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Description and evolution of wood anatomical characters in the ebony wood genus *Diospyros* and its close relatives (Ebenaceae): a first step towards combatting illegal logging

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ABSTRACT

The typical black coloured ebony wood (*Diospyros*, Ebenaceae) is desired as a commercial timber because of its durable and aesthetic properties. Surprisingly, a comprehensive wood anatomical overview of the genus is lacking, making it impossible to fully grasp the diversity in microscopic anatomy and to distinguish between CITES protected species native to Madagascar and the rest. We present the largest microscopic wood anatomical reference database for ebony woods and reconstruct evolutionary patterns in the microscopic wood anatomy within the family level using an earlier generated molecular phylogeny. Wood samples from 246 *Diospyros* species are described based on standardised light microscope observations. For the ancestral state reconstruction, we selected eight wood anatomical characters from 88 Ebenaceae species (including 29 Malagasy *Diospyros* species) that were included in the most recently reconstructed family phylogeny. Within *Diospyros*, the localisation of prismatic crystals (either in axial parenchyma or in rays) shows the highest phylogenetic value and appears to have a biogeographical signal. The molecular defined subclade *Diospyros* clade IX can be clearly distinguished from other ebony woods by its storied structure. Across Ebenaceae, *Lissocarpa* is distinguishable from the remaining genera by the combined presence of scalariform

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and simple vessel perforation plates, and *Royena* typically has silica bodies instead of prismatic crystals. The local deposition of prismatic crystals and the presence of storied structure allow identifying ebony wood species at the subgeneric level, but species-level identification is not possible. In an attempt to improve the identification accuracy of the CITES protected Malagasy woods, we applied computer vision algorithms based on microscopic images from our reference database (microscopic slides from ca. 1000 *Diospyros* specimens) and performed chemical profiling based on DART TOFMS.

Keywords: Ancestral state reconstruction; CITES; timber identification; wildlife trade; wood anatomy.

INTRODUCTION

Globally, it is estimated that 10–30% of the timber trade is illegally harvested (Irwin 2019; Nellemann 2012). If we only consider timber trade in tropical forests, an estimation between 30–90% is more likely (Hirschberger 2008; Hoare 2015). Mixing legally and illegally logged wood makes it challenging for customs officers to assess the validity of the official documents that are linked to a particular shipment (McClure *et al.* 2015). Efficient and accurate identification tools are therefore critical for species identification and origin assessment of traded timbers and will likely contribute to protecting forests and their associated biodiversity (Dormontt *et al.* 2015; Koch & Haag 2015; Tacconi *et al.* 2016). To this end, these tools must be embedded in law enforcement, especially in developing countries that produce the majority of tropical timbers (Dormontt *et al.* 2015).

Ebony wood belongs to the genus *Diospyros*, which is the largest genus in the medium-sized pantropical family Ebenaceae (Samuel *et al.* 2019). The genus comprises more than 800 species (ca. 720 described) of trees and shrubs (Linan *et al.* 2019). The inner portion of a mature trunk, referred to as heartwood, of a typical ebony tree is coloured dark brown to jet black and is durable, which makes it highly desirable for the production of amongst others high valued musical instruments, ornaments, and furniture (Belemtougri *et al.* 2006). The typical black colour of ebony heartwood is the result of dark-coloured organic deposits in the vessels, parenchyma cells, and fibres during heartwood formation. This dark or marbled coloured heartwood is documented in about 40 *Diospyros* species (Gottwald 1984), but there must be many more ebony wood species with black heartwood, especially amongst the tree species.

The genus *Diospyros* is in desperate need of an updated taxonomic revision due to overlapping species descriptions (Van Den Brink 1936; Wallnöfer 2001, 2006, 2008, 2009, 2010, 2012, 2013, 2014, 2016, 2017, 2018, 2019; White & Verdcourt 1996). The taxonomic “chaos” for the Malagasy *Diospyros* species is particularly serious: 91 species have been described in Madagascar, of which 88 are endemic to the island (Madagascar Catalogue 2019), but it is estimated that there are about 200 Malagasy endemics in total, including ca. 50 undescribed tree species with potential black heartwood. Since 2013, all the Malagasy species have been listed on CITES Appendix II due to rapid decline in the wild as a result of extensive logging during a governmental crisis in 2009, meaning that nowadays Malagasy ebony woods can only be imported or exported with a CITES permit (Mason 2019; UNODC 2016). To implement CITES legislation, species identification of Malagasy *Diospyros* species is of utmost importance, especially because the hardest and most precious black wood samples from Madagascar are known to grow in the north-eastern part of the island, a region with many undescribed *Diospyros* species (Porter P. Lowry II, pers. comm.). The complex taxonomic status of *Diospyros* in Madagascar is currently under study by an ongoing EU-funded consortium that is revising all known Malagasy species and describing many new ones (Schatz & Lowry 2018).

When zooming out of the challenging taxonomy in Malagasy *Diospyros*, also the delimitation of genera that have been associated with *Diospyros* has been controversial for many decades. According to the latest molecular phylogeny of the family (Samuel *et al.* 2019), four genera are currently recognised within Ebenaceae: *Lissocarpa*, which is sister to the rest of the family, the closely related genera *Euclea* and *Royena*, and the expanded genus *Diospyros* (including the former genera *Cargillia*, *Gunisanthus*, *Maba*, *Macreightia* and *Tetraclis*). Molecular phylogenies show support for 11 subclades within *Diospyros* (subclades I–XI in (Duangjai *et al.* 2009), but resolution amongst these subclades remains rather low.

There has been considerable debate whether or not anatomy would be a good method to identify *Diospyros* to species level (Morton 1994; Wallnöfer 2001). While most studies agree that wood identification at the species level is often not possible (Gasson 2011), wood anatomy remains the most frequently used method for timber identification, as highlighted in the recent UN report on the Best Practice Guide on Forensic Timber Identification (UNODC 2016) and guidelines of the Global Timber Tracking Network (GTTN) (Schmitz *et al.* 2019). However, wood anatomical descriptions for *Diospyros* are rather scarce and scattered in the literature (Kanehira 1921, 1924; Janssonius & Moll 1926; Yao 1932; Brown & Panshin 1940; Record 1943; Metcalfe & Chalk 1950; Panshin & Zeeuw 1970; Normand & Paquis 1976; Détienne & Jacquet 1983; Gregory 1994; Wickremasinghe & Heart 2006; Grubben 2004; Wheeler 2011; Ravaomanalina *et al.* 2017). The only studies that provide descriptions of many more species are the unpublished PhD theses of Morton (1994) who studied 148 wood samples from 93 species, based on the sections and observations by Helmut Gottwald (Thünen Institute, Hamburg, Germany), and the one by Frederic Lens (2005); 22 species).

Our first objective was to compile the largest wood anatomical reference dataset for Ebenaceae in the world, including complete descriptions of 256 species (including 246 *Diospyros* species, four *Euclea* species, two *Lissocarpa* species and four *Royena* species) based on samples from Naturalis Biodiversity Center (Leiden, The Netherlands), the Royal Museum for Central Africa (Tervuren wood collection, Tervuren, Belgium) and the Thünen Institute (Hamburg, Germany). Our second objective was to assess the value of wood anatomy for identification purposes at the subgeneric and species level, especially with respect to distinguishing CITES protected species from the non-protected species. As a third objective, we confronted our wood anatomical descriptions with molecular phylogeny at the family level to investigate evolutionary patterns for selected features via ancestral state reconstruction analyses. This paper represents the first part of our project, where the general objective was to develop a species identification tool for ebony woods based on microscopic wood anatomical traits (this study), image recognition, and chemical profiling with DART-TOFMS (Direct Analysis in Real Time-Time Of Flight Mass Spectrometry) (follow-up studies).

MATERIALS AND METHODS

Sampling strategy

Wood sections of 246 *Diospyros* species, four *Euclea* species (*E. divinorum*, *E. lanceolate*, *E. natalensis* and *E. schimperia*), four *Royena* species (*R. glabra*, *R. lucida*, *R. lycioides*, and *R. pallens*), and two *Lissocarpa* species (*L. bentami* and *L. guianensis*) were available for this study (see Table A1 in the Appendix). Mature wood samples (stem diameters of at least 15 mm when a mature sample was not available) were collected from the wood collections of Tervuren (Tw; 67 species), Naturalis Biodiversity Center (Lw, WAGw, Uw; 75 species), and Thünen Institute (RBHw; 112 species). In total, 93 original wood anatomical descriptions are provided in this study, and added to existing, unpublished descriptions by H. Gottwald (72 species; summary available in Gottwald 1984), F. Lens (25 species; Lens 2005), S. Pronk (29 species; Pronk 2008), and A. Pletsers (28 species; Pletsers 2006). In addition, we collected seven extra Malagasy species from the Thünen Institute (Hamburg, Germany) which had already been described in (Ravaomanalina *et al.* 2017). To increase consistency across wood anatomical descriptions from different persons, we have done extra observations to standardize features that were measured differently (e.g., Gottwald measured vertical intervessel pit diameter instead of horizontal diameter as recommended by IAWA Committee (1989)), and to complement features that were not measured (e,g., extra maceration slides needed to measure vessel element and fibre length for several species).

Wood slides preparation and light microscopy

Wood samples of approximately 1 cm^3 were put in water at 70–80°C for one day. Transverse, tangential, and radial sections of about 21–25 μm in thickness were cut using a sledge microtome (Reichert, Vienna, Austria). After sectioning, the wood sections were pressed between two glass microscope slides and placed in warm water overnight. After bleaching with sodium hypochlorite 1–3% for 1 minute (three minutes for black sections) and rinsing with distilled water, the sections were briefly stained with a 1:2 mixture of safranin (0.5% in 50% ethanol) and alcian blue (1% in water) for 15 seconds (only 3–5 seconds for black sections); after staining, the sections were dehydrated in an ethanol series (50%, 70%, 96%), treated with Histoclear clearing agent (AURION Immuno Gold Reagents and Accessories, Wageningen, The Netherlands) and mounted in Euparal (Carl Roth, Waldeck, Germany). The slides were then stored in an oven at 50° C for a minimum of 6 weeks with weights on top of the slides. Maceration slides were prepared according to (Franklin 1945). The wood sections were examined with a Leica DM2500 light microscope with objective lenses in the range of 5–40× (NA 0.12–0.75) and photographed with a Leica DFC-425C digital camera (Leica Microscopes, Wetzlar, Germany). The wood anatomical terminology follows the 'IAWA list of microscopic features for hardwood identification' (IAWA Committee 1989).

Scanning electron microscopy

A total of 17 *Diospyros* species (*D. caribaea*, *D. cinnabarina*, *D. cooperii*, *D. dictyoneura*, *D. heterotricha*, *D. heudelotii*, *D. lolin*, *D. longistyla*, *D. maingayi*, *D. malabarica*, *D. mannii*, *D. montana*, *D. piscatoria*, *D. pseudoxylopia*, *D. texana*, *D. vignei*, and *D. virginiana*), one *Royena* (*R. lucida*) and one *Lissocarpa* species (*L. guianensis*) were selected for SEM observations. The selection was based on the presence of characters for which high magnification illustrations (such as crystals, pits, or vessel wall sculpturing) were desired. For each of the ten species, 1 cm^3 per wood sample was boiled for one day at 90 degrees. With a razor blade, the boiled wood sample was split in a tangential and radial plane, resulting in two orientations of one sample. The wood surfaces were submerged in 4% sodium hypochlorite for one hour. Next, the surfaces were rinsed three times with distilled water and subsequently dehydrated in 50%, 70%, and 95% alcohol for 10 minutes each. The samples were then air-dried, mounted on a stub, coated with platinum-palladium in a Quorum Q150TS sputter coater (Quorum Technologies, Laughton, UK), and observed with a Jeol JSM-7600F field emission scanning electron microscope (JEOL, Tokyo, Japan) at a voltage of 5 kV.

Phylogenetic reconstruction

Phylogenetic reconstruction of Ebenaceae was mostly based on the aligned matrix from Duangjai *et al.* (2009) based on four chloroplast markers: *atpB*, *rbcL*, *trnK-matK*, and *trnS-G*; DNA sequences from 16 species were added based on a more recent study (Linan *et al.* 2019). Only species for which wood anatomical descriptions could be generated were included (88 species, including 81 *Diospyros* species). Nucleotide substitution models were tested using the Akaike Information Criterion (AIC) in jModeltest v.2.1.10 for each gene region individually (Darriba *et al.* 2012) (see Table A2 in the Appendix). Bayesian phylogenetic reconstruction was carried out using BEAST v.2.6.1 (Bouckaert *et al.* 2014). Each of the four gene regions was given its own partition and analysed under the log-relaxed lognormal molecular clock and Yule speciation process with the preferred substitution model as determined by jModeltest. We used the (Linan *et al.* 2019) protocol for setting the ingroup time calibration priors (see Tables A3 and A4 in the Appendix). Two independent Markov chain Monte Carlo (MCMC) runs were simulated. Each run had a 50-million chain length. By sampling every 1000 generations, 50 000 trees were produced for each run. LogCombiner v.2.6.1 and TreeAnnotator v.2.6 were used, respectively, to combine the resulting trees and build a maximum clade credibility (MCC) tree (burn-in = 20%). Convergence of all runs separately and the combined runs was evaluated with Tracer v.1.7.1 (Rambaut *et al.* 2014).

Ancestral state reconstruction

We assessed the ancestral state reconstructions with three main approaches: stochastic character mapping (SCM), Maximum Likelihood (ML), and Reversible-Jump Markov chain Monte Carlo (RJ-MCMC). For the ML approach, we used the ACE function implemented in the R-package 'phytools' with three models: all rates different (ARD), equal rates (ER), and symmetrical (SYM) models relying on a re-rooting method (Yang *et al.* 1995). The best-fitting model was selected based on likelihood ratio tests. For the SCM, we performed 1000 simulations (nsim = 1000) on the MCC tree. Results of the proportion of time spent in each state and transitions were summarised with the functions '*make.simmap*' and '*describe.simmap*' from the 'phytools' package. We performed these analyses following previously published scripts (Bogarín *et al.* 2019). RJ-MCMC analyses were executed in the program BayesTraits V3.0.2 by selecting the Multistate and MCMC options under the following conditions: 50 million iterations, sample period of 1000, with the first 10 million iterations discarded as the burn-in, using the AddNode option to reconstruct ancestral states, stepping-stone simulation with 100 steps, sampling 10 000 states from each step and the *revjump* option with an exponential prior with a mean of 10 (Meade & Pagel 2016).

RESULTS

Wood anatomical descriptions (Figs. 1–3)

An overview of the most important wood anatomical features is provided in Table A1 in the Appendix. A summary description for *Diospyros* (based on 246 species including the Malagasy species) studied is given below.

