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MICROSCOPIC CHARACTERISATION OF FOUR EXOTIC SPECIES FOR HISTORIC FURNITURE CONSERVATION

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Abstract: *Wood species identification is a compulsory step in the scientific conservation of the historic furniture. A visual examination of an investigated sample does not always bring enough information about the original species and a microscopic approach is more reliable. This paper is providing the microscopic characterisation with identification keys for four exotic species used in historic furniture. They can serve for wood identification purposes in the laboratories working in the field of wood cultural heritage conservation.*

Key words: *microscopy, wood identification, historic furniture, conservation.*

1. Introduction

Furniture history goes back to the Antiquity and evolved as an important part of the human culture and civilization [1], [2]. The ingenuity of structures, elegance of shapes, skilfulness of decoration and diversity of finishing techniques employing natural materials are to be remarked and many historic furniture objects remained known as appreciated objects of art from both aesthetical and technical point of view, continuing to be a valuable source of historic information.

Given the variety of wood species that have been used in furniture history being employed from ancient to modern times, any restoration intervention that involves wood completion or a replacement should be very well documented and in accordance with the original material. This involves in a first instance a macroscopic analysis of the wood part to identify its main features. Although sometimes a careful macroscopic examination of a clean transparently finished surface or a freshly sanded surface is solving the problem, there are many cases when a microscopic investigation is needed and reference microscopic samples are employed for comparison and identification. Wood species identification is based on the characteristic macroscopic and microscopic structural features included in an identification key.

The paper is referring to such microscopic characterization for four exotic species, American mahogany - *Swietenia macrophylla* King, African mahogany - *Khaya ivorensis* A. Chev., wenge - *Milletia laurentii* De Wild. and eucalypt - *Eucalyptus globulus* Labill., to be used for wood identification

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purposes by the laboratories working in the field of wood cultural heritage conservation. This work is part of a recent research project aiming at developing and implementing a scientific investigation in furniture conservation [7].

2. Methodology

Reference microscopic samples were produced as aids for species identification during the further conservation activities of any historic furniture. The work principle consists in comparing the microscopy of wood samples prelevated from the historic artwork with a complete set of reference images produced in this research as well as with the descriptions that accompany those images and which are meant to guide the user towards features identification.

The selection of species was based on the knowledge regarding some of the commonly used wood in historic furniture: American mahogany - *Swietenia macrophylla* King, African mahogany - *Khaya ivorensis* A.Chev., wenge - *Milletia laurentii* De Wild. and eucalypt - *Eucalyptus globulus* Labill.

In order to produce the reference microslides all materials above were conditioned by storing in a controlled environment (20 °C and 65% relative air humidity). Then two prisms of 30 × 10 × 10 mm were cut out of each type of material. They were then boiled in flasks with refluxing condenser until saturated (about 24 hours). The prisms were trimmed to expose the transverse, radial and tangential surfaces. Sections were cut from each surface with a sledge microtome to 25 micron thickness. Ethanol solution was used to prevent surface tension attaching the sections to the knife. To enhance the contrast, the sections were coloured with safranine solution and then washed thoroughly in baths of ethanol solution of increasing concentration, finishing with 100%. After this, sections were permanently mounted on glass slides, one for each prism, by using a mountant with refractive index close to that of glass: dried Canada balsam dissolved in xylene [4]. By positioning the cover slip, the slides were gently pressed with a rubber tip to uniform the spread of mountant and to remove air bubbles from inside. The mountant was then allowed to cure by storing the slides for a few days in a warm environment at 60 °C. Finally, the surplus of Canada balsam was removed with a razor blade and the slides were cleaned and polished with a cloth and a little xylen before labelling.

From each slide were taken several images on each section at magnifications of 40x, 100x and 200x by means of an optical microscope BIOSTAR OPTECH B5 fitted with an image capture system.

The features of interest used also as keys of identification for those species were:

- The presence of pores, which is the essential indicator of a hardwood species compared to softwoods where they are absent. The pores appear as holes of various magnitude on the cross sections and with a specific distribution. They are rather uniformly spread in the growth areas if they are diffuse-porous (Figure 1).
- The pores size is also important in differentiating between species: some, with diameters less than 100 μm can be very small visible only with the magnifying glass and easily distinguishable with the microscope and those visible with the naked eye from 101 to over 300 even 500 μm.
- The pores arrangement and their proportion are other type of information which is looked for, as they can be solitary bounded entirely by other cell types (Figure 1 - C); can appear as a characteristic group of pores in the latewood or can be multiple pores when two or several features are disposed as radial arrangement (Figure 1- D).

