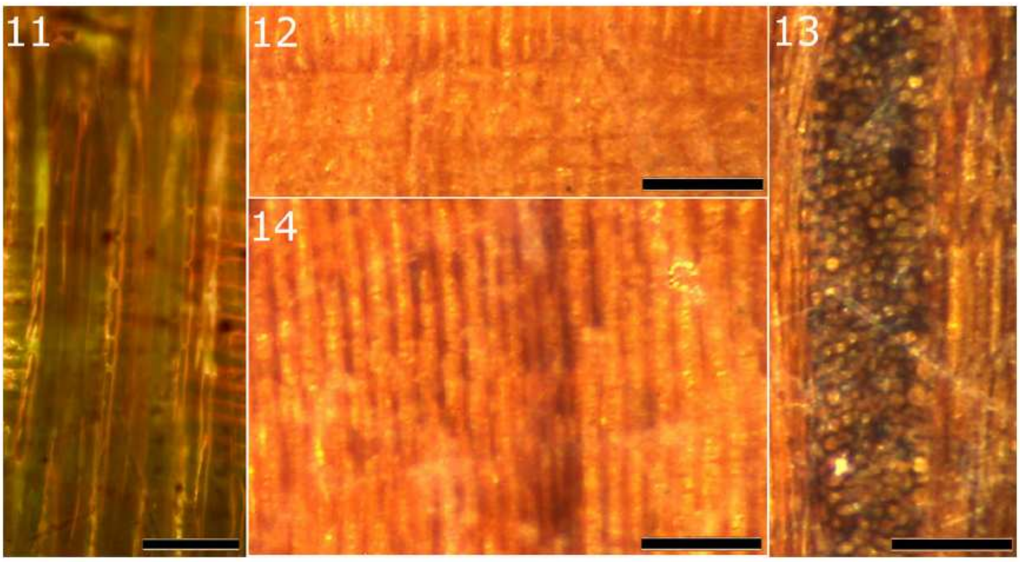
|---|---|---|---|---|
| | | | *poorly visible*);<br>average ray height medium (103; 100x);<br>rays exclusively uniseriate (107; 100x). | |
| Carlo X table | Veneer “a” | Radial and tangential; transverse surface not perfectly orientated and of limited size.<br>Finished with shellac. | Growth ring boundaries distinct (1; 40x);<br>wood diffuse-porous (5; 40x);<br>mean tangential diameter of vessel lumina 100-200 µm (42; 100x);<br>septate fibres present (65; 100x);<br>larger rays commonly 4- to 10-seriate (98; 100x; *Fig. 15*);<br>all ray cells procumbent (104; 100x);<br>heartwood basically yellow or shades of yellow (199). | Hardwood: uncertain |
| | Inlay “b” | Tangential.<br>Finished with shellac. | Mean tangential diameter of vessel lumina ≥ 200 µm (43; 100x);<br>mean vessel element length ≤ 350 µm (52; 100x);<br>rays exclusively uniseriate (96; 100x; *Fig. 16*);<br>all rays storied (118; 100x; *Fig. 16*);<br>heartwood with streaks (201). | Hardwood: *Pterocarpus* sp. |
| Military trophy | Piece “5” | Uneven tangential and small radial and transverse surfaces.<br>Finishing absent. | Wood diffuse-porous (5; 50x);<br>simple perforation plates (13; Pf; 100x);<br>helical thickenings in vessel elements present (36; 200x; *Fig. 17*);<br>larger rays commonly 4- to 10-seriate (98; 200x; *Fig. 17*);<br>rays of two distinct sizes (103; 200x);<br>all ray cells procumbent (104; Bf; 200x);<br>axial parenchyma abundant (tangential surface; 100x). | Hardwood: probably *Tilia* sp. (*Tilia cordata* or *Tilia platyphyllos*) |
| | Piece “6” | Uneven tangential, transverse surface of limited size.<br>Finishing absent. | Wood diffuse-porous (5; 50x);<br>vessels in diagonal and/or radial pattern (7; 50x);<br>helical thickenings in vessel elements present (36; 500x);<br>fibre pits common in both radial and tangential walls (63; Pf; 500x);<br>helical thickenings in ground tissue fibres (64; 500x; *Fig. 18*);<br>larger rays commonly 4- to 10-seriate (98; 200x);<br>ray height > 1 mm (102; Pf; 100x);<br>rays of two distinct sizes (103; Bf; 200x);<br>sheath cells (110; 200x);<br>uniseriate ray margins (tangential surface; 200x). | Hardwood: *Ilex* sp. (*Ilex aquifolium*) |
| | Piece “7” | Uneven tangential and small radial | Simple perforation plates (13; 126x);<br>mean tangential diameter of vessel lumina ≤ 50 µm (40; tangential | Hardwood: *Pyrus* sp., *Sorbus* sp. or *Malus* |