Growth rings generally indistinct or absent (Fig. 1), but distinctly marked by relatively thick-walled latewood fibres in *Diospyros acuminata*, *D. andamanica*, *D. anisandra*, *D. apiculata*, *D. areolata*, *D. argentea*, *D. bipindensis*, *D. bourdilloni*, *D. brandisiana*, *D. bullata*, *D. bussei*, *D. canaliculata*, *D. chevalieri*, *D. christophersenii*, *D. clusiifolia*, *D. confertiflora*, *D. conocarpa*, *D. conzattii*, *D. crassiflora*, *D. dasyphylla*, *D. dendo*, *D. dichrophylla*, *D. dictyonema*, *D. ebenifera*, *D. euphlebia*, *D. fasciculosa*, *D. frutescens*, *D. glandulosa*, *D. grex*, *D. guatterioides*, *D. hallierii*, *D. heterotricha*, *D. hillebrandii*, *D. inconstans*, *D. insularis*, *D. juruensis*, *D. kaki*, *D. lasiocalyx*, *D. lissocarpoides*, *D. longibracteata*, *D. lotus*, *D. macrophylla*, *D. maingayi*, *D. managabensis*, *D. martini*, *D. matheriana*, *D. morrisiana*, *D. mweroensis*, *D. natalensis*, *D. nicaraguensis*, *D. pallens*, *D. palmeri*, *D. philippinensis*, *D. pyrrhocarpa*, *D. quaesita*, *D. samoensis*, *D. sandwicensis*, *D. saxosa*, *D. sericea*, *D. squamosa*, *D. squarrosa*, *D. tenuiflora*, *D. tetrasperma*, *D. texana*, *D. toposia*, *D. toxicaria*, *D. venosa*, *D. verrucosa*, *D. virginiana* (Fig. 1A), *D. viridicans* and *D. vitiensis*. Wood almost always diffuse-porous, semi-ring-porous in *D. virginiana* (Fig. 1A) and variably diffuse to weakly semi- ring- porous in some samples of *D. kaki* and *D. lotus*. Tangential diameter of vessels (10)-50-115-(260) µm, vessel elements (80)-290-635-(1300) µm long. Vessels (1)-15-30-(260)/mm^2, usually solitary and in radial multiples of 2-5-(10) (Fig. 1A–C), sometimes also clusters up to 13 vessels (Fig. 1D), predominantly solitary vessels in *D. argentea*, *D. barteri*, *D. conocarpa*, *D. conzattii*, *D. cooperii*, *D. ebenum* (Fig. 1E), *D. ferruginescens*, *D. fragrans*, *D. grisebachii*, *D. lolin*, *D. managabensis*, *D. philippinensis*, *D. pilosanthera*, *D. puncticulosa*, *D. squamosa* and *D. tenuiflora*. Vessel outline circular. Vessel perforation plates always simple (Fig. 2A). Intervessel pits predominantly

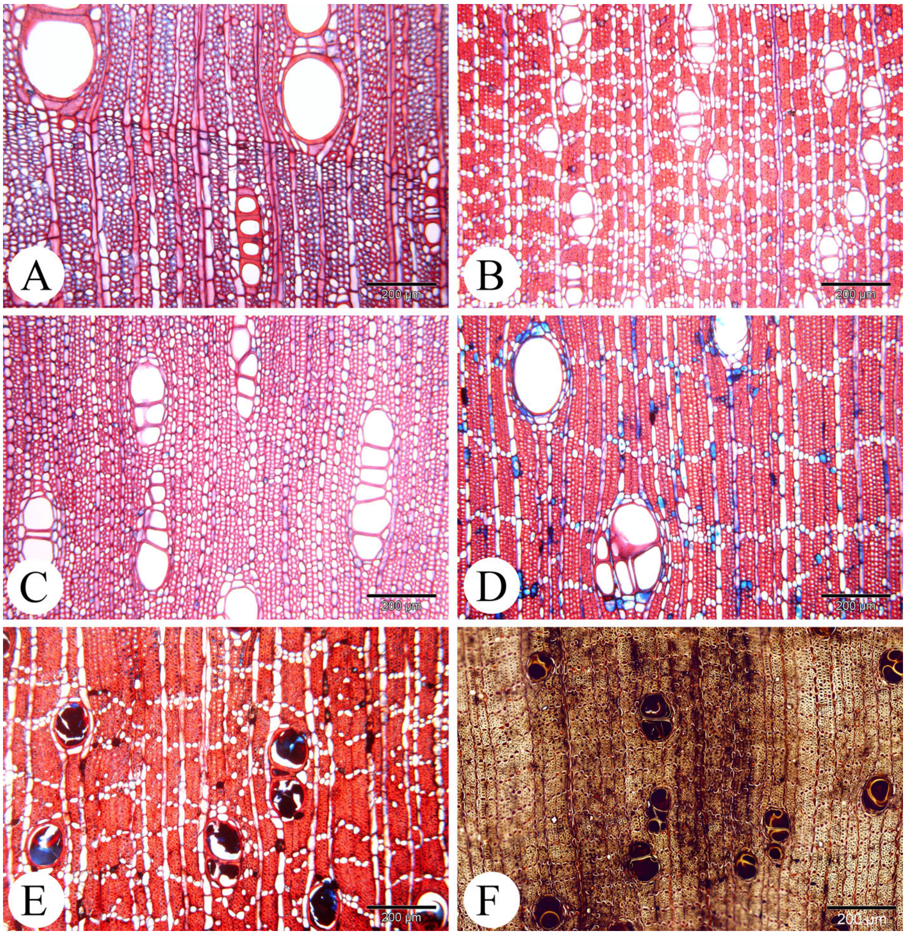

Figure 1. Microscopic images of *Diospyros* wood sectioned in a transverse orientation. (A) *Diospyros virginiana*, semi ring-porous, vessels solitary or in short radial multiples, scanty to vasicentric paratracheal parenchyma (B) *Diospyros ferrea*, vessels solitary or in short radial multiples, banded apotracheal parenchyma, scanty to vasicentric paratracheal parenchyma. (C) *Diospyros heterotricha*, vessels mainly in radial multiples, axial parenchyma diffuse-in-aggregates with slight tendency to form short interrupted bands. (D) *Diospyros malabarica*, vessels solitary or in clusters, banded apotracheal, and scanty to vasicentric paratracheal parenchyma. (E) *Diospyros ebenum*, black heartwood, unstained, vessels solitary or in short radial multiples, thick-walled fibres. (F) *Diospyros perrieri*, black heartwood, vessels solitary or in short radial multiples, banded axial parenchyma, thick-walled fibres.

alternate (Fig. 2B) or alternate to opposite, intervessel pits (3)-4-6-(10) µm in horizontal diameter. Vessel-ray pits predominantly alternate or alternate to opposite, distinctly bordered, pits (3)-4-6-(10) µm in horizontal diameter, often unilaterally compound. Helical thickenings absent. Tracheids absent. Fibres non-septate, mostly with simple to minutely

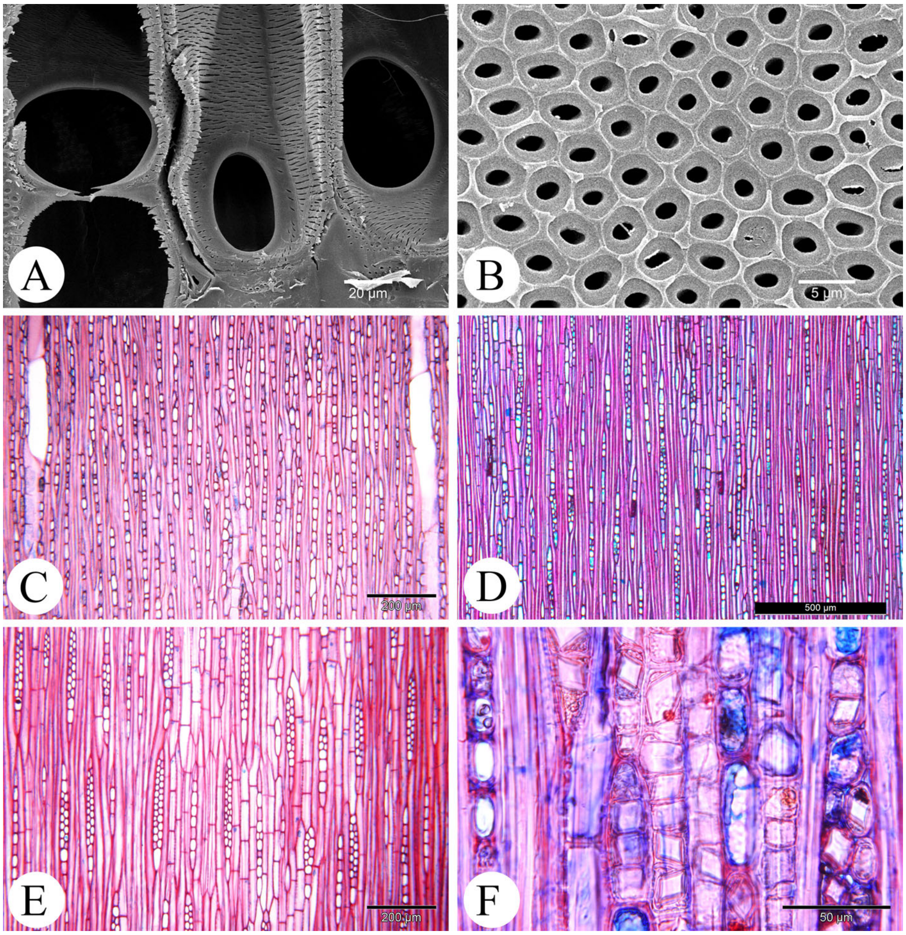

Figure 2. Illustrations of longitudinal SEM surfaces (A, B) and tangential light microscope (LM) sections (C–F) of *Diospyros* wood. (A) *Diospyros heterotricha*, radial section, simple vessel perforations. (B) *Diospyros caribaea*, tangential section, alternate intervessel pits. (C) *Diospyros heterotricha*, tangential section, rays predominantly uniseriate. (D) *Diospyros lanceifolia*, tangential section, uniseriate and multiseriate. (E) *Diospyros morissiana*, tangential section, storied structures. (F) *Diospyros natalensis*, tangential section, prismatic crystals in chambered axial parenchyma, and ray cells.

bordered pits concentrated in radial walls, or sometimes with distinctly bordered pits concentrated in tangential and radial walls. Fibres (390)-770-1340-(2550) µm long and usually thin-to-thick walled (Fig. 1D), but very thick-walled in *D. amazonica*, *D. analamerensis*, *D. borneensis*, *D. brandisiana*, *D. bullata*, *D. celebica*, *D. cinnabarina*, *D. conocarpa*, *D. crassinervis*, *D. cupulifera*, *D. dichroa*, *D. discolor*, *D. ebenum* (Fig. 1E), *D. ferrea* (Fig. 1B), *D. fragrans*, *D. gabunensis*, *D. haplostylis*, *D. humbertiana*, *D. impressinervis*, *D. iturensis*, *D. kamerunensis*, *D. korthalsiana*, *D. kurzii*, *D. lanceolata*, *D. lokohensis*, *D. longistyla*, *D. martini*, *D. mellinoni*,

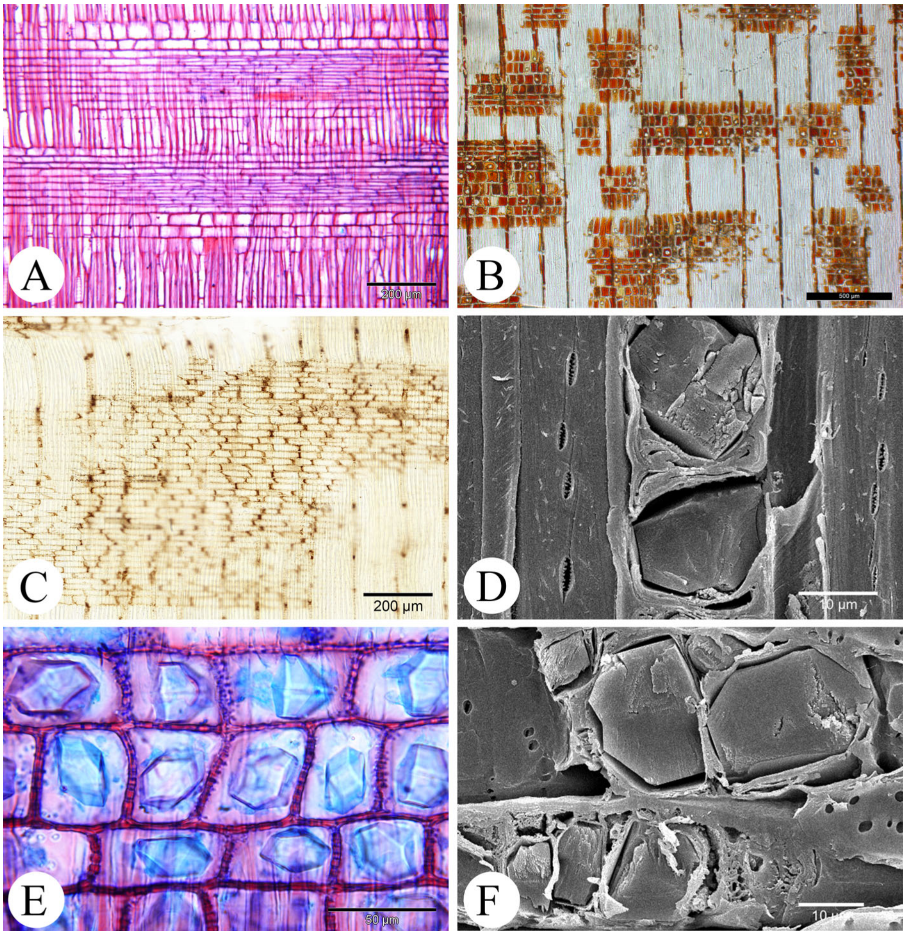

Figure 3. Illustrations of longitudinal sections (LM) and surfaces (SEM). (A) *Diospyros morissiana*, radial section, heterocellular rays. (B) *Diospyros oblonga*, radial section, unstained, heterocellular rays. (C) *Diospyros maingayi*, radial section, unstained, homocellular rays. (D) *Diospyros cooperi*, tangential section, prismatic crystals in chambered axial parenchyma cells. (E) *Diospyros mespiliformis*, radial section, prismatic crystals in rays. (F) *Diospyros caribaea*, radial section, prismatic crystals in rays.