• The rays, appearing like stips on the cross section are other indicators of a species by their width and proportion (Figure 1 - E). On the tangential and radial surfaces, the height of rays can be measured as different information in species identification.

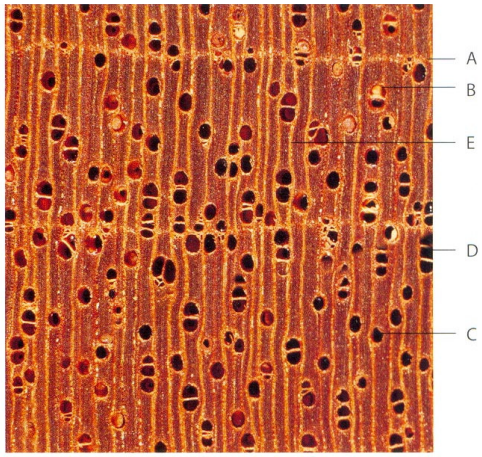

Fig. 1. *An example of an exotic diffuse porous species, American mahogany (Swietenia spp.) - Hoadley, 2000: A - concentric lines of terminal parenchyma; B - vessels with white or gum deposits; C - solitary pores; D - radial multiple pores; E - rays, barely visible to the naked eye on cross section*

• The parenchyma cells, distinguished by a more porous appearance and different colour (usually lighter) compared to the neighbouring wood cells, can confirm, by their presence and characteristic arrangement, the affiliation to a certain species. When the parenchyma cells appear independent from vessels are called apotracheal (Figure 1 - A) When the parenchyma is associated with vessels is called paratracheal, taking certain shapes around the pores, that helps the identification (Figure 4a).

Together with the microscopic images of all four species the macroscopic appearance on the radial section of the samples was included for completeness of the identification key.

3. Results and Discussions

From the images produced at various magnifications, the larger magnification 200x contains more detailed information, but the area included has less anatomical details, while the smaller magnification 40x gives more information about the pores distribution within and between annual rings, but some details, like parenchyma, are not really visible. Therefore 100x was chosen to be representative for the species as the best compromise for the space limit of an article. The reference images for identification purposes of the four investigated species: American mahogany, African mahogany, wenge and eucalypt are presented in Figure 3 and Figure 4 on the transversal, tangential and radial sections.

The macroscopic views of the radial section for these species are contained in Figure 2 and are used as references for the macroscopic characterisation of the species considered in this study.

For all four species detailed identification keys were thought based on the knowledge from the reference literature [5], [6], which are available as an electronic catalogue developed within the framework of this research project and guiding the user through sequential steps towards identification, but here, only the main characteristics are briefly presented in correlation with the microscopic images and the macroscopic views.

American mahogany (*Swietenia macrophylla* King.) Characterised as an exotic diffuse porous species, American mahogany has a narrow light pinkish-greyish sapwood and a yellowish brown heartwood (Figure 2a). The pores, visible also with the naked eye, appear in proportion of about 9% with a distribution

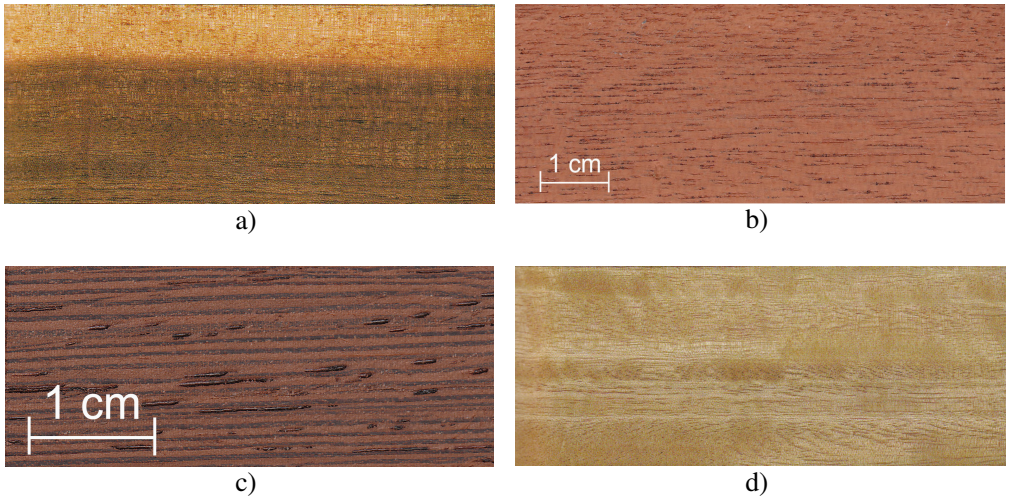

Fig. 2. *Macroscopic views of the radial sections of: a) American mahogany; b) African mahogany; c) wenge; d) eucalypt*

