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Letter to the Editor

Comments on the IAWA Hardwood List now available on the web

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The List of Microscopic Features for Hardwood Identification published by an IAWA Committee in 1989 is now freely available on the web (both on www.iawa-website.org and on the InsideWood website insidewood.lib.ncsu.edu/search). This list of microscopic features was intended as a concise list of features useful for microscopic hardwood identification purposes.

The roots of the IAWA List go far back in time. The founding fathers of IAWA saw the standardisation of terms used in describing woods as their first challenge in 1931, and the first *Glossary of Terms Used in Describing Woods* was published in 1933 by an IAWA Committee chaired by Samuel J. Record. In 1938 Clarke set the basis for anatomical features classification designing a multiple entry card-key for the anatomical identification of hardwoods with 88 features. Varoissieau and Kukachka (1948) translated the card-key system in an electromechanical tabulation system for data analysis and Huber (1951) translated it to German. Then Brazier and Franklin (1961) expanded Clarke's list. Subsequently different IAWA committees produced first a *Multilingual Glossary of Terms Used in Wood Anatomy* (1964), and then a *Standard List of Characters Suitable for Computerized Hardwood Identification* published in 1981 with an explanation of the coding procedure by Miller (1981). In 1989 an IAWA committee defined the *IAWA List of Microscopic Features for Hardwood Identification* currently in use, which was so far reprinted four times without changes.

Although the IAWA List has 163 anatomical and 58 miscellaneous features, it is not a complete list encompassing all the structural patterns that one can encounter in hardwoods, but it represents a selection of anatomical features thought to be useful in wood identification. The IAWA List is well approved for wood identification and descriptive wood anatomy, especially for "normal" grown stem material, as it is commonly available in the timber trade or stored in wood collections. However, if wood is defined as xylem resulting from secondary growth (Schweingruber & Büntgen 2013), the IAWA List is hardly applicable to describe anatomically the xylem of most plants. In fact, about nine tenths of all plant species – mostly herbs and dwarf shrubs of any growth form, size and age – cannot be codified properly in their anatomical structure applying the IAWA List as it is. The consequence is that the IAWA List is not the proper tool for plant anatomists, ecologists and taxonomists aiming to use xylem anatomical features as a source of knowledge in vegetation science in unforested parts of most biomes (Büntgen *et al*. 2014). Also the tremendous sources of herb specimens available from herbaria remain excluded.

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The number of anatomical features needed to properly describe the anatomical structure of the xylem of small plants that are missing in the IAWA List is long. Here we mention only a few of such features. In smaller growth forms extremely small vessel diameters are common (tangential diameter of vessel lumina less than 50 μm or even less than 20 μm) as well as reticulate intervessel pits, xylem without fibers, with pervasive parenchyma, with unlignified axial or radial parenchyma, with confluent rays, or with species with sectorial secondary xylem separated by extremely wide rays (see feature A50 in Crivellaro and Schweingruber 2015), and the huge diversity of cambial variants. Counting vessel number per square millimeter is problematic in species with permanently remaining vascular bundles forms and extremely large rays between them. On the other hand, vestured pits are often difficult to see with a light microscope, and only clearly visible with a scanning electron microscope, therefore difficult to evaluate when examining samples from small growth forms (*e.g.* alpine Brassicaceae). Moreover, some cell types and cell wall compositions in xylem and bark can only be differentiated in double stained slides. Double staining with safranin and astrablue (Gärtner & Schweingruber 2013, Srebotnik & Messner 1994), improves the qualitative recognition of lignified and unlignified cell walls in xylem and bark (*e.g.* Gričar *et al.* 2015, Piermattei *et al.* 2015).

If scientists intend to characterize plant stems in an ecological, ecophysiological and/or taxonomical context many features have to be considered in addition to the ones described in the IAWA List, *e.g.* from which part of the plants the analysed material comes from, how the proportions between xylem and bark and pith are related to growth forms or stem forms. Moreover, the anatomical variability within a single plant is as great as the anatomical variability between different plants. As a consequence sample origin along the stem and sample position within the stem cross-sectional area are factors determining *e.g.* conduits size (Anfodillo *et al.* 2013). Furthermore, anatomical markers of external events such as tension wood would be also important additions. Even if without or with limited value in wood identification, such features provide a huge potential to answer ecologically oriented questions. The number of ecologically interpretable features goes far beyond the features characterized by the IAWA List.

In conclusion, the IAWA List is an excellent base for tree-wood anatomical studies and it can be used as a preliminary checklist of potential functional traits in trees (Baas *et al.* 2016). However it must be critically evaluated and has to be expanded for taxonomical, ecological and ecophysiological studies including dwarf shrubs, herbs, succulent, and annual plants from tropical, subtropical, arid, temperate, boreal to arctic zones. Our list of *Stem Anatomical Features in Dicotyledons – Xylem, Phloem, Cortex and Periderm Characteristics for Ecological and Taxonomical Analysis* (Crivellaro & Schweingruber 2015) was created to fulfil this gap.

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