D. mespiliformis, *D. mindanaensis*, *D. mollis*, *D. montana*, *D. myriophylla*, *D. natalensis*, *D. nidiformis*, *D. nitida*, *D. occlusa*, *D. olacinoides*, *D. perfida*, *D. perrieri* (Fig. 1F), *D. pervilleana*, *D. philippinensis*, *D. pilosanthera*, *D. platycalyx*, *D. poncei*, *D. pseudoxylopia*, *D. ridleyi*, *D. rostrata*, *D. sandwicensis*, *D. sogeriensis*, *D. soubreana*, *D. spinescens*, *D. squarrosa*, *D. subrhomboidea*, *D. tetrandra*, *D. tsaratananensis*, *D. velutipes*, *D. vescoi* and *D. vignei* and thin-walled in *D. artanthifolia*, *D. buxifolia*, *D. coriacea*, *D. curraniopsis*, *D. dasyphylla*, *D. dictyonema*, *D. hallierii*, *D. heterotricha* (Fig. 1C), *D. kirkii*, *D. lanceifolia*, *D. lotus*, *D. malam*, *D. minahasae*, *D. morrisiana* and *D. texana*. Apotracheal axial parenchyma mostly in narrow bands (usually continuous (reticulate) or sometimes interrupted) of 1-2-(3) cells wide (Fig. 1B, D-F), sometimes diffuse-in-aggregates (Fig. 1A, C), paratracheal parenchyma always as a combination of scanty or scanty to vasicentric axial parenchyma (Fig. 1A–D), strands of (2)-3-6-(12) cells. Uniseriate rays always present and often more frequent than multiseriate rays (Fig. 2C), (50)-190-715-(1620) µm high, consisting of procumbent or upright cells (Fig. 3A), (1)-9-14-(35) rays/mm. Multiseriate rays 2-(3)-seriate (Fig. 2D–F), (80)-250-800-(2300) µm high, consisting of mainly procumbent (sometimes square) body cells, and 1–4 marginal rows of upright (sometimes square) cells (Fig. 3A, B), (1)-3-6-(13) rays/mm. Homocellular rays with nearly all ray cells procumbent in *D. andamanica*, *D. bejaudii*, *D. dichroa*, *D. discolor*, *D. ebenaster*, *D. euphlebia*, *D. grex*, *D. hallierii*, *D. hebecarpa*, *D. lolin*, *D. longibracteata*, *D. maingayi*, *D. manausensis*, *D. mannii*, *D. mollis*, *D. monbuttensis*, *D. morrisiana*, *D. olacinoides*, *D. pervilleana*, *D. pilosanthera*, *D. poncei*, *D. pseudoxylopia*, *D. ridleyi*, *D. sogeriensis*, *D. soubreana*, *D. subrhomboidea*, *D. tenuiflora*, *D. trichophylla*, *D. variegata* and *D. walkeri*. Sheath cells absent. Prismatic crystals common in either (mostly chambered) axial parenchyma cells (Fig. 2F) or (mostly non-chambered) ray cells (Fig. 3E). No mineral inclusions observed in *D. bejaudii*, *D. bullata*, *D. evena*, *D. ferruginescens*, *D. foxworthyi*, *D. guianensis*, *D. heterotricha*, *D. hirsuta*, *D. lasiocalyx*, *D. longistyla*, *D. macrophylla*, *D. muricata*, *D. nilagirica*, *D. pentamera*, *D. pseudoxylopia*, *D. rufa*, *D. toposia*, and *D. tristis*. Storied structures (vessel elements, fibres, axial parenchyma, and rays) presents only in *D. glandulosa*, *D. kaki*, *D. lotus*, *D. morissiana* (Fig. 2E), and *D. virginiana*.

The following wood description is based on the 29 Malagasy *Diospyros* species observed: Growth rings typically indistinct or absent, but distinct and marked by relatively thick-walled latewood fibres in *D. managabensis*, *D. squamosa*, *D. squarrosa*, and *D. toxicaria*. Wood diffuse-porous. Tangential diameter of vessels (10)-30-70-(120) µm, vessel elements (150)-250-530-(1000) µm long. Vessels (2)-50-80-(260)/mm^2, usually solitary and in radial multiples of 2-8-(10). Vessel outline circular. Vessel perforation plates always simple. Intervessel pits alternate to opposite and between 3–7 µm horizontal diameter; vessel ray pits mostly alternate to opposite and 3–7 µm in horizontal diameter. Fibre pits simple to minutely bordered in radial walls, fibres usually very thick-walled, but thin to thick-walled in *D. aculeata*, *D. calophylla*, *D. conifera*, *D. fuscovelutina*, *D. leucocalyx*, *D. managabensis*, *D. megaphylla*, *D. namoroensis*, *D. scalerophylla*, *D. squamosa*, *D. toxicaria*, and *D. tropophylla*, between (400)-750-1260-(1700) µm long. Apotracheal parenchyma mostly banded in the shape of short interrupted bands or continuous bands (reticulate) with strands of 2-5-(8) cells, paratracheal parenchyma scanty or scanty to vasicentric. Rays mostly uni- and multiseriate but exclusively uniseriate in *D. analamerensis*, *D. calophylla*, *D. olacinoides*, *D. perrieri*, *D. conifera*, *D. velutipes*, *D. leucocalyx*, *D. pervilleana*, *D. managabensis*, *D. haplostylis*, *D. namoroensis*, *D. squamosa*, *D. lokohensis* and *D. tropophylla*, with uniseriate ray height from (75)-180-650-(1600) µm, number of rays per mm a (3)-11-16-(35), multiseriate ray height from (120)-220-820-(1803) µm, number of rays per mm 1-5-(10), rays composed of mostly procumbent/(square) body ray cells with 1–4 upright marginal ray cells. Prismatic crystals in chambered axial parenchyma cells (exclusively in non-chambered cells of *Diospyros squamosa*), together with few crystals in non-chambered ray cells. Storied structures absent.

For wood descriptions and anatomical illustrations of the other genera (*Euclea*, *Lissocarpa*, and *Royena*), see see Table A1 in the Appendix.

Ancestral state reconstruction

Based on the variation of wood characters throughout the genus, eight potential phylogenetically informative characters were selected for ancestral state reconstruction analysis of which four are visualised (Fig. 4): apotracheal parenchyma distribution (banded,

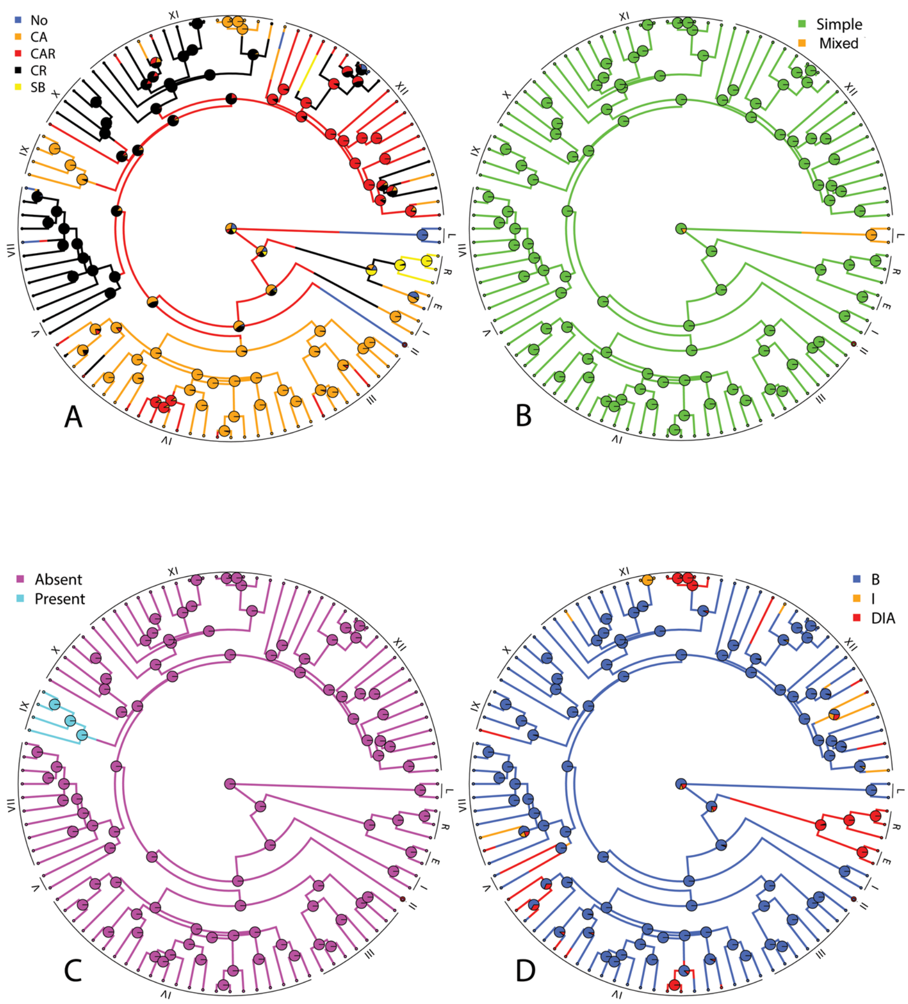

Figure 4. Ancestral state reconstructions of selected wood anatomical characters from stochastic character mapping analyses. (A) Location of mineral inclusions (No: no mineral inclusions observed, CA: crystals in axial parenchyma cells, CAR: crystals in either axial parenchyma and ray cells, CR: crystals in rays, SB: silica bodies present). (B) Vessel perforation plates. (C) Storied structures. (D) Apotracheal parenchyma distribution (B: banded, IB: interrupted bands, DIA: diffuse-in-aggregates).

interrupted bands, diffuse-in-aggregates), mineral inclusions (prismatic crystals in axial parenchyma, prismatic crystals in rays, prismatic crystals in either axial parenchyma and rays, silica bodies in rays, no mineral inclusions), storied structure (absent, present) and vessel perforation plates (exclusively simple, mixed simple and scalariform). For the other traits including ray width (predominantly uniseriate, uniseriate, and multiseriate), vessel grouping (predominantly solitary, predominantly in radial multiples, solitary and in radial multiple), paratracheal parenchyma (scanty, scanty to vasicentric and vasicentric), uniseriate ray height (short, medium and long), see Table A2 in the Appendix. The ancestral trait reconstruction for the three remaining characters are: uniseriate ray height (short <400 µm, medium 400–700 µm and long >700 µm), multiseriate ray height (short, medium, long), and paratracheal parenchyma (scanty, scanty to vasicentric, vasicentric). The log-likelihood test shows that the ER model fits much better than ARD and slightly better than SYM (see Table A5 in the Appendix). The ACE and SIMMAP yielded identical scaled likelihoods at the root state. The RJ-MCMC revealed different results for vessel perforation plates with ambiguous estimations for the characters of uniseriate and multiseriate ray height, mineral inclusion, and vessel grouping. ACE and SIMMAP suggest the following features based on their marginal probability for the family root state: apotracheal parenchyma with regular narrow bands along with scanty paratracheal parenchyma, crystals in either rays or axial parenchyma, non-storied short rays, vessels with exclusively simple perforation plates solitary to radial multiples grouping (RJ-MCMC analysis suggests simple and scalariform vessel perforation plates). None of the methods estimates any clear root state for ray width.

DISCUSSION

This study presents the most extensive wood anatomical survey of the ebony wood genus *Diospyros* to date. It includes descriptions of 246 species (representing novel descriptions of 93 species, and revised descriptions of 153 species from previous unpublished studies) that cover all geographic ranges and all of the major subclades of *Diospyros* (see Fig. A3 in the Appendix).

Diversity and evolutionary patterns in the wood anatomy of Ebenaceae and related families

The descriptions of our extended ebony wood dataset are largely in agreement with the earlier wood anatomical studies (Gottwald 1984; Lens 2005; Morton 1994; Richter 2000). *Diospyros* is characterized by simple-perforated vessels often arranged in radial multiples in combination with solitary vessels, vessels mainly with alternate intervessel pits, fibres non-septate with mostly simple to minutely bordered pits, axial parenchyma mainly apotracheal and often distributed in interrupted or complete bands of one cell wide, uniseriate rays often co-occurring with narrow and short multiseriate rays, and prismatic crystals present either in chambered axial parenchyma or non-chambered ray cells. *Euclea* cannot be separated from *Diospyros* based on the wood anatomical structure. The South African genus *Royena*, however, can easily be distinguished from *Diospyros* (and the other Ebenaceae genera) based on the presence of silica bodies in the rays. (Morton 1994) also observed silica in three species of the genus *Diospyros* (*D. acuminata*, *D. montana*, and *D. sylvatica*), but our observations combined with those of Gottwald did not confirm this. In one species, *Royena lycioides*, a couple of prismatic crystals in rays were observed next to the abundant silica bodies. Finally, the combination of unique wood anatomical characters in the South American *Lissocarpa*, such as the sporadic occurrence of scalariform perforations with many bars (up to 30), the relatively long vessel elements and fibres (ca. 1000 and 2000 μm, respectively), long multiseriate rays (1000–1500 μm), and the lack of mineral inclusions, corroborate the isolated position of this genus as sister to all the other Ebenaceae (see Appendix). Especially the presence of scalariform perforations is interesting and provides extra support for the many independent transitions from scalariform to simple-plated clades across the asterids clade (Lens *et al.* 2016).

The Ebenaceae family belongs to the order of the Ericales, with the extended Primulaceae and Sapotaceae as sister groups (Larson *et al.* 2020; Rose *et al.* 2018). From a wood anatomical point of view, the Ebenaceae are most similar to Sapotaceae due to the shared occurrence of banded axial parenchyma (also present in Lecythidaceae), short multiseriate rays (less than 1 mm; also in Styracaceae and sometimes in Lecythidaceae), the presence of storied structure in at least one genus (also in Primulaceae), and crystals in chambered axial parenchyma cells (also in Lecythidaceae and Styracaceae) (Dickison & Phend 1985; Lens *et al.* 2005, 2007). On the other hand, Ebenaceae wood can be easily distinguished from Sapotaceae by the presence of distinctly bordered vessel-ray pits (versus two distinct types of vessel-ray pitting in Sapotaceae), absence of crystal sand (versus presence in Sapotaceae), and the dominance of uniseriate rays (versus uniseriate rays scarce in Sapotaceae) (Lens 2005).

Although the sampling for ancestral state reconstruction was reduced to 88 Ebenaceae species to match the species overlap between our wood anatomical database and the available molecular phylogenies, we could find a number of wood anatomical traits that seem to have high phylogenetic signal across Ebenaceae as well as within *Diospyros*. The presence of silica bodies only occurs in *Royena* (Fig. 4A) and the mixed presence of scalariform and simple perforation plates defines the genus *Lissocarpa* (Fig. 4B). This unique occurrence of mixed perforation plates in the genus that is sister to all other Ebenaceae is interesting from an evolutionary point of view: it is consistent with the Baileyan trends corresponding to evolutionary transitions from scalariform to simple perforation plates that have evolved in a dozen of early diverging lineages throughout the asterids, probably triggered by peak conductive rates (Lens *et al.* 2016). Consequently, it is likely that the ancestor of Ebenaceae had a proportion of scalariform perforations as well, which was reconstructed with RJ-MCMC but not with the other methods (Fig. 4B).

With respect to presence and location of prismatic crystals, some interesting evolutionary and biogeographic patterns can be retrieved: absence of crystals may be ancestral within the family (Fig. 4A), and crystals could have been lost in 18 *Diospyros* species (*D. bejaudii*, *D. bullata*, *D. evena*, *D. ferruginescens*, *D. foxworthyi*, *D. guianensis*, *D. heterotricha*, *D. hirsuta*, *D. lasiocalyx*, *D. longistyla*, *D. macrophylla*, *D. muricata*, *D. nilagirica*, *D. pentamera*, *D. pseudoxylopia*, *D. rufa*, *D. toposia*, and *D. tristis*). Interestingly, crystals seem to have developed first in axial parenchyma and are mostly confined to species native to

Africa, including all the species observed from Madagascar, while crystal occurrence in rays evolved later in species that are mainly distributed in Asia. In addition to this biogeographic pattern, the position of crystals in axial parenchyma or rays can be used as a synapomorphy to define subclades IV, VII, and XII. Another character with clear phylogenetic signal is the presence of storied structure (Fig. 4C). There are only four species that are characterized by storied structure: *D. glandulosa*, *D. kaki*, *D. lotus*, and *D. virginiana*. These species all belong to *Diospyros* clade IX and also show a tendency to form vasicentric parenchyma (the latter is also present in a number of species outside clade IX, see Fig. A2C in the Appendix). *Diospyros japonica* is also part of *Diospyros* clade IX following Duangjai *et al.* 2009 (included as *D. glaucifolia*) and has storied structures as well (InsideWood, 2004-onwards; Wheeler 2011). The presence of storied structures in *D. crassiflora* and *D. ehretioides* by Lens (2005) could not be supported in this study based on multiple samples of both species.