of 2-7-12/mm^2. Their diameters range between 100-150-200 µm, are partially filled with brown deposits, and are either solitary or radially grouped (frequently in pairs) (Figure 3a). Rays are heterogeneous (horizontal and vertical parenchyma cells), in proportion of 13% and 1 to 4 seriated with heights between 300-460-550 µm, meaning 18-24 cells on the height (Figure 3b,c). Fibers are present in a proportion of app. 74%, have lumenii between 10.8-17.6-27.1 µm, wall thickness (2 walls) of 4.2-4.8-6.2 µm and lengths ranging from 700 to 1300 µm. American mahogany contains continuous stripes of terminal apotracheal parenchyma grouped in 3-4 cells (Figure 3a,b).

African mahogany (*Khaya ivorensis* A.Chev.) African mahogany is an exotic species, diffuse porous with a pinkish-brown to dark reddish heartwood and narrow sapwood coloured as light greyish pink (Figure 2b). The pores, in percentage of 10-17.7-29%, are solitary or in pairs, rarely grouped in radial rows. They are partially filled with dark brown deposits and have diameters between 35-145-230 µm as it can be seen in Figure 3d. The rays are heterogeneous, 14.8-20.8-28.2%, with a frequency of 3-5-9/mm. They can be uniseriated or 5-7 seriated with 9-19-43 cells on the height, meaning about 300-520-1100 µm (Figure 3e). Fibers appear in proportion of 47.2-57.2-72.4%, have lumenii of 4,6-15.5-26.3 µm, cell wall thickness (2 walls) of 3,3-5,2-9,7 µm and lengths ranging from 500-1289-2000 µm. African mahogany contains paratracheal vasicentric parenchyma, which can be continuous or, in Figure 3d,e, unilateral.

Wenge (*Milletia laurentii* De Wild). As an exotic species with diffuse pores, wenge has narrow sapwood with a light grey colour and a stripped dark brown to dark-violet heartwood (Figure 2c). The pores, visible with the naked eye, are solitary or in small groups, 1-2-3/mm^2 with diameters varying between 80-235-380 µm and with a proportion of 1.1-6.3-11.5% (Figure 4a). The heterogeneous rays appear 6-7-8/mm in various proportions between 17-19-21.8%, are 1-3-4 seriated and have variable