| | | | | |
|---|---|---|---|---|
| | | surface.<br>Finishing absent. | surface; 126x);<br>ray width 1 to 3 cells (97; 200x; *Fig. 19*);<br>all ray cells procumbent (104; 126x);<br>heartwood basically brown or shades of brown (197). | sp. |
| | Piece “8,a” | Uneven tangential and small transverse surface.<br>Finishing absent | Wood diffuse-porous (5; 50x; *Fig. 20*);<br>helical thickenings in vessel elements present (36; 200x);<br>mean tangential diameter of vessel lumina ≤ 50 µm (40; 50x; *Fig. 20*);<br>rays exclusively uniseriate (96; Bf; 200x);<br>vessels solitary or in short radial rows (transverse surface; 50x; *Fig. 20*). | Hardwood: *Aesculus* sp. (*Aesculus hippocastanum*) |
| | Piece “8,b” | Uneven radial and small tangential and transverse surfaces.<br>Finishing absent. | Wood diffuse-porous (5; 50x);<br>scalariform perforation plates (14; 500x; *Fig. 21, only bar residuals visible*);<br>mean tangential diameter of vessel lumina ≤ 50 µm (40; 50x);<br>fibres with distinctly bordered pits (62; Bf; 500x);<br>ray width 1 to 3 cells (97; Bf; 500x);<br>body ray cells procumbent with one to four rows of upright and/or square marginal cells (106 & 107; Bf; 200x);<br>vessel lumina mean tangential diameter ≈ 20 µm (transverse surface; 50x). | Hardwood: probably *Buxus* sp.<br>(*Buxus sempervirens*) |
| | Piece “9” | Uneven radial and small tangential and transverse surfaces.<br>Finishing absent. | Wood diffuse-porous (5; 50x);<br>simple perforation plates (13; 200x; *Fig. 22*);<br>helical thickenings in vessel elements present (36; 200x; *Fig. 22*);<br>mean tangential diameter of vessel lumina ≤ 50 µm (40; 50x);<br>mean vessel element length 350-800 µm (53; 200x);<br>rays exclusively uniseriate (96; 126x);<br>all ray cells procumbent (104; Bf; 200x);<br>vessels solitary or in short radial rows (transverse surface; 50x). | Hardwood: *Aesculus* sp. (*Aesculus hippocastanum*) |
| | Piece “10” | Extremely uneven radial and transverse.<br>Finishing absent. | Growth ring boundaries distinct (1; Bf; 100x; *Fig. 23*);<br>wood diffuse-porous (5; Bf; 100x; *Fig. 23*);<br>simple perforation plates (13; 100x);<br>mean tangential diameter of vessel lumina 50-100 µm (41; Bf; 100x; *Fig. 23*);<br>rays exclusively uniseriate (96; Bf; transverse surface; 100x; *Fig. 23*);<br>all ray cells procumbent (104; Bf; 200x). | Hardwood: *Populus* sp.<br>(*Populus alba*, *Populus nigra*, *Populus tremula*) |