Then there are a number of features in Ebenaceae with weaker phylogenetic signals, such as uniseriate and multiseriate ray height. Multiseriate rays are often longer (on average 700 µm or more) in the early-diverging Ebenaceae lineages (*Lissocarpa*, *Euclea*, *Royena*, although there is some variation), pointing to an evolutionary shortening of rays when moving up from the basal lineages to the tips of the phylogeny. For apotracheal parenchyma distribution (Fig. 4D), the banded pattern is characteristic of most clades with multiple transitions towards interrupted bands or diffuse-in-aggregates (e.g. *Royena* and *Euclea*). For vessel grouping (Fig. 4E), the main type is solitary mixed with radial vessel multiples, with multiple transitions towards mainly radial multiples (e.g. *Royena*) or mainly solitary vessels.

Bottlenecks in wood identification of CITES protected ebony from Madagascar

Based on our current sampling, we are unable to distinguish Malagasy from non-Malagasy wood samples based on microscopic anatomy, which has also been reported in the database CITES*woodID* (Richter *et al.* 2014). This problem is mainly related to the wood anatomical resemblance across *Diospyros* species, the occurrence of Malagasy species in multiple clades (see Fig. A2 in the Appendix), and further hampered by the "chaotic" taxonomy situation resulting in overlapping species descriptions, many undescribed species, and poor sampling of *Diospyros* (29 out of 246 *Diospyros* species in our study). This is in line with other wood anatomical studies that have repeatedly demonstrated that species identification based on wood anatomy is often not possible, especially when trying to identify close relatives belonging to the same genus (Gasson 2011; Koch *et al.* 2011). However, wood anatomy can give us some arguments to confirm that an unknown ebony wood sample is not derived from Madagascar, for instance by the presence of crystals predominantly in rays and presence of storied structure. To improve species identification of ebony woods, we are currently applying a complementary chemical profiling technique based on DART TOFMS. This chemical profiling method uses species-specific wood chemical composition in order to identify species (Cody *et al.* 2005) and has been successfully applied to several tree genera, such as *Aquilaria* (Lancaster & Espinoza 2012; Espinoza *et al.*

2014), *Dalbergia* (Lancaster & Espinoza 2012; Espinoza *et al.* 2014), and *Quercus* (Cody *et al.* 2012).

To conclude, this study presents wood anatomical observations in a phylogenetic framework based on the world's largest reference collection of ebony woods to date. Within the Ebenaceae family, *Lissocarpa* and *Royena* can be easily distinguished from the other Ebenaceae genera by the presence of mixed simple and scalariform vessel perforation plates and the occurrence of silica bodies, respectively. Also, the clade of *Diospyros* species producing edible fruits (clade IX) is strongly supported by storied structures. Likewise, the position of prismatic crystals characterises several molecular-based clades and relates to general biogeographical patterns, but other characters such as axial parenchyma distribution, number of cells per axial parenchyma strand, ray width and height, and ray composition, are highly homoplasious. At this point, we are not able to distinguish CITES protected Malagasy species from the rest based on microscopic wood anatomy, but a better sampling from Malagasy woods and integration of wood anatomy with complementary datasets based on chemical profiling will hopefully generate an improved identification tool for ebony woods in the future.

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APPENDIX

Wood anatomical descriptions of Royena, Euclea and Lissocarpa

Royena (*based on R. glabra RBHw17909, R. lucida Tw21536, R. lycioides RBHw3447 and R. pallens Tw28101*)

Growth rings distinctly marked by relatively thick-walled latewood fibres. Wood diffuse-porous. Vessels (12)-32-50-(80)/mm², usually in radial multiples of 2-6-(15), sometimes also clusters up to 12 vessels (Fig. A1A). Tangential diameter of vessels 35-85-(100) µm, vessel elements 330-650-(1200) µm long. Vessel outline circular. Vessel perforation plates always simple. Intervessel pits typically alternate to opposite but the alternate type often dominates, intervessel pits 3–4 µm in horizontal diameter but 4–7 µm in *Royena pallens*. Vessel-ray pits opposite to alternate, distinctly bordered, 3–4 µm in horizontal diameter. Helical thickenings absent. Tracheid absent. Fibres non-septate, with simple to minutely bordered pits concentrated in radial walls. Fibres 650–1200 µm long and usually thin-walled, but very thick-walled in *Royena pallens*. Apotracheal axial parenchyma mostly in interrupted bands of 1–2 cells wide to diffuse-in-aggregate, paratracheal parenchyma always in combination with scanty or scanty to vasicentric axial parenchyma, strands of 3-4-(8) cells. Uniseriate rays always present and often more frequent than multiseriate rays, 180-750-(1450) µm high, consisting of procumbent or square body ray cells, and 1–4 rows of upright marginal ray cells, with (2)-6-11-(14) rays/mm. Multiseriate rays 2-(3)-seriate, 250–1000 µm high, consisting of mainly procumbent (sometimes square) body ray cells, and 1–4 rows of upright marginal ray cells, 2-6(9) rays/mm. Sheath cells absent. Prismatic crystals common in non-chambered ray cells. Silica bodies present in ray cells (Fig. A1B).

Euclea (*based on E. divinorum Tw28287, E. lanceolate Tw39136, E. natalensis RBHw17909 and E. schimperia TW33870*)

Growth rings absent but distinctly marked by relatively thick-walled latewood fibres in *E. natalensis*. Wood diffuse-porous. Tangential diameter of vessels (25)-60-(110) µm, vessel elements (200)-355-(480) µm long. Vessels (5)-18-(40)/mm², usually solitary or in radial multiples of 2–4 (Fig. A1C). Vessel outline circular. Vessel perforation plates always simple. Intervessel pits typically alternate to opposite, intervessel pits 3–4 µm. Vessel-ray pits alternate to opposite, but the alternate type often dominates, distinctly bordered, 3–4 µm. Helical thickenings absent. Tracheids absent. Fibres non-septate, with simple to minutely bordered pits concentrated in radial walls. Fibres (700)-960-(1280) µm long, thin- to thick-walled but very thick-walled in *E. divinorum*. Apotracheal axial parenchyma mostly in in-

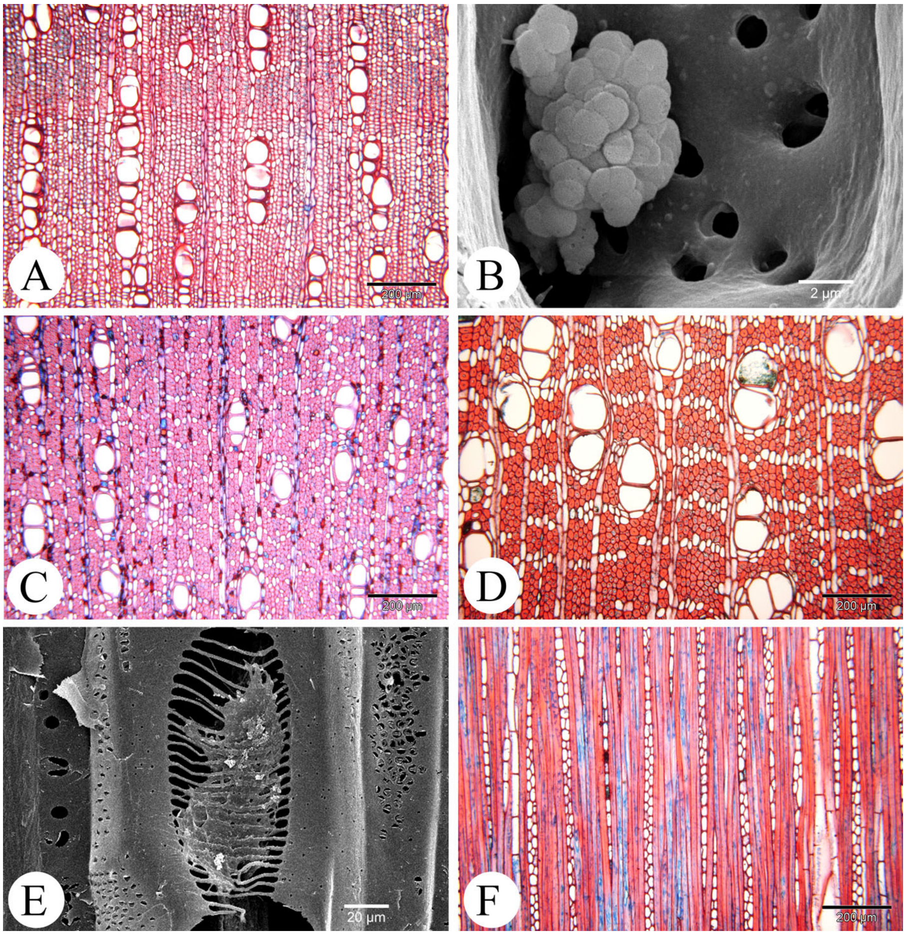

Figure A1. Wood anatomical sections of *Euclea*, *Lissocarpa*, *and Royena*. (A, B) *Royena lucida*, vessels in radial multiples (A), silica bodies (B). (C) *Euclea divinorum*, vessels solitary, or in short radial multiples. (D)–(F) *Lissocarpa guianensis*, vessels in short radial multiples (D), scalariform perforation plates (E), long multiseriate rays (F).

terrupted bands of 1–2 cells wide to diffuse-in-aggregates, paratracheal parenchyma scanty, strands of 3–5 cells. Uniseriate and multiseriate rays always present, (150)-365-(1200) µm high, consisting of procumbent or square body ray cells, and 1–4 rows of upright marginal ray cells, with 4–10 rays/mm. Multiseriate rays 2-(3)-seriate, (260)-500-(1300) µm high, consisting of mainly procumbent (sometimes square) body ray cells, and 1–4 rows of upright marginal ray cells, 3–7 rays/mm. Sheath cells absent. Prismatic crystals present in axial parenchyma and ray cells in *E. schimperia*, ray cells in *E. lanceolate* and in chambered axial parenchyma in *E. natalensis*, no mineral inclusion observed in *E. divinorum*.

Table A1.
Anatomical characteristics of Ebenaceae described in this study.

