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Short Communication

An interactive identification key for Atlantic Forest tree species based on macroscopic wood anatomy

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Abstract

The Atlantic Forest is considered a biodiversity hotspot because of its exceptional species richness, endemism, and habitat losses. Commercial logging, industrial forestry, and agriculture represent threats to the Atlantic Forest, and even though it has been protected by law since 2006, forest suppression continues and large volumes of Atlantic Forest wood are traded every year. To promote environmental conservation and prevent illegal logging, the verification of wood species' identifications is fundamental throughout several stages of the wood supply chain by supervisory bodies, traders, and even consumers. Macroscopic wood anatomy analysis has been shown to be an efficient method for screening, although tools to streamline the efficiency of that process are necessary. We introduce here an interactive identification key for Atlantic Forest tree species, based on standard wood macroscopic features that is now available online at http://gbg.sites.uff.br/lamad/.

Key words: forensic wood anatomy, identification key, illegal logging, timber commerce, wood identification.

Resumo

A Mata Atlântica é considerada um hotspot de biodiversidade devido à sua excepcional riqueza de espécies, endemismo e perda de habitat. Embora seja protegida por lei desde 2006, a extração de madeira comercial, a silvicultura e a agricultura representam ameaças a Mata Atlântica e a supressão florestal continua a ocorrer e grandes volumes de madeiras da Mata Atlântica são comercializados todos os anos. Para promover a conservação ambiental e prevenir a extração ilegal de madeira, a verificação das espécies pelos órgãos de supervisão, comerciantes e até mesmo pelos consumidores, é fundamental em várias etapas da cadeia de suprimento de madeira. A análise macroscópica da anatomia da madeira tem se mostrado um método eficiente de triagem, embora sejam necessárias ferramentas para agilizar a eficiência desse processo. Apresentamos aqui uma chave de identificação interativa para árvores da Mata Atlântica, baseada em características macroscópicas da madeira, que está disponível online em http://gbg.sites.uff.br/lamad/.

Palavras-chave: anatomia forense da madeira, chave de identificação, extração ilegal de madeira, comércio de madeira, identificação de madeira.

Huge stretches of Atlantic Forest have been lost over the centuries to plantation agriculture, pasture formation, urban expansion, and logging. Important Brazilian economic cycles, such as those of wood (brazilwood), sugar cane, and coffee, along with expressive urban development in recent decades, have generated huge environmental and social consequences in this biome. Commercial logging, industrial forestry, and agriculture have all drastically expanded in the 20th and 21st centuries, resulting in severe reductions of Atlantic Forest cover (Dean 1996; Colombo & Joly 2010; Cabral

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2014, Joly *et al*. 2014, Oliveira & Hecht 2016). The Atlantic Forest is considered a biodiversity hotspot due to its elevated richness and endemism, but is threatened by habitat reduction and fragmentation (Myers *et al*. 2000). The flora is composed of 19,355 species, of which 7,646 are endemic (equivalent to 40% of all endemic Brazilian species), and the Atlantic Forest represents the richest biome for seed plants in Brazil (Forzza *et al*. 2012; BFG 2015). The remaining forest cover is in a fragmented landscape, accounting for only 28% of its original area, and is composed mostly of small fragments (<50 ha) (Ribeiro *et al*. 2009; Rezende *et al*. 2018). Our limited knowledge concerning Atlantic Forest tree communities is aggravated by deforestation, as only 0.01 % of those remnant areas have been studied (Lima *et al*. 2015).

Only 30% of the remnant Atlantic Forest is located in conservation areas protected by the Brazilian Ministry of Environment; the remaining 70% is protected by the federal Atlantic Forest Law (L11428, December 22, 2006), although numerous loopholes allow ongoing forest suppression (Brasil 2006, Rezende *et al*. 2018, Eisfeld *et al*. 2019). The law is more restrictive for advanced successional stages (primary and secondary forests in advanced stages of regeneration) but more permissive for early successional stages (secondary vegetation in mid- and initial stages of regeneration) (Brasil 2006). That situation is worrisome because the Atlantic Forest is suffering from 'secondarization' processes involving biotic homogenization and the replacement of mature forests by early successional stages (Joly *et al*. 2014). Even with legal restrictions on suppressing native vegetation, the Atlantic Forest continues to be cleared, with 168,718 ha being lost between 2008 and 2017 (SOS Mata Atlântica & INPE 2018). Additionally, several Atlantic Forest species are commercialized for their wood (IBAMA 2014; Nascimento *et al*. 2017; Brandes *et al*. 2020a), and some are endangered but still harvested in high volumes (Nascimento *et al*. 2017; Eisfeld *et al*. 2019; Brandes *et al*. 2020a). Although illegal logging continues in Brazil, instead of strengthening regulations, the government persists in weakening environmental agencies and their abilities to prevent deforestation (Wellesley 2014; Abessa *et al*. 2019).