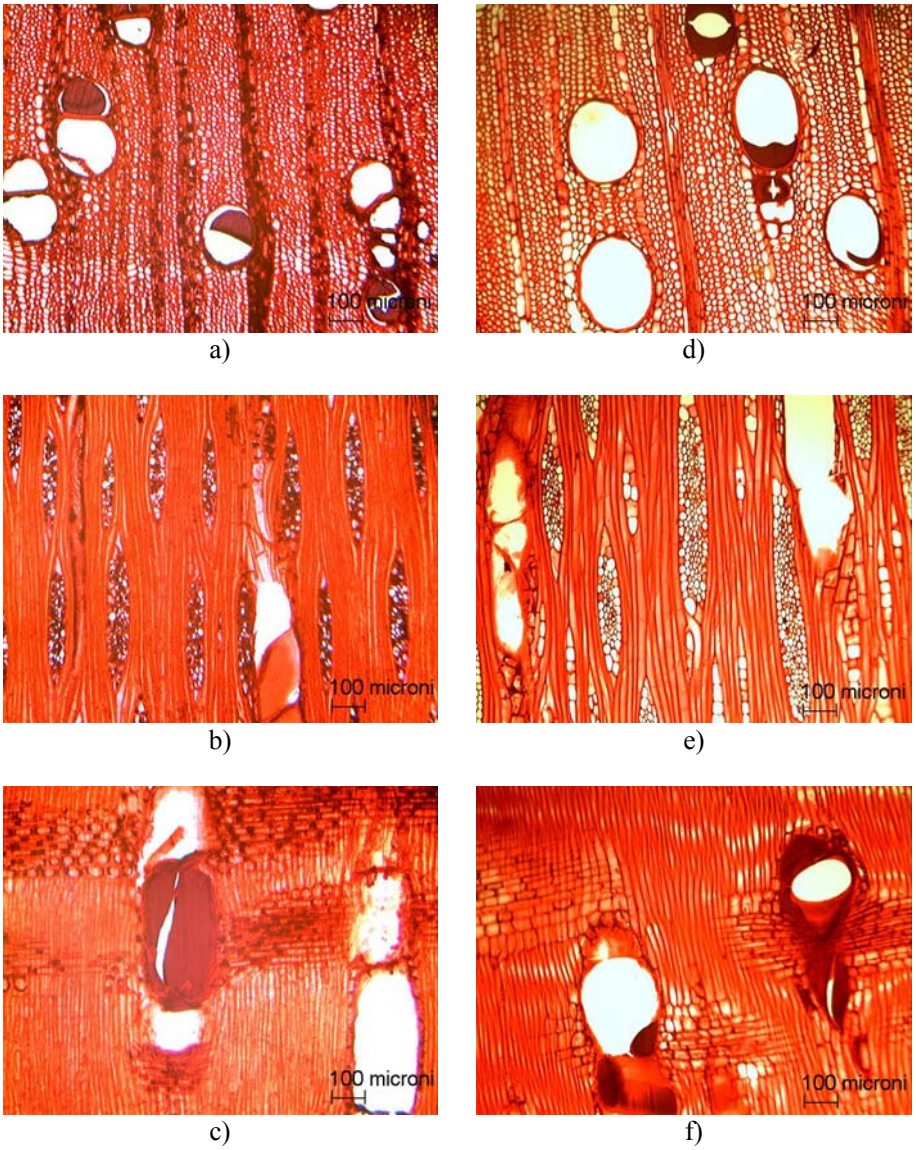

Fig. 3. *Micrographs at 100x magnification: a), b), c) American mahogany* (*Swietenia macrophylla King.); d), e), f) African mahogany* (*Khaya ivorensis A. Chev.*); *a), d) transversal sections; b), e) tangential sections; c), f) radial sections*

heights between 175-210-235 μm (Figure 4b). Fibers are longer than in mahogany, with values ranging between 1540-1760-2060 μm. They appear in proportion of 35.6-43.3-55.1%, have lumen of 1.3-4.4-7 μm and thick walls of 4.8-9.7-14.5 μm (2 walls). The presence of paratracheal confluent parenchyma is obvious as lighter brown tissues around the pores in Figure 4a or as lighter strips with stratified regular cells in Figure 4c.

Eucalypt (*Eucalyptus globulus* Labill.) Also an exotic diffuse porous species, eucalypt has a pink-brown to dark reddish-pink heartwood, while its sapwood is narrow with a light greyish pink colour (Figure 2d). The pores are small to medium, with diameters ranging between 80-110-150 µm, visible with the naked eye. They are numerous, in proportion of app. 21%, contain tylosses and appear solitary or in radial groups (Figure 4d). Rays can be homogeneous or heterogeneous,