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
Diospyros abyssinica	FHOw83	S, RM(2-7(10)), (C(4-13))	(20)-35-(55)	(80)-95-(110)	(170)-350-(555)	A	4–7	T-T	(600)-890-(1100)	I(B)1(2),(S)	(3)-4-(5)	U-(M)	(125)-270-(625)	(190)-285-(545)	(10)-14-(18)	(3)-6-(7)	He	–,C	+
D. acris	RBHw13036	RM(2-4(7)), (S)	(50)-95-(140)	(5)-10-(20)	(310)-400-(500)	A	3–4	T-T	?	B1,S	(3)-4-(5)	U-(M)	(150)-580-(750)	(300)-490-(880)	(8)-12-(15)	(2)-3-(5)	He	–	+
*D. aculeata**	RBHw17926	RM((2)4-6(8)), (S)	(30)-50-(80)	(45)-55-(75)	(180)-280-(420)	A(O)	3–4	T-(T)	?	D,S	(3)-4-(5)	U-M	(150)-240-(450)	(120)-360-(630)	(3)-9-(14)	(4)-5-(6)	He	–,C	+
D. acuminata	RBHw17872	S, RM(2-3(4))	(40)-50-(60)	(5)-10-(10)	(460)-555-(650)	A(O)	3–4	T-T	(940)-1100-(1260)	B1,S	(7)-8-(9)	U-(M)	(155)-255-(470)	(195)-245-(295)	(5)-9-(11)	(1)-1-(2)	He	+,C	+,C
D. acurea	RBHw13009	RM(2-4), (S)	(50)-110-(150)	(0)-5-(10)	(0)-0-(0)	O(A)	3–4	T-T	?	B1(2),S	(3)-4-(4)	U	(200)-420-(600)	?	(14)-17-(18)	?	He	+	+
D. acuta	RBHw17871	S, (RM(2-5))	(30)-50-(65)	(5)-10-(15)	?	A(O)	3–4	VT	?	B1,S-V	(2)-3-(4)	U	(220)-520-(1220)	?	(13)-14-(16)	?	He	–	+,C
D. affinis	RBHw17873	RM(2-6), (S), C(6-14)	(25)-45-(60)	(25)-35-(50)	?	A(O)	3–4	T-T	?	IB(1-2),S	(3)-4-(5)	U-(M)	(145)-320-(740)	(240)-410-(690)	(8)-10-(13)	(2)-2-(3)	He	–	+
D. albiflora	RBHw 17874	RM(2-3(4)), (S)	(50)-80-(110)	(5)-5-(15)	?	A(O)	4–7	T-T	?	B1,S	(3)-4-(4)	U	(200)-440-(750)	?	(16)-18-(21)	?	He	–	+
D. amazonica	Tw33963	S, RM(2-6)	(60)-95-(125)	(5)-5-(10)	(1200)-1385-(1660)	A(O)	6–8	VT	(1200)-1385-(1600)	B1(2),V	(4)-7-(8)	U-M	(350)-525-(700)	(500)-670-(1050)	(6)-7-(9)	(2)-3-(4)	He	–,C	–
D. amboinensis	RBHw17257	S, RM(2-5)	(75)-120-(140)	(5)-5-(10)	?	A	4–7	T-T	?	B1,(S)	(3)-4-(5)	U	(130)-450-(960)	?	(12)-15-(17)	?	He	–	+
*D. analamerensis**	Tw66661	S, RM(2-6(10))	(20)-35-(40)	(130)-155-(180)	(150)-195-(240)	A(O)	4–7	VT	?	IB1(2),S	(3)-5-(8)	U	(100)-305-(510)	?	(22)-25-(29)	?	He	–,C	–
D. andamanica	L0087838	RM (2-5(7)), (S)	(50)-110-(170)	(0)-5-(15)	(500)-825-(950)	A(O)	3–4	T-T	(900)-1450-(1800)	B1,(S)	(4)-7-(8)	U	(250)-625-(1050)	?	(13)-16-(19)	?	Ho	–,C	–,C
D. andersonii	RBHw13385	S, RM(2-6)	(50)-65-(80)	(10)-15-(25)	?	A(O)	4–7	T-T	?	B1(2),S	(3)-4-(5)	U-M	(200)-360-(450)	(250)-430-(780)	(4)-6-(10)	(3)-4-(6)	He	–,C	–
D. anisandra	RBHw13393	S, RM(2-5)	(25)-40-(50)	(50)-65-(85)	?	A(O)	3–4	T-(T)	?	B1,S	(3)-4-(4)	U-(M)	(220)-430-(760)	(275)-325-(385)	(7)-8-(10)	(2)-3-(3)	He	–	–,C
D. apiculata	RBHw13219	RM(2-6(9)), (S)	(45)-75-(95)	(15)-20-(25)	?	A	3–4	VT	?	IB(1-2),S-V	(3)-4-(6)	U	(180)-430-(740)	?	(12)-14-(17)	?	He	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. areolata	RBHw17374	S, RM(2-5)	(55)-110-(145)	(0)-5-(10)	(400)-500-(900)	A(O)	3–4	T-T	?	B1,S	(3)-5-(8)	U	(210)-380-(560)	?	(16)-18-(22)	?	He	–	+
D. argentea	RBHw13123	S, (RM(2-3))	(30)-70-(100)	(0)-5-(5)	?	A(O)	4–7	VT	?	B1(2),S	(3)-4-(4)	U	(230)-530-(1000)	?	(16)-18-(20)	?	He	+	+
D. artanthifolia	RBHw13614	S, RM(2-4(6)), (C(7))	(35)-100-(140)	(5)-5-(20)	(200)-380-(640)	A(O)	4–7	T	(640)-1135-(1500)	(I)B(1-2),(S)-V	(3)-4-(4)	U-M	(185)-545-(1285)	(425)-940-(1750)	(6)-9-(11)	(3)-6-(11)	He	–,C	+
D. attenuata	RBHw17875	S, RM(2-5)	(45)-70-(100)	(5)-10-(20)	(180)-450-(700)	A(O)	3–4	VT	?	B(1-2),S	(2)-3-(4)	U	(160)-350-(630)	?	(15)-16-(18)	?	He	–	+
D. barteri	RBHw13319	S, (RM(2-3))	(70)-95-(120)	(5)-5-(10)	?	A(O)	4–7	VT	?	B1,S	(3)-4-(5)	U-M	(200)-380-(670)	(250)-420-(620)	(9)-12-(15)	(1)-3-(4)	He	–	+
D. batocana	Tw28273	S, RM(2-4(6))	(40)-70-(90)	(10)-15-(20)	(780)-960-(1100)	A(O)	4–7	VT	(780)-960-(1100)	IB1, D,S-V	(3)-4-(6)	U-(M)	(350)-690-(1150)	(400)-620-(950)	(10)-14-(16)	(0)-1-(2)	He	–,C	–
D. bejaudii	RBHw13170	RM(2-3(4)), S	(35)-110-(140)	(0)-5-(10)	(420)-520-(720)	O(A)	3–4	T-T	?	B1,S	(2)-4-(6)	U-(M)	(170)-420-(830)	(160)-400-(750)	(9)-12-(16)	(2)-2-(3)	Ho	–	–
D. bipindensis	Tw50658	S, RM(2-6)	(40)-50-(60)	(25)-35-(40)	(1100)-1330-(1600)	A(O)	3–4	T-T	(1100)-1330-(1600)	(I)B(1-2),S	(4)-6-(10)	U-(M)	(300)-680-(1100)	(220)-445-(750)	(9)-10-(11)	(1)-2-(3)	He	–,C	–
D. blancoi	L0967790	S, RM(2-4)	(45)-105-(155)	(5)-10-(15)	(320)-470-(690)	A	4–7	T-T	(720)-895-(1050)	(I)B(1-2),(S)-V	(4)-4-(5)	U-M	(60)-380-(810)	(100)-540-(1440)	(11)-14-(16)	(1)-4-(6)	He	–	+,C
D. boala	Tw8170	RM(2-3(6)), (S)	(50)-120-(175)	(5)-10-(15)	(300)-525-(700)	A(O)	4–7	T-T	(700)-1150-(1500)	B1-2,(S)	(4)-5-(7)	U	(150)-325-(625)	?	(8)-11-(14)	?	He	–,C	–,C
D. borneensis	L0967791	S, RM(2-5), (C(3-9))	(80)-120-(150)	(0)-5-(15)	(320)-535-(650)	A	4–7	VT	(600)-1020-(1420)	B(1-2(3)),(S)-V	(4)-4-(7)	U-(M)	(60)-335-(680)	(180)-375-(660)	(4)-8-(12)	(1)-2-(4)	He	–	+
D. bourdilloni	MADw43207	S, RM(2-4(5))	(40)-75-(105)	(25)-30-(30)	(230)-335-(480)	A(O)	3–4	T-T	(590)-790-(1030)	IB1(2),S	(3)-3-(4)	U-M	(225)-270-(320)	(115)-225-(320)	(6)-8-(9)	(1)-1-(2)	He	–,C	–
D. brandisiana	RBHw13050	S, RM(2-5)	(50)-80-(100)	(10)-15-(20)	(210)-480-(705)	A(O)	3–4	VT	?	IB1,S	(3)-4-(5)	U-M	(350)-525-(775)	(250)-600-(1400)	(9)-11-(14)	(6)-7-(8)	He	–	+,C
D. bullata	RBHw13445	S, RM(2-5)	(60)-85-(110)	(5)-5-(10)	(200)-520-(850)	A	4–7	VT	?	B1(2),S	(2)-4-(6)	U-M	(220)-520-(900)	(350)-690-(990)	(6)-6-(8)	(3)-4-(5)	He	–	–
D. bussei	RBHw951	RM(2-6), S,	(40)-60-(90)	(30)-45-(55)	(180)-310-(430)	A	4–7	T-T	?	IB1(2),S	(2)-3-(4)	U	(130)-200-(300)	?	(13)-16-(20)	?	He	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. buxifolia	L0967788	RM(2-4), S, (C(4-8))	(30)-75-(115)	(5)-10-(10)	(320)-495-(700)	A	3–4	T	(870)-1115-(1400)	B1,(S)-V	(4)-5-(8)	U-M	(60)-310-(620)	(140)-365-(920)	(3)-10-(16)	(1)-5-(10)	He	–,C	–
*D. calophylla**	RBHw24408	RM(2-8), (S), (C(6-8))	(10)-30-(50)	(15)-25-(40)	(220)-360-(460)	A	4–7	T-T	(700)-960-(1150)	(I)B1,S-V	(2)-3-(4)	U	(160)-420-(710)	?	(15)-16-(19)	?	He	–,C	+
D. canaliculata	Tw35917	RM(2-3), S, (C(4-8))	(25)-50-(80)	(10)-15-(20)	(450)-630-(790)	A(O)	3–4	T-T	(450)-630-(790)	(I)B1(2),S	(2)-4-(5)	U-M	(100)-225-(350)	(150)-285-(400)	(6)-7-(9)	(5)-6-(7)	He	–,C	–
D. carbonaria	RBHw13320	S, RM(2-3)	(85)-120-(140)	(0)-5-(5)	?	A	4–7	T-T	?	B1,S	(2)-3-(5)	U	(170)-370-(550)	?	(8)-11-(14)	?	He	–,C	–
D. caribaea	Tw35917	S, RM(2-9)	(35)-60-(80)	(10)-15-(25)	(870)-1065-(1260)	A(O)	3–4	VT	(870)-1065-(1260)	IB1, D,S	(4)-5-(7)	U-M	(150)-250-(400)	(200)-395-(600)	(5)-5-(6)	(7)-9-(9)	He	–,C	–,C
D. castanea	RBHw17361	S, RM(2-6), (C(8-12))	(30)-75-(105)	(25)-30-(50)	?	A(O)	3–4	T-(T)	?	IB1,S	(4)-5-(6)	U	(180)-255-(430)	?	(13)-14-(15)	?	He	+,C	+,C
D. caudisepala	RBHw13019	S, RM(2-4)	(60)-115-(160)	(5)-5-(10)	(240)-620-(590)	A(O)	3–4	T-T	?	B1,S	(3)-4-(4)	U	(180)-400-(760)	?	(12)-13-(14)	?	He	–	–,C
D. cauliflora	L0967784	S, RM(2-3(5))	(50)-70-(85)	(5)-10-(10)	(300)-540-(750)	A(O)	4–7	T-T	(820)-1095-(1500)	B1(2),S-V	(4)-5-(7)	U-(M)	(130)-430-(800)	(250)-400-(660)	(14)-16-(19)	(1)-1-(3)	He	–	–,C
D. cayennensis	RBHw13387	S, RM(2-5(7))	(75)-110-(140)	(0)-5-(5)	(250)-435-(640)	A(O)	4–7	T-T	?	B1(2),S	(3)-4-(5)	U-M	(170)-240-(330)	(210)-330-(600)	(3)-4-(7)	(4)-5-(7)	He	–	–,C
D. celebica	Tw36073	S, RM(2-4)	(70)-105-(145)	(5)-5-(10)	(240)-455-(600)	A(O)	6–8	VT	(700)-1115-(1590)	B1(2),(S)	(4)-7-(10)	U-(M)	(440)-580-(1000)	(280)-390-(515)	(10)-12-(14)	(1)-1-(2)	He	–	+
D. chaetocarpa	RBHw17876	S, RM(2-3), (C(4-7(10)))	(70)-100-(140)	(10)-15-(25)	(320)-465-(550)	A(O)	3–4	T-T	?	B1(2),S	(2)-4-(7)	U	(110)-230-(310)	?	(10)-13-(15)	?	He	–,C	+
D. chevalieri	WAG0455684	RM(2-6(15))	(20)-60-(100)	(10)-15-(20)	(200)-350-(550)	A	4–7	T-T	(450)-850-(1100)	(I)B1(2),(S)	(2)-4-(4)	U	(250)-800-(1450)	?	(15)-17-(18)	?	He	–,C	–
D. christopher-senii	RBHw13410	RM(2-6),S	(40)-65-(95)	(5)-15-(20)	?	A	4–7	VT	?	B1(2),(S)	(2)-4-(4)	U	(350)-530-(880)	?	(12)-14-(16)	?	He	–,C	–
D. cinnabarina	WAG0157266	S, (RM (2-4)), (C(4))	(40)-75-(100)	(10)-10-(15)	(450)-600-(800)	A(O)	3–4	VT	(800)-1300-(1500)	(I)B1(2),(S)	(3)-4-(5)	U-M	(250)-475-(700)	(200)-350-(475)	(9)-10-(11)	(0)-2-(4)	He	–,C	–
D. clusiifolia	RBHw17981	S, RM(2-3(5))	(30)-35-(40)	(80)-95-(110)	(255)-350-(445)	O(A)	3–4	T-T	(610)-715-(820)	D,S	(4)-4-(4)	U-(M)	(340)-615-(890)	(325)-350-(375)	?	?	He	–	+