Conservation strategies will only be effective if there is strong control over forestry products and deforestation through environmental inspections and regulations. Wood anatomy has been one of the most valuable and useful methods for verifying the species named in commercial transactions and legal documents (Dormontt *et al*. 2015; Koch *et al*. 2015; Lowe *et al*. 2016; UNODC 2016). Wood anatomy studies have been undertaken with Atlantic Forest species by researchers at the Rio de Janeiro Botanical Garden (Jardim Botânico do Rio de Janeiro) since the early 20th century. Indeed, some of those scientists were founding members of International Association of Wood Anatomists (IAWA) and published the Portuguese version of the IAWA glossary of terms used in describing wood – which represented one of the first efforts to create standard terminologies for wood identification (IAWA 1932, IAWA Committee 1933, Milanez & Bastos 1936, Bastos 1937). In the 1990s, anatomical research was boosted by research grants through the Atlantic Forest Program (Barros & Callado 1997). Three books were published describing the microscopic features of 84 Atlantic Forest timber species following the standardized terminology for hardwood identification (Barros & Callado 1997; IAWA Committee 1989; Barros *et al*. 2001, 2008). Those species occur in different Atlantic Forest vegetation types (dense ombrophilous, mixed ombrophilous, semi-deciduous, and deciduous forests) as well as in forest formations related to elevational gradients (alluvial, sub-montane, montane, upper montane) (IBGE 2012). In this communication, we introduce an interactive key to those species based on macroscopic features, following the latest standardized terminology for wood identification (Ruffinatto *et al*. 2015; Ruffinatto & Crivellaro 2019).

The samples used for wood descriptions are held in the Rio de Janeiro Botanical Garden wood collection (RBw) (Barros & Callado 1997; Barros *et al*. 2001, 2008). The specimens examined were polished with 80–1200 grit sandpaper or cut with a knife along their transversal, longitudinal tangential, and longitudinal radial surfaces (Nascimento *et al*. 2017). The sections were photographed using a Leica DMC 4500 digital camera coupled to a Leica MZ16 light stereomicroscope, and processed with Image Manager (IM50) software. Macroscopic descriptive data were stored, managed, and shared on the Xper3 web platform (Ung *et al*. 2010).

The interactive "Macroscopic wood identification key for Atlantic Forest species" is available online at <http://gbg.sites.uff.br/lamad/> (Brandes *et al*. 2020b). Users can access the anatomical features and figures using taxa names or through the identification module, where, in choosing features, the software will retain taxa with

the identified features but eliminate taxa without them. The interactive key requires a knowledge of wood anatomy, and is suitable for trained front-line technicians or professional wood anatomists. We recommend having the list of macroscopic features (Ruffinatto *et al*. 2015) or the Atlas of Macroscopic Wood Identification (Ruffinatto & Crivellaro 2019) ready at hand during the process of hardwood or softwood identification. The identification key can give strong results for wood identity, but does not replace further identification procedures, including comparing the sample with reference wood collection or reference descriptions, additional microscopic analyses, or applying other methods for precise identifications of species belonging to certain taxonomic groups (*e.g*., *Ocotea*, *Nectandra*, *Manilkara*, *Pouteria*) (Gasson 2011; Dormontt *et al*. 2015; Koch *et al*. 2015).

Computer-aided tools have been developed for wood identification, principally of commercial and endangered species, which can lend support to wood anatomists, supervisory bodies, traders, and even consumers (Coradin *et al*. 2010; Gasson *et al*. 2011; Sarmiento *et al*. 2011; Wheeler 2011; Richter *et al*. 2014; Ruffinatto *et al*. 2019; Novello *et al*. 2020a,b; Richter & Dallwitz 2000). Some of those tools include information about species occurring in the Atlantic Forest that could help in their identification [together with other reference materials, such as (Mainieri 1983, Mainieri & Chimelo 1989; Barros & Callado 1997; Barros *et al*. 2001, 2008; Ruffinatto & Crivellaro 2019)].

In summary, we present here an identification tool for Atlantic Forest species based on macroscopic anatomical features. It can be used for the verification of species' identifications in timber supply chains and detect illegal trading and logging, as well as support legal procedures against criminal fraud. Implicitly, it can promote sustainable forestry and avoid deforestation of natural areas of Atlantic Forest. We intend to expand the interactive key and keep it up to date, adding more species descriptions and correcting eventual problems. In this context, we will appreciate user feedback.

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