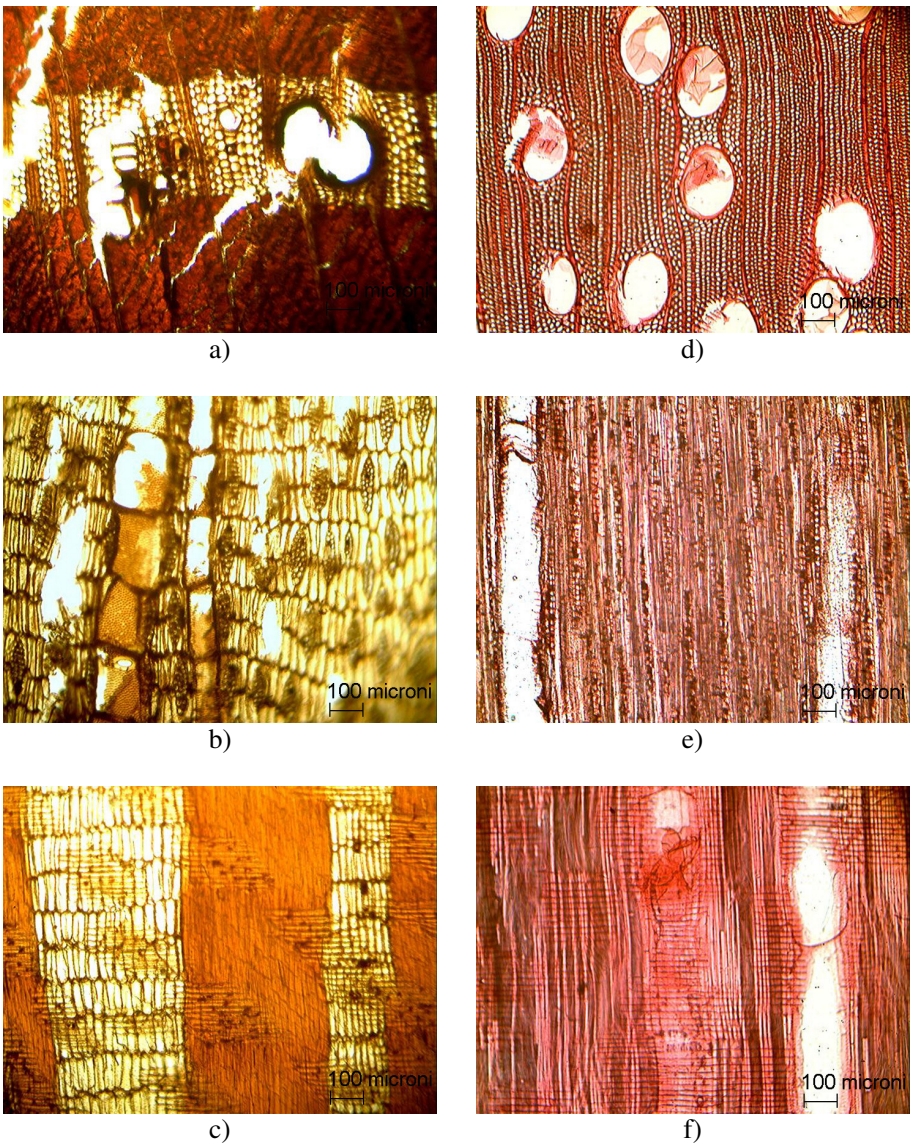

Fig. 4. *Micrographs at 100x magnification: a), b), c) wenge (Milletia laurentii De Wild); d), e), f) eucalypt - Eucalyptus globulus Labill; a), d) transversal sections; b), e) tangential sections; c), f) radial sections*

uniseriated, having widths of 8-12-22 μm and heights of 90-160-230 μm (9-19-43 cells), (Figure 4d,e). Their proportion is about 14% and are distributed 11-13-15/mm. The fibres are present in proportion of app.49%, have lengths of 1000-1210-1480 μm, with thick walls 4.2-5.6-7.5 μm (for 2 walls), while the lumenii range between 4.4-6.7-13.2 μm. Eucalypt presents paratracheal vasicentric parenchyma in proportion of 16% more visible on transversal and tangential sections as the magnification gets higher (Figure 4d,e).

The results presented above can be used as reference images for species identification, where guiding keys are narrowing the search from the most common characteristics (e.g. the species is a hardwood), to a more specific indicator (e.g. distribution of pores and growth areas can differentiate an exotic species from a temperate hardwood).

The four species studied in this paper are among the 22 wood species important for historic furniture, studied as a part of a research project ID_856: Development and implementation of an advanced scientific research methodology for sustainable furniture restoration-conservation and eco-design, for which a comprehensive collection of microscopic images at various magnifications together with their identification keys have been prepared as an electronic catalogue.

4. Conclusions

The conservation of historic furniture has lately become more and more involved with a scientific interdisciplinary approach. In this sense, knowing the species characteristics of a certain historic style has an important role in the identification of the respective style. Also, any restoration intervention that involves wood completion or a well justified replacement should be very well documented and in accordance with the original material. Most often, a visual examination of an investigated sample does not bring enough information about the original species, but this can be definitely resolved by a microscopic investigation.

Species identification can be performed if the microscopic images are interpreted for their common, but also specific features and characteristics by means of identification keys and in comparison with reference images.

This paper referred to four species commonly used in historic furniture, for which reference microscopic images were prepared together with their identification keys: American mahogany (*Swietenia macrophylla)*, African mahogany (*Khaya ivorensis*), wenge (*Milletia laurentii*) and eucalypt (*Eucalyptus globulus).* The results can be used in activities of species identification in laboratories working in the field of wood cultural heritage conservation and more information as an electronic catalogue referring to 22 wood species important for historic furniture is available for those interested in wood species identification.

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