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. confertiflora	L0087897	RM(2-4(6)), (S), (C(3-4(5)))	(40)-90-(130)	(15)-25-(50)	(200)-525-(650)	A	4–7	T-(T)	(700)-925-(1200)	(I)B1-2,(S)	(4)-5-(7)	U	(200)-350-(950)	?	(10)-11-(12)	?	Ho	–,C	+,C
*D. conifera**	Tw66517	S, (RM2-4)	(15)-25-(35)	(60)-80-(100)	(250)-450-(550)	A(O)	4–7	VT	(600)-1100-(1600)	B1,S	(3)-5-(6)	U	(300)-450-(700)	?	(10)-12-(15)	?	He	–,C	–
D. conocarpa	Tw49213	S, (RM(2-3))	(25)-40-(50)	(5)-10-(10)	(1200)-1500-(1850)	A(O)	4–7	VT	(1200)-1500-(1850)	B(1-2),(S)-V	(4)-5-(6)	U-M	(300)-510-(850)	(400)-890-(1600)	(6)-7-(9)	(2)-3-(4)	Ho	–,C	–
D. conzattii	RBHw13394	S, (RM(2-4))	(35)-55-(80)	(5)-10-(10)	?	A(O)	3–4	T-T	?	B1,S	(3)-3-(4)	U-(M)	(150)-265-(480)	(225)-505-(710)	(6)-7-(9)	(3)-3-(5)	He	–,C	–,C
D. cooperii	Tw26579	S, (RM(2-3))	(35)-65-(95)	(5)-10-(15)	(1020)-1250-(1410)	A	3–4	T-T	(1020)-1250-(1410)	B1(2),S-V	(4)-5-(6)	U-(M)	(300)-460-(850)	(250)-520-(950)	(9)-11-(13)	(0)-1-(2)	He	–,C	–
D. coriacea	L0967782	S, RM(2-5), (C(4-6))	(40)-110-(170)	(5)-10-(15)	(320)-475-(610)	A	3–4	T	(530)-860-(1090)	B1(2),S	(3)-4-(4)	U-M	(125)-385-(720)	(155)-545-(960)	(6)-9-(12)	(2)-4-(7)	He	–	+
D. crassiflora	Tw33268	S, RM(2-4(6))	(50)-85-(120)	(5)-20-(30)	(800)-955-(1200)	A(O)	4–7	T-T	(800)-955-(1200)	B(1-2(3)),S-V	(3)-4-(7)	U-(M)	(200)-390-(1050)	(200)-425-(650)	(10)-11-(12)	(0)—(1)	He	–,C	–
D. crassinervis	Tw57356	S, RM(2-3(5))	(40)-70-(100)	(10)-15-(15)	(150)-350-(450)	A	3–4	VT	(600)-900-(1200)	(I)B1, D,(S)	(4)-5-(6)	U-M	(100)-300-(600)	(150)-300-(450)	(4)-8-(12)	(3)-5-(8)	Ho	–,C	–,C
*D. cupulifera**	RBHw17925	S, RM((2)4-8)	(30)-35-(50)	(135)-150-(180)	?	A	4–7	VT	?	D,(S)	(3)-4-(4)	U-(M)	(150)-305-(460)	(200)-265-(315)	(10)-13-(16)	(1)-2-(3)	He	–,C	–
D. curranii	Tw18643	S, RM(2-3(4))	(70)-145-(210)	(5)-5-(15)	(190)-375-(540)	A(O)	4–7	T-(T)	(580)-975-(1280)	(I)B1(2),S	(3)-4-(5)	U-M	(110)-315-(710)	(320)-450-(515)	(2)-3-(4)	(9)-10-(10)	He	–	+
D. curraniopsis	L0967779	S, RM(2-5), (C(3-8))	(55)-105-(145)	(5)-15-(20)	(260)-400-(500)	A	3–4	T	(520)-835-(1100)	I(B)1(2),(S)-V	(3)-4-(4)	U-M	(80)-225-(460)	(150)-240-(520)	(12)-14-(16)	(1)-1-(2)	He	–	+
D. dasyphylla	L0967775	S, RM(2-6(8)), (C(4-6(12)))	(50)-70-(90)	(30)-45-(65)	(360)-445-(700)	A	3–4	T	(440)-755-(1010)	IB(1-2(3)), D,S-V	(3)-4-(4)	U-M	(130)-440-(930)	(120)-590-(1220)	(8)-11-(14)	(4)-5-(5)	He	–,C	–,C
D. decandra	RBHw13217	S, RM(2-3(4))	(40)-75-(100)	(10)-15-(25)	(300)-415-(650)	O(A)	4–7	T-T	?	IB1,S	(2)-4-(6)	U-M	(160)-270-(520)	(130)-345-(460)	(2)-5-(9)	(9)-10-(13)	He	+	–,C
D. dendo	WAG0113399	S, RM(2-6(8))	(30)-50-(70)	(25)-35-(45)	(150)-325-(450)	A	3–4	T-T	(600)-750-(900)	B1,S	(3)-4-(5)	U-(M)	(130)-270-(450)	(80)-350-(820)	(14)-16-(17)	(1)-2-(4)	He	–,C	–
D. dichroa	U0076945	S, RM(3-8)	(75)-155-(180)	(0)-5-(5)	(400)-550-(700)	A	4–7	VT	(800)-1450-(2000)	B1(2),S	(3)-4-(4)	U	(250)-450-(800)	?	(10)-13-(14)	?	Ho	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. dichrophylla	RBHw17942	S, RM(2-6)	(55)-65-(75)	(5)-10-(15)	(330)-395-(460)	A	4–7	T-T	(1070)-1225-(1380)	D,S	(2)-3-(4)	U-(M)	(160)-345-(530)	(140)-220-(300)	(11)-14-(16)	(4)-5-(6)	He	–	+,C
D. dictyonema	L0967773	S, RM(2-4(5))	(60)-90-(125)	(5)-10-(20)	(320)-490-(665)	A	4–7	T	(700)-890-(1030)	D,V	(4)-4-(5)	U	(225)-545-(1050)	?	(19)-22-(25)	?	He	–	+
D. dictyoneura	L0087787	S, RM(2-3(4)), (C(3-5))	(70)-120-(190)	(5)-10-(15)	(225)-450-(625)	A	4–7	T-(T)	(500)-725-(900)	D,(S)	(4)-4-(6)	U	(150)-370-(650)	?	(13)-15-(17)	?	He	–	+
D. discocalyx	Tw30371	RM(2-3), (S)	(60)-140-(190)	(0)-5-(5)	(400)-550-(900)	A	8–10	VT	(900)-1300-(1900)	B1,S	(3)-4-(5)	U-M	(400)-500-(600)	(500)-600-(900)	(9)-13-(16)	(1)-3-(6)	He	–	+
D. discolor	L0087860	S, RM(2)	(70)-130-(180)	(0)-5-(5)	(400)-650-(800)	A(O)	8–10	VT	(900)-1200-(1450)	(I)B1(2),(S)	(4)-6-(7)	U	(150)-350-(650)	?	(9)-11-(12)	?	Ho	–	+
D. ebenaster	RBHw13396	S, RM(2-3)	(90)-125-(160)	(5)-5-(10)	(160)-365-(480)	O(A)	4–7	T-T	?	B1(2),S	(3)-4-(5)	U-M	(130)-215-(330)	(190)-325-(570)	(2)-4-(7)	(3)-6-(8)	Ho	–,C	–
D. ebenifera	RBHw17984	S, RM(2-3)	(30)-35-(40)	(100)-120-(140)	(250)-315-(400)	O(A)	3–4	T-T	?	B,S	(3)-3-(3)	U-(M)	(145)-315-(485)	(500)-625-(790)	?	?	He	–,C	–
D. ebenum	Tw36100	S, (RM(2-4))	(40)-85-(125)	(5)-10-(15)	(1100)-1280-(1650)	A(O)	4–7	VT	(1100)-1280-(1650)	IB1(2),S-V	(4)-6-(8)	U-M	(150)-305-(400)	(250)-440-(850)	(7)-10-(12)	(2)-5-(7)	He	–	+
D. ehretioides	MADw28764	S, RM(2-3(4))	(85)-150-(190)	(5)-5-(5)	(220)-385-(550)	A(O)	3–4	T-T	(700)-935-(1120)	I(B)1(2),S	(3)-4-(4)	U-M	(210)-415-(255)	(350)-475-(730)	(5)-6-(6)	(2)-4-(6)	He	–	+
D. elliptifolia	L0967767	S, RM(2-4(5)), (C(3-6))	(40)-90-(115)	(5)-10-(10)	(320)-555-(800)	A(O)	3–4	T-T	(700)-1370-(1820)	B1(2),(S)-V	(3)-4-(4)	U-M	(240)-440-(1000)	(275)-540-(1010)	(5)-8-(10)	(5)-7-(8)	He	–,C	–
D. eriantha	RBHw16924	RM(2-4), (S)	(45)-65-(105)	(5)-10-(20)	(200)-465-(800)	A	3–4	T-T	?	B1(2),S	(3)-4-(4)	U	(240)-470-(690)	?	(19)-24-(29)	?	He	–,C	–,C
D. euphlebia	L0967766	S, RM(2-5(7)), (C(3-6(10))	(30)-55-(70)	(25)-30-(35)	(120)-490-(1050)	A	3–4	VT	(1050)-1720-(2320)	I, B(1-2),S-V	(2)-7-(9)	U	(300)-670-(1480)	?	(10)-13-(16)	?	Ho	–,C	+
D. evena	RBHw13030	S, RM(2-4)	(100)-175-(210)	(0)-5-(5)	(450)-630-(800)	A(O)	4–7	T-T	?	B(1-2),S	(2)-3-(5)	U	(170)-640-(980)	?	(9)-12-(12)	?	He	–	–
D. fasciculosa	RBHw13110	S, RM(2-5)	(30)-70-(100)	(25)-30-(40)	(290)-345-(490)	A(O)	3–4	T-T	?	IB1,S	(2)-3-(4)	U-M	(250)-525-(1200)	(100)-425-(850)	(10)-13-(18)	(1)-2-(4)	He	–	+,C
D. ferrea	Tw43751	S, RM(2-4)	(45)-70-(100)	(5)-10-(15)	(880)-1110-(1330)	A(O)	3–4	VT	(880)-1110-(1330)	(I)B(1-3),(D),(S)	(4)-5-(6)	U-M	(150)-320-(600)	(300)-475-(800)	(6)-7-(8)	(5)-6-(7)	He	–,C	+

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. ferruginescens	RBHw13118	S, (RM(2-3))	(35)-105-(140)	(0)-5-(5)	(190)-450-(780)	A(O)	4–7	T-T	?	(I)B1(2),S	(3)-4-(5)	U-M	(110)-400-(650)	(200)-425-(650)	(10)-11-(13)	(4)-4-(5)	He	–	–
D. foxworthyi	RBHw13000	S, RM(2-3(5))	(85)-120-(170)	(5)-5-(15)	?	O(A)	3–4	T-(T)	?	B1,S	(3)-5-(7)	U	(170)-290-(390)	?	(12)-14-(15)	?	He	–	–
D. fragrans	WAG0101898	S, (RM(2-3))	(30)-55-(75)	(10)-15-(20)	(250)-400-(550)	A	4–7	VT	(600)-1000-(1300)	B1,V	(3)-4-(5)	U	(200)-400-(500)	?	(13)-14-(15)	?	He	–,C	–
D. frutescens	RBHw13237	S, RM(2-3), (C(3-11))	(55)-80-(115)	(5)-5-(10)	(250)-500-(660)	A(O)	3–4	T-T	?	B1,S-V	(4)-5-(6)	U	(355)-710-(1295)	?	(16)-18-(19)	?	He	–	+
*D. fuscovelutina**	RBHw22406	S, RM(2-4)	(40)-50-(65)	(20)-35-(40)	(150)-305-(460)	A	4–7	T-T	(800)-1000-(1550)	(I)B1,S	(2)-3-(4)	U-M	(270)-630-(1580)	(290)-805-(1745)	(6)-7-(9)	(2)-2-(3)	He	–,C	+
D. gabunensis	Tw24311	S, (RM(2-3(6))), (C(4-7))	(25)-45-(60)	(20)-25-(30)	(300)-400-(500)	A	3–4	VT	(550)-775-(900)	(I)B1(2),S	(3)-4-(6)	U-(M)	(100)-275-(450)	(200)-300-(550)	(7)-9-(11)	(1)-2-(2)	He	–,C	–
D. glandulosa	RBHw17368	S, RM(2-3(4))	(50)-120-(200)	(5)-10-(15)	(170)-315-(400)	A(O)	4–7	T-T	(990)-1130-(1270)	B1(2),S-V	(4)-4-(4)	U-M	(290)-355-(425)	(260)-375-(490)	(4)-6-(8)	(4)-6-(8)	He	–,C	–
D. gracilescense	RBHw7477	S, RM(2-3)	(85)-110-(150)	(5)-5-(10)	(260)-555-(800)	A(O)	3–4	T-T	?	B1,S	(3)-4-(5)	U-M	(190)-425-(670)	(200)-475-(710)	(10)-13-(16)	(1)-2-(2)	He	–,C	+
D. gracilipes	RBHw17921	RM(2-6), (S), (C(3-12))	(25)-70-(100)	(5)-10-(10)	(460)-560-(715)	A(O)	3–4	T-T	?	(I)B1,S	(3)-4-(5)	U-M	(220)-335-(605)	(245)-380-(580)	(6)-8-(10)	(4)-5-(7)	He	–,C	+,C
D. grex	Tw5154	S, RM(2-5(12))	(30)-50-(75)	(50)-65-(95)	(375)-475-(600)	A(O)	6–8	VT	(900)-1100-(1500)	B1(2),S	(3)-4-(5)	U	(150)-325-(725)	?	(7)-10-(13)	?	Ho	–,C	+
D. grisebachii	Tw57357	S, (RM(2-3))	(50)-90-(130)	(5)-10-(15)	(300)-500-(625)	A	4–7	T-T	(700)-975-(1250)	(I)B1,S	(4)-5-(8)	U-M	(100)-300-(700)	(250)-425-(700)	(6)-7-(7)	(4)-5-(7)	He	–,C	–,C
D. guatterioides	RBHw13441	S, RM(2-5(6))	(50)-90-(120)	(5)-5-(10)	?	A	4–7	T-T	?	B1(2),S	(2)-4-(4)	U	(160)-520-(1060)	?	(14)-15-(17)	?	He	–,C	–
D. guianensis	RBHw13285	RM(2-7), S, (C(4-7))	(50)-80-(105)	(5)-10-(10)	(415)-625-(850)	A(O)	3–4	T	?	B1(2),S	(4)-4-(4)	U	(220)-380-(675)	?	(10)-13-(15)	?	He	–	–
D. hainanensis	RBHw16922	RM(2-4), (S)	(60)-85-(110)	(5)-5-(10)	(300)-485-(600)	A(O)	3–4	T-T	?	IB1,S	(3)-4-(6)	U	(260)-320-(400)	?	(12)-13-(14)	?	He	–	+
D. hallierii	RBHw13120	S, RM(2-3(4))	(80)-140-(210)	(10)-10-(15)	(200)-420-(700)	A(O)	4–7	T	(1160)-1255-(1350)	IB1,S	(3)-3-(4)	U-M	(175)-305-(435)	(280)-555-(830)	(1)-3-(4)	(5)-8-(10)	Ho	–	+