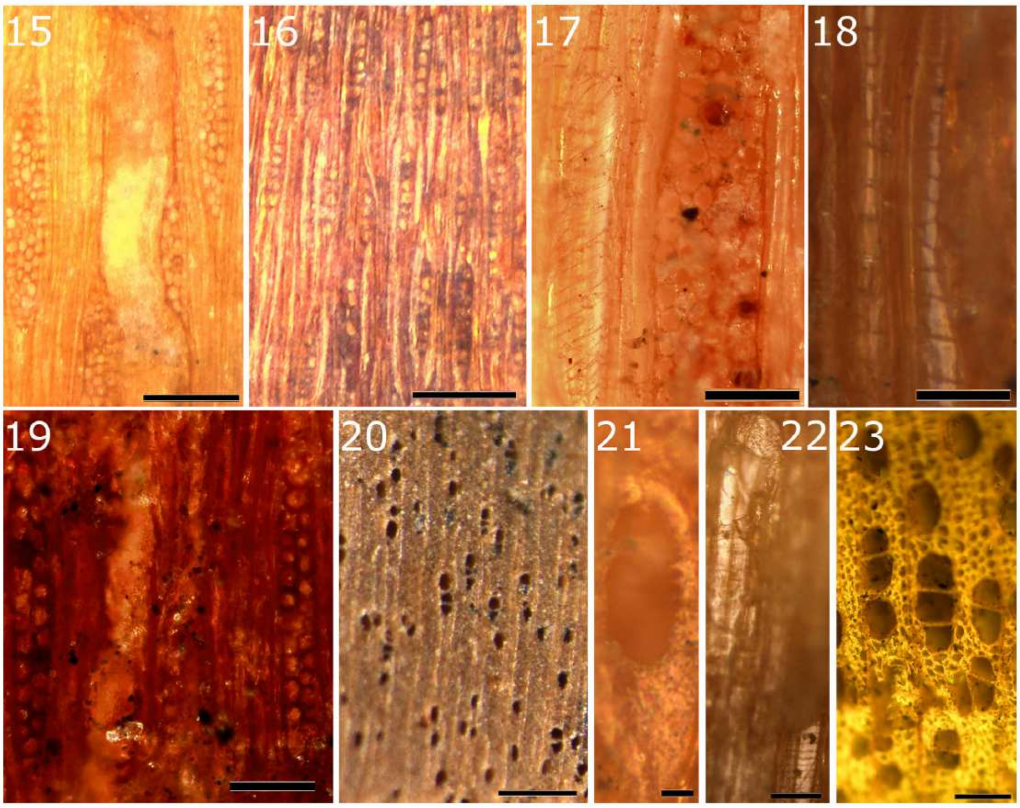

(a)
1
2
(a)
(b)
3
(a)
(b)
4

Figures 1-4. Artefacts details. – 1: Pietro Piffetti; Secretary chest of drawers with shelves, Decorative arts museum of the “Pietro Accorsi” Foundation, Turin. – 2: Giovanni Galletti; Centre table, Palazzina di Caccia di Stupinigi. – 3: Giovanni Galletti; Table, Palazzina di Caccia di Stupinigi. – 4: Gabriele Capello; Carlo X table, Reggia di Valcasotto, Garessio.


Figures 5-10. Artefacts details. – Giuseppe Maria Bonzanigo; Military trophy, Palazzo Madama, Turin. Scale bars = 1 cm.



Figures 11-14. Identified characters; blue filter when used (Bf) and IAWA codes (for listed features) reported in brackets. – 11 (Bf): eight (5-8) cells per parenchyma strand (93). – 12: body ray cells procumbent with mostly 2-4 rows of upright and/or square marginal cells (107). – 13: fusiform parenchyma cells (90); larger rays commonly 4- to 10-seriate (98). – 14: growth ring boundaries distinct (40); transition from earlywood to latewood gradual (43); helical thickenings in longitudinal tracheids present (61). – Scale bars: 11 = 50 μm; 12–14 = 150 μm. – Microscopes: 11: Olympus BX51; 12–14: Scalar DG-3.




Figures 15-23. Identified characters; blue filter when used (Bf) and IAWA codes (for listed features) reported in brackets. – 15: larger rays commonly 4- to 10-seriate (98). – 16: rays exclusively uniseriate (96); all rays storied (118). – 17: helical thickenings in vessel elements present (36); larger rays commonly 4- to 10-seriate (98). – 18: helical thickenings in ground tissue fibres (64). – 19: ray width 1 to 3 cells (97). – 20: wood diffuse-porous (5); mean tangential diameter of vessel lumina ≤ 50 μm (40); vessel solitary or in short radial rows. – 21: scalariform perforation plates (14). – 22: simple perforation plates (13); helical thickenings in vessel elements present (36). – 23 (Bf): growth ring boundaries distinct (1); wood diffuse-porous (5); mean tangential diameter of vessel lumina 50-100 μm (41); rays exclusively uniseriate (96). – Scale bars: 17, 19, 22, 23 = 50 μm; 15–16 = 150 μm; 18 = 25 μm; 20 = 250 μm; 21 = 10 μm. – Microscopes: 17–19, 21–23: Olympus BX51; 15–16: Scalar DG-3; 20: Olympus SZX10.