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
*D. haplostylis**	Tw66540	S, RM(2-4)	(50)-75-(100)	(10)-15-(25)	(250)-350-(450)	A	4–7	VT	(450)-700-(900)	B(1-2),S	(3)-4-(4)	U	(125)-200-(250)	?	(11)-12-(13)	?	He	–,C	–
D. hasseltii	RBHw12997	S, RM(2-4)	(90)-125-(170)	(0)-5-(10)	?	A(O)	4–7	T-(T)	?	IB1,S	(3)-5-(7)	U	(170)-380-(680)	?	(14)-15-(16)	?	He	–,C	–,C
D. hebecarpa	L0734086	RM(2-4(6)), (S), (C(4-8))	(75)-120-(180)	(5)-10-(15)	(300)-450-(650)	A(O)	4–7	T-T	(700)-875-(1000)	B1(2)(I)(D),S-V	(4)-5-(7)	U-(M)	(150)-275-(500)	(100)-175-(300)	(12)-16-(20)	(4)-5-(7)	Ho	–	+
D. heterotricha	Tw41542	RM(2-12), (C(3-10))	(40)-70-(100)	(10)-15-(20)	(1750)-1915-(2200)	A(O)	4–7	T	(1750)-1915-(2200)	D,S	(3)-4-(4)	U-(M)	(100)-520-(1300)	(200)-475-(1000)	(12)-14-(17)	(0)-1-(2)	He	–	–
D. heudelotii	WAG0455685	S, RM(2-3), (C(2-4))	(70)-150-(180)	(5)-5-(5)	(300)-425-(600)	A(O)	6–8	VT	(600)-850-(1150)	D-(I)B1,(S)	(3)-4-(7)	U-M	(150)-375-(675)	(375)-625-(975)	(2)-6-(10)	(4)-6-(8)	Ho	–,C	–
D. hillebrandii	RBHw13435	RM(2-6), (S), (C(6-12))	(25)-40-(50)	(10)-25-(75)	?	A	3–4	T-T	?	IBto B(1-2),S	(3)-4-(4)	U	(210)-380-(855)	?	(12)-15-(17)	?	He	–,C	–
D. hirsuta	L0967758	S, RM(2-4), (C(3-6))	(65)-80-(105)	(5)-10-(20)	(400)-600-(770)	A(O)	4–7	T-(T)	(650)-890-(1240)	B(1-2),(S)-V	(3)-5-(8)	U-M	(90)-530-(1200)	(250)-675-(1730)	(12)-18-(23)	(1)-2-(4)	He	–,	–
D. hoyleana	Tw38469	S, RM(2-6)	(30)-50-(75)	(25)-35-(55)	(200)-350-(500)	A	3–4	VT	(700)-1000-(1800)	B1(2),S	(3)-4-(5)	U-M	(350)-610-(1120)	(490)-925-(1880)	(5)-7-(8)	(6)-7-(9)	He	–,C	–
*D. humbertiana**	RBHw24398	S, RM	(10)-20-(25)	(130)-160-(195)	(200)-300-(400)	A	4–7	VT	(650)-880-(1050)	ID,(S)	(2)-3-(4)	U-M	(180)-420-(890)	(250)-400-(650)	(14)-17-(22)	(2)-3-(5)	He	–,C	–
D. humilis	RBHw3446	RM(2-8), (S), (C(6-8))	(25)-55-(80)	(15)-30-(40)	?	A(O)	3–4	VT	?	IB1,S	(3)-4-(5)	U-M	(130)-285-(425)	(175)-290-(605)	(5)-7-(10)	(4)-6-(8)	He	+,C	+
D. impressinervis	Tw66521	S, (RM(2-4(5)))	(20)-40-(60)	(25)-40-(50)	(200)-425-(575)	A(O)	3–4	VT	(600)-975-(1250)	(I)B1(2),(S)	(3)-4-(5)	U-M	(150)-450-(925)	(275)-375-(650)	(11)-13-(15)	(3)-4-(4)	He	–,C	–
D. inconstans	L0967755	S, RM(2-6), (C(4-10))	(25)-40-(45)	(25)-35-(50)	(215)-355-(500)	A(O)	3–4	T-(T)	(465)-795-(1015)	IB(1-2),(D),(S)	(3)-4-(6)	U-(M)	(105)-425-(1300)	(200)-495-(1030)	(5)-11-(14)	(1)-1-(5)	He	–	+,C
D. insignis	RBHw17371	S, RM(2-3)	(50)-80-(130)	(5)-10-(25)	(100)-250-(500)	A(O)	3–4	T-T	?	B(1-2),S	(4)-5-(8)	U	(190)-485-(880)	?	(14)-17-(20)	?	He	+	–,C
D. insularis	RBHw17905	S, RM(2-5)	(55)-100-(125)	(5)-10-(15)	?	A(O)	4–7	VT	?	B1,S	(3)-4-(5)	U	(180)-385-(600)	?	(12)-15-(18)	?	He	–,C	+
D. iturensis	Tw30658	S, RM(2-3)	(60)-90-(120)	(15)-15-(15)	(200)-400-(550)	A	3–4	VT	(600)-1000-(1400)	B1(2),S	(3)-4-(4)	U-M	(150)-300-(700)	(300)-450-(600)	(5)-7-(9)	(3)-4-(6)	He	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. juruensis	RBHw13443	RM(2-4), (S)	(90)-110-(120)	(5)-5-(10)	?	A(O)	3–4	T-(T)	?	IB(1-2),S-V	(2)-4-(7)	U-M	(260)-420-(600)	(400)-675-(950)	(10)-12-(14)	(1)-1-(2)	He	–,C	–,C
D. kaki	Tw42074	S, RM(2-3(5))	(60)-140-(200)	(0)-5-(10)	(220)-325-(400)	A(O)	3–4	T-(T)	(880)-1115-(1360)	B1(2),S-V	(3)-4-(9)	U-M	(190)-240-(310)	(210)-275-(360)	(2)-6-(8)	(4)-6-(8)	He	+	–
D. kamerunensis	WAG0368928	S, RM(2-4(7)), (C(4-7(10)))	(30)-80-(130)	(5)-10-(20)	(500)-600-(725)	O(A)	4–7	VT	(850)-1300-(1600)	B1(2),(S)	(4)-6-(12)	U	(100)-550-(850)	?	(9)-12-(15)	?	He	–,C	–
D. kirkii	Tw28194	RM(2-6)	(45)-65-(90)	(15)-20-(30)	(720)-895-(1140)	A(O)	4–7	T	(720)-895-(1140)	D,S	(3)-4-(5)	U-M	(250)-385-(600)	(250)-405-(750)	(8)-10-(12)	(1)-2-(4)	He	–	–,C
D. koenigii	RBHw17885	S, RM(2-3)	(85)-120-(160)	(5)-5-(5)	?	A	4–7	T-T	?	IB(1-2),S	(3)-5-(7)	U	(240)-375-(600)	?	(9)-12-(15)	?	He	–	–,C
D. korthalsiana	L0967752	S, RM(2-4(8))	(60)-85-(105)	(5)-10-(15)	(250)-565-(770)	A(O)	3–4	VT	(1020)-1200-(1370)	B1,(S)	(4)-5-(7)	U	(210)-565-(870)	?	(13)-16-(18)	?	He	–	+
D. kurzii	L0967749	S, RM(2-4(8))	(45)-60-(80)	(20)-30-(55)	(290)-470-(710)	A	3–4	VT	(660)-1100-(1360)	B1(2),(S)	(4)-4-(5)	U-(M)	(120)-330-(620)	(200)-295-(380)	(9)-13-(16)	(1)-1-(1)	He	–,C	–
D. lanceifolia	L0087827	S, (RM(2-4)), (C(4-8))	(50)-130-(210)	(0)-5-(15)	(400)-575-(800)	A	4–7	T	(850)-1150-(1500)	(I)B1(2),(S)	(4)-6-(9)	U-M	(275)-475-(900)	(125)-650-(850)	(4)-7-(8)	(4)-6-(8)	He	–	+
*D. lanceolata**	Tw66357	S, RM(2-5)	(30)-50-(70)	(20)-25-(30)	(250)-400-(600)	A	3–4	VT	(700)-950-(1100)	B1(2),S	(2)-3-(5)	U-M	(200)-350-(600)	?	(8)-10-(14)	(2)-5-(10)	He	–,C	–
D. lasiocalyx	RBHw13438	S, RM(2-5), (C(4-6))	(40)-70-(95)	(10)-15-(20)	?	A	3–4	T-T	?	IB(1-2),S	(2)-4-(7)	U-M	(155)-310-(615)	(145)-340-(670)	(9)-11-(15)	(1)-3-(5)	He	–	–
D. latisepala	RBHw13148	S, RM(2-3)	(95)-125-(145)	(5)-5-(10)	(250)-505-(750)	A(O)	3–4	VT	?	B1,S	(3)-4-(6)	U-M	(200)-400-(700)	(180)-495-(750)	(9)-12-(15)	(1)-1-(2)	He	–,C	–,C
*D. leucocalyx**	Tw66542	S, RM(2-4)	(50)-60-(80)	(15)-20-(30)	(320)-450-(650)	A	4–7	T-T	?	D,S	(2)-3-(4)	U	(120)-690-(1050)	?	(17)-20-(22)	?	He	–,C	–
D. lissocarpoides	L0967671	S, RM(2-6), (C(4-12))	(30)-40-(65)	(10)-15-(25)	(145)-495-(650)	A(O)	3–4	T-(T)	(740)-970-(1280)	B1(2),S-V	(3)-5-(10)	U	(190)-395-(750)	?	(9)-10-(11)	?	He	–,C	–
*D. lokohensis**	Tw66569	S, RM2-4	(40)-60-(75)	(15)-20-(20)	(350)-550-(750)	A(O)	4–7	VT	(900)-1150-(1300)	B1(2),S	(5)-7-(8)	U	(200)-400-(600)	?	(10)-12-(13)	?	He	–,C	–
D. lolin	U0077061	S, (RM(2-4))	(60)-110-(150)	(0)-5-(10)	(325)-550-(675)	A	8–10	VT	(900)-1100-(1300)	B1(2),(S)	(4)-5-(7)	U-(M)	(100)-300-(650)	(200)-375-(825)	(6)-9-(13)	(1)-2-(4)	Ho	–	+

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. longibracteata	RBHw16923	S, RM(2-4)	(65)-80-(115)	(5)-10-(15)	(300)-425-(600)	A(O)	3–4	T-T	?	B1,S	(3)-4-(5)	U	(130)-390-(630)	?	(12)-14-(17)	?	Ho	–	–,C
D. longiflora	WAG0368925	S, (RM(2-4)), (C(3-9))	(30)-80-(140)	(5)-10-(10)	(300)-575-(800)	A	3–4	T-T	(850)-1150-(1400)	B1(2),(S)	(4)-6-(7)	U-(M)	(150)-350-(800)	(150)-525-(900)	(6)-8-(10)	(0)-2-(3)	He	–,C	–
D. longistyla	U0077059	S, (RM2-3)	(70)-120-(150)	(5)-5-(10)	(400)-650-(850)	A	6–8	VT	(1100)-1350-(1600)	B1(2),(S)	(4)-4-(5)	U	(250)-600-(1600)	?	(10)-11-(14)	?	He	–	–
D. lotus	Tw42077	S, RM(2-3)	(85)-120-(150)	(0)-5-(5)	(360)-395-(460)	A(O)	4–7	T	(450)-1110-(1500)	IB1,S-V	(3)-4-(11)	U-M	(100)-205-(320)	(180)-225-(270)	(2)-3-(4)	(5)-6-(8)	He	–,C	–
D. maclurei	RBHw16919	S, RM(2-3)	(80)-110-(135)	(5)-5-(10)	(400)-475-(570)	O(A)	4–7	T-T	?	B1(2),S	(2)-3-(4)	U	(240)-340-(640)	?	(10)-11-(12)	?	He	+	+
D. macrophylla	RBHw13220	S, RM(2-7), (C(4-6))	(65)-115-(165)	(0)-5-(10)	(420)-545-(835)	O(A)	6–8	T-(T)	?	B1,S	(4)-4-(5)	U-M	(200)-615-(1620)	(370)-705-(1610)	(7)-9-(10)	(3)-4-(5)	He	–	–
D. maingayi	L0087835	S, RM(2-6), (C(3-10))	(100)-195-(255)	(0)-5-(5)	(400)-850-(1100)	A	6–8	T-T	(1250)-1550-(1800)	B1(2),S-V	(4)-7-(8)	U	(200)-450-(850)	?	(4)-5-(7)	?	Ho	–,C	–
D. malabarica	Tw30850	S, RM(2-4), (C(3-6))	(40)-95-(140)	(0)-5-(5)	(970)-1140-(1340)	A(O)	4–7	T-T	(970)-1140-(1340)	B1(2),S-V	(4)-6-(7)	U-(M)	(100)-475-(850)	(250)-405-(900)	(19)-21-(22)	(0)-1-(1)	He	–	+
D. malam	L0967665	S, RM(2-5), (C(4-12))	(70)-100-(140)	(0)-5-(10)	(430)-570-(900)	A(O)	4–7	T	(910)-1100-(1320)	IB(1-2),S-V	(3)-4-(6)	U	(100)-545-(1180)	?	(13)-17-(19)	?	He	+	+
*D. managabensis**	RBHw24509	S, (RM(2-7)), (C(4-8))	(20)-40-(50)	(5)-10-(20)	(240)-350-(500)	A(O)	3–4	T-T	(900)-1100-(1200)	B1(2),S-V	(4)-4-(5)	U	(260)-310-(470)	?	(10)-12-(13)	?	He	–,C	–
D. manausensis	U0077017	S, RM(2-4(8)), (C(6))	(50)-70-(100)	(15)-25-(40)	(225)-450-(550)	A	4–7	T-T	(650)-875-(1100)	(I)B1(2-3),S-V	(4)-6-(8)	U	(150)-450-(850)	?	(8)-13-(15)	?	Ho	–	+
D. mannii	WAG0368923	S, RM(2-5(7))	(50)-100-(150)	(5)-5-(10)	(250)-475-(650)	A	8–10	T-T	(700)-1150-(1550)	B(I)1(2),(S)	(4)-5-(6)	U-M	(200)-350-(525)	(275)-475-(850)	(4)-7-(11)	(3)-4-(7)	Ho	–,C	–,C
D. maritima	L0087839	S, RM(2-5(7)), (C(3-5(8)))	(40)-100-(200)	(10)-15-(20)	(275)-575-(925)	A	4–7	T-(T)	(600)-950-(1250)	(I)B1(2),(S)	(4)-5-(6)	U-M	(150)-225-(450)	(225)-400-(600)	(1)-1-(3)	(6)-8-(10)	He	–,C	+
D. marmorata	RBHw13055	RM(2-5), (S)	(40)-80-(110)	(25)-45-(130)	(170)-340-(510)	O(A)	3–4	VT	?	B1,S	(4)-4-(6)	U	(150)-315-(500)	?	(18)-19-(20)	?	He	–,C	–,C
D. martini	L0967681?	S, RM(2-8), (C(3-14))	(35)-55-(80)	(20)-35-(40)	(210)-480-(705)	A	4–7	VT	(720)-1010-(1250)	(I)B1(2),(S)-V	(4)-5-(7)	U	(155)-535-(990)	?	(11)-12-(14)	?	He	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. matheriana	RBHw13429	S, RM(2-5), (C(5-6))	(60)-70-(90)	(5)-10-(10)	(160)-455-(720)	A(O)	4–7	VT	?	B1(2),S	(3)-4-(5)	U	(150)-420-(880)	?	(14)-15-(16)	?	He	–,C	–
*D. megaphylla**	Tw66359	S, RM(2-6)	(40)-70-(100)	(15)-20-(30)	(200)-350-(450)	A(O)	3–4	VT	(600)-850-(1100)	B(1-2),S	(4)-4-(4)	U-(M)	(200)-300-(450)	(150)-350-(500)	(8)-11-(14)	(1)-2-(3)	He	–,C	+
D. melanoxylon	RBHw228	RM(2-4), (S)	(35)-80-(110)	(5)-10-(10)	(310)-445-(560)	A(O)	3–4	T-T	?	B1,S	(3)-5-(7)	U-M	(160)-350-(470)	(180)-420-(600)	(10)-11-(13)	(1)-2-(3)	He	–	–,C
D. mellinoni	L0967659	S, RM(2-4(9))	(50)-75-(100)	(5)-10-(15)	(350)-505-(700)	A(O)	4–7	VT	(610)-1105-(1470)	B(1-2),(S)-V	(3)-4-(4)	U-M	(90)-455-(1025)	(270)-570-(1010)	(8)-12-(16)	(2)-3-(4)	He	–,C	–
D. melocarpa	WAG0368919	S, RM(2-3(4)), (C(4-6))	(40)-80-(110)	(10)-15-(20)	(250)-425-(575)	A	3–4	T-(T)	(650)-900-(1200)	B1(2),(S)	(4)-5-(8)	U-(M)	(100)-325-(650)	(200)-400-(600)	(7)-8-(10)	(0)-1-(2)	He	–,C	–
D. mespiliformis	Tw30059	S, RM(2-5)	(50)-90-(130)	(5)-10-(10)	(1530)-1330-(1600)	A(O)	4–7	VT	(930)-1330-(1600)	(I)B1,S	(4)-5-(7)	U-(M)	(250)-380-(650)	(200)-385-(650)	(10)-12-(13)	(1)-2-(4)	He	–	+
D. minahasae	L0967656	S, RM(2-3(5))	(50)-110-(170)	(0)-5-(10)	(410)-655-(830)	A(O)	3–4	T	(875)-1310-(1625)	IB(1-2),(D),(S)-V	(3)-4-(5)	U-M	(210)-625-(1170)	(340)-670-(1350)	(7)-10-(15)	(2)-5-(8)	He	–	+
D. mindanaensis	L0733918	RM(2-4(8)), (S), (C(3-6))	(50)-110-(170)	(5)-10-(15)	(350)-600-(700)	A(O)	4–7	VT	(850)-1300-(1550)	B1(2),S-V	(4)-5-(8)	U	(275)-550-(1000)	?	(12)-13-(15)	?	He	–	+
D. mollis	L0087842	RM (2-5), (S)	(40)-70-(100)	(25)-40-(65)	(300)-425-(500)	A	4–7	VT	(750)-950-(1250)	(I)B1(2),(S)	(3)-4-(4)	U	(75)-225-(350)	?	(7)-9-(10)	?	Ho	–	+
D. monbuttensis	WAG0368914	RM(2-6), (S), (C(4-9(11)))	(40)-100-(150)	(15)-25-(40)	(275)-425-(550)	A	8–10	T-T	(700)-1000-(1400)	(I)B1(2),(S)	(3)-4-(5)	U-M	(100)-225-(575)	(200)-300-(450)	(7)-9-(11)	(4)-5-(5)	Ho	–,C	–
D. montana	Tw3871	RM(2-5)	(40)-65-(95)	(10)-15-(20)	(830)-1120-(1270)	A	4–7	VT	(830)-1120-(1270)	(I)B1(3),S	(3)-4-(7)	U-(M)	(200)-375-(750)	(200)-465-(1150)	(13)-15-(16)	(0)-1-(2)	He	–	+
D. moonii	RBHw17892	S, RM(2-4)	(105)-130-(155)	(5)-5-(10)	(330)-470-(680)	O(A)	3–4	T-T	?	B1,S	(3)-4-(4)	U	(100)-360-(600)	?	(16)-17-(18)	?	He	–	–,C
D. morrisiana	Tw42078	S, RM(2-(3))	(70)-110-(180)	(5)-5-(5)	(1120)-1285-(1450)	A(O)	3–4	T	(1120)-1285-(1450)	IB(1), D,V	(3)-4-(7)	U-M	(200)-290-(400)	(300)-395-(650)	(2)-3-(5)	(7)-8-(10)	Ho	–,C	–
D. mun	Tw20644	S, RM(2-5)	(60)-100-(140)	(5)-10-(10)	(940)-1290-(1410)	A(O)	4–7	VT	(940)-1290-(1410)	B1(2),S	(4)-5-(5)	U-(M)	(300)-445-(850)	(200)-315-(450)	(13)-16-(18)	(0)-1-(1)	He	+	+
D. muricata	RBHw13067	S, RM(2-3)	(90)-120-(150)	(0)-5-(5)	(300)-520-(850)	A(O)	3–4	VT	?	B1,S	(3)-4-(6)	U-M	(170)-350-(500)	(340)-515-(800)	(4)-7-(9)	(1)-2-(3)	He	–	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. mweroensis	L0967653	S, RM(2-6), (C(3-6))	(45)-60-(80)	(20)-35-(45)	(110)-270-(380)	A	4–7	VT	(650)-975-(1300)	IB(1-2), D,(S)-V	(4)-4-(5)	U-M	(80)-305-(610)	(135)-335-(755)	(6)-9-(13)	(5)-6-(10)	He	–,C	–,C
*D. myriophylla**	Tw66508	S, RM(2-9)	(20)-30-(35)	(80)-95-(110)	(150)-300-(450)	A	3–4	VT	(600)-950-(1400)	B(1-2),S	(3)-4-(5)	U-(M)	(200)-350-(500)	(0)-0-(0)	(9)-10-(11)	(2)-2-(3)	He	–,C	+
D. myrmecocarpus	RBHw17590	RM(2-6), (S)	(40)-85-(125)	(5)-10-(15)	?	O(A)	3–4	T-T	?	IB1,S	(3)-4-(7)	U-M	(195)-475-(1000)	(285)-600-(1000)	(3)-6-(7)	(5)-8-(11)	He	–	–,C
*D. namoroensis**	Tw66400	S, RM(2-5)	(60)-90-(120)	(15)-20-(30)	(500)-600-(750)	A	3–4	VT	(1000)-1150-(1300)	B1,S	(2)-3-(5)	U	(75)-300-(500)	?	(13)-14-(15)	?	He	–,C	+
D. natalensis	Tw45576	S, RM(2-7)	(25)-35-(50)	(60)-70-(85)	(800)-950-(1200)	A(O)	4–7	VT	(800)-950-(1200)	B(1-2(3)),S-V	(4)-4-(5)	U-M	(300)-395-(550)	(450)-845-(1400)	(3)-7-(9)	(4)-6-(7)	He	–,C	–
D. nicaraguensis	RBHw15842	S, RM(2-3(4)), (C(3-6))	(45)-65-(80)	(10)-20-(30)	?	A(O)	4–7	VT	?	(I)B1,(S)	(2)-4-(5)	U-M	(85)-290-(635)	(195)-325-(435)	(4)-7-(10)	(2)-4-(6)	He	–	+,C
*D. nidiformis**	Tw66451	RM(2-7), (S)	(15)-30-(40)	(160)-195-(260)	(200)-350-(500)	A	3–4	VT	(700)-950-(1200)	IB1,S	(3)-4-(4)	U-M	(150)-250-(400)	(200)-275-(350)	(10)-11-(12)	(3)-4-(5)	He	–,C	–
D. nigra	Tw53201	S, RM(2-3), (C(3-5))	(50)-120-(150)	(5)-10-(10)	?	O(A)	4–7	T-T	?	IB1-2, D,S-V	(3)-4-(5)	U-M	(100)-175-(300)	(200)-275-(400)	(3)-3-(4)	(7)-9-(12)	He	–,C	+
D. nilagirica	RBHw13056	RM(2-4), (S), (C(5-9))	(55)-75-(100)	(10)-15-(20)	(310)-470-(600)	A(O)	3–4	T-T	?	IB1(2),S	(3)-4-(4)	U	(230)-475-(700)	?	(9)-11-(13)	?	He	–	–
D. nitida	Tw47432	S, RM(2-6), (C(3-12))	(70)-140-(170)	(5)-10-(10)	(920)-1175-(1350)	A(O)	4–7	VT	(920)-1175-(1350)	B1,S	(4)-6-(8)	U-(M)	(200)-450-(700)	(350)-595-(1200)	(13)-14-(15)	(0)-1-(2)	He	–	+
D. oblonga	RBHw13178	S, RM(2-3)	(70)-120-(165)	(5)-5-(10)	?	A(O)	3–4	T-T	?	IB1,S	(3)-7-(9)	U-M	(400)-700-(1400)	(170)-385-(920)	(11)-12-(14)	(4)-7-(8)	He	–	+
*D. occlusa**	RBHw24399	S, RM(2-3)	(80)-95-(115)	(0)-5-(10)	(200)-295-(440)	A(O)	3–4	VT	(650)-860-(1200)	B1(2),(S)-V	(3)-4-(7)	U-M	(270)-430-(785)	(320)-730-(1805)	(4)-6-(9)	(4)-4-(6)	He	–,C	–
*D. olacinoides**	Tw66498	S, RM(2-6)	(40)-55-(80)	(110)-130-(150)	(190)-290-(400)	A	4–7	VT	?	D,S-V	(2)-3-(4)	U	(190)-350-(780)	?	(18)-22-(25)	?	Ho	–,C	–
D. oocarpa	U0077008	S, RM(2-4(6))	(30)-70-(100)	(15)-30-(45)	(350)-500-(675)	A	4–7	T-T	(500)-850-(1200)	B1(2),(S)	(4)-4-(5)	U-(M)	(100)-300-(550)	(100)-350-(550)	(11)-13-(15)	(0)-1-(1)	He	–	+
D. palmeri	RBHw13378	RM(2-4), (S)	(30)-50-(70)	(50)-65-(80)	(190)-255-(460)	A(O)	3–4	T-(T)	?	IB1(2),S-V	(3)-4-(4)	U-M	(80)-190-(320)	(120)-215-(430)	(10)-11-(11)	(5)-6-(7)	He	–,C	–,C

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. paniculata	L0967650	S, RM(2-4(5))	(55)-100-(140)	(0)-5-(10)	(220)-440-(660)	A	4–7	VT	(700)-945-(1110)	(I)B(1-(2)),(S)-V	(3)-4-(6)	U-M	(70)-375-(840)	(140)-445-(825)	(7)-10-(15)	(2)-4-(6)	He	–	+
D. papuana	Tw52622	S, RM(2-3(4))	(50)-130-(180)	(5)-10-(10)	(375)-575-(750)	A	4–7	VT	(800)-1100-(1300)	B1(2),(S)	(3)-4-(5)	U	(150)-350-(600)	?	(11)-15-(18)	?	He	–	+
D. paraoesi	RBHw13018	S, RM(2-3)	(50)-90-(120)	(5)-5-(10)	?	A(O)	3–4	VT	?	B1,(S)	(3)-4-(5)	U	(230)-420-(700)	?	(8)-10-(12)	?	He	–,C	–
D. peekelii	RBHw16024	S, RM(2-3)	(45)-60-(70)	(5)-10-(15)	?	A(O)	4–7	T-T	?	IB1,S	(3)-4-(4)	U	(200)-435-(870)	?	(14)-16-(19)	?	He	–	–,C
D. pegophia	RBHw17880	S, RM(2-3(5))	(25)-50-(80)	(15)-20-(20)	(200)-470-(650)	A(O)	4–7	VT	?	B1,S	(2)-4-(6)	U-(M)	(170)-380-(800)	(200)-410-(600)	(10)-15-(21)	(1)-2-(3)	He	–,C	–
D. pendula	L0087853	S, RM(2-3(4)), (C(3-7))	(40)-100-(160)	(5)-5-(10)	(300)-500-(675)	A	4–7	T-T	(750)-1000-(1200)	B1(2),(S)	(2)-4-(5)	U-(M)	(100)-400-(775)	(150)-400-(875)	(8)-10-(11)	(1)-3-(6)	He	–	+
D. pentamera	RBHw13345	S, RM(2-5)	(65)-75-(85)	(5)-10-(15)	(380)-455-(520)	O(A)	3–4	T-T	?	(I)B1-2,S	(2)-3-(5)	U-M	(235)-565-(895)	(455)-470-(485)	(4)-6-(8)	(4)-5-(5)	He	–	–
D. perfida	L0967743	S, RM(2-5(8)), (C(4-8))	(40)-85-(110)	(10)-15-(20)	(350)-480-(650)	O(A)	4–7	VT	(790)-1090-(1430)	B1(2),S-V	(3)-4-(4)	U-M	(150)-290-(450)	(200)-375-(670)	(3)-5-(9)	(6)-8-(10)	He	–	+
*D. perrieri**	Tw66496	RM(2-6), (S)	(25)-60-(80)	(20)-25-(30)	(200)-350-(400)	A(O)	4–7	VT	(800)-1000-(1300)	B(1-2),S	(3)-4-(5)	U	(200)-300-(600)	?	(13)-16-(18)	?	He	–,C	–
*D. pervilleana**	Tw66407	S, RM(2-6)	(20)-35-(50)	(20)-35-(45)	(230)-330-(410)	A	4–7	VT	?	(I)B1(2),S	(2)-3-(4)	U	(130)-395-(850)	?	(22)-26-(35)	?	Ho	–,C	–
D. philippinensis	RBHw13621	S, (RM(2-3)), (C(4-8))	(75)-100-(150)	(0)-5-(10)	(260)-285-(480)	A(O)	6–8	VT	?	B1(2),(S)	(3)-4-(5)	U-(M)	(185)-385-(560)	(330)-435-(625)	(17)-19-(23)	(1)-2-(4)	He	–	+,C
D. physocalycina	RBHw14355	S, RM(2-5)	(45)-70-(80)	(20)-25-(30)	?	A	3–4	T-T	?	IB1,S	(2)-4-(5)	U	(185)-410-(785)	?	(11)-14-(17)	?	He	–,C	+,C
D. pilosanthera	L0087816	S, (RM(2-4))	(70)-150-(200)	(5)-5-(10)	(425)-675-(900)	A	4–7	VT	(600)-1200-(1450)	B1(2),S-V	(4)-8-(11)	U-(M)	(250)-500-(850)	(275)-425-(650)	(12)-15-(18)	(0)-2-(3)	Ho	–	+,C
D. pilosiuscula	U0077040	RM(2-4(6)), (S), (C(4-7))	(30)-70-(100)	(25)-35-(45)	(225)-500-(650)	A	3–4	T-(T)	(600)-900-(1200)	(I)B1(2),(S)	(4)-6-(8)	U-M	(150)-250-(400)	(150)-300-(450)	(1)-4-(7)	(6)-6-(7)	He	–,C	–,C
D. piscatoria	WAG0368912	S, (RM(2-3(5))), (C(5-13))	(50)-100-(150)	(5)-10-(15)	(350)-475-(550)	A	4–7	T-T	(750)-1050-(1400)	B1(2),(S)	(2)-4-(5)	U	(200)-350-(775)	?	(9)-10-(12)	(0)-1-(1)	He	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
*D. platycalyx**	RBHw24405	RM(2-7), (S), (C(6-12))	(25)-45-(60)	(145)-165-(200)	(270)-400-(600)	O(A)	4–7	VT	(950)-1100-(1600)	IB(1-2), D,(S)	(4)-4-(5)	U-M	(175)-260-(395)	(215)-405-(740)	(6)-8-(12)	(5)-8-(10)	He	–,C	–
D. poeppigiana	U0077011	S, RM(2-3(10))	(50)-120-(190)	(0)-0-(5)	(350)-575-(750)	A	4–7	T-T	(950)-1200-(1500)	(I)B,S-V	(3)-4-(5)	U-(M)	(175)-375-(700)	(250)-450-(750)	(6)-8-(10)	(2)-2-(3)	He	–,C	–
D. polystemon	WAG0368911	S, RM(2-3)	(50)-80-(110)	(0)-5-(5)	(425)-525-(650)	A	4–7	T-T	(800)-1100-(1300)	(I)B1(2),(S)	(4)-6-(8)	U	(150)-350-(800)	?	(9)-11-(14)	?	He	–,C	+
D. poncei	L0087866	S, RM(2-3)	(60)-150-(210)	(5)-5-(10)	(350)-550-(725)	A	6–8	VT	(800)-1250-(1600)	B1(2),(S)	(3)-4-(5)	U	(125)-325-(500)	?	(9)-10-(13)	?	Ho	–	+
D. pseudoxylopia	U0077123	S, RM(2-3(5))	(50)-130-(200)	(5)-10-(15)	(450)-550-(675)	A	4–7	VT	(700)-1000-(1250)	(I)B1(2),(S)	(3)-5-(7)	U-M	(150)-475-(750)	(400)-750-(1300)	(6)-8-(11)	(1)-4-(6)	Ho	–	–
D. puncticulosa	RBHw13017	S, (RM(2-3))	(90)-160-(205)	(0)-5-(5)	?	A(O)	6–8	T-T	?	B1(2),S	(6)-6-(7)	U	(200)-550-(1050)	?	(7)-9-(11)	?	He	–,C	–
D. pyrrhocarpa	Tw47433	S, RM(2-3(4))	(75)-95-(130)	(5)-10-(10)	(250)-560-(720)	A(O)	3–4	T-T	(500)-1095-(1420)	B1(2),S	(4)-5-(5)	U	(280)-470-(690)	?	(16)-17-(18)	?	He	–	+
D. quaesita	RBHw13301	S, RM(2-3)	(75)-100-(125)	(5)-10-(15)	(180)-385-(600)	A(O)	4–7	VT	?	B1(2),S	(4)-5-(7)	U-M	(190)-275-(370)	(180)-330-(550)	(7)-9-(11)	(2)-3-(4)	He	–,C	+
D. ridleyi	RBHw13001	S, RM(2-3(4))	(100)-130-(155)	(5)-5-(10)	?	A(O)	3–4	VT	?	B1(2),S	(2)-3-(4)	U	(160)-340-(700)	?	(13)-15-(17)	?	Ho	–	+
D. rigida	RBHw13039	S, RM(2-4)	(70)-120-(150)	(10)-10-(10)	?	O(A)	6–8	T-T	?	B1,(S)	(3)-4-(6)	U-(M)	(275)-475-(675)	(300)-500-(750)	(12)-16-(19)	(1)-2-(4)	He	–	+
D. rostrata	L0967738	S, RM(2-3), (C(3-4))	(70)-90-(110)	(5)-10-(10)	(360)-740-(960)	O(A)	3–4	VT	(840)-1260-(1470)	B1,S-V	(4)-5-(7)	U	(250)-635-(1100)	?	(16)-19-(21)	?	He	–,C	–,C
D. rufa	RBHw13181	RM(2-4(5)), (S), (C(4))	(40)-75-(100)	(10)-15-(20)	(330)-510-(750)	A(O)	3–4	VT	?	IB1(2),S	(3)-4-(5)	U-M	(150)-370-(740)	(160)-470-(810)	(9)-14-(18)	(2)-2-(3)	He	–	–
D. rumphii.	WAG0368916	S, RM(2-4)	(70)-120-(175)	(5)-5-(10)	(475)-625-(750)	A	4–7	T-T	(750)-1150-(1500)	B1(2),(S)	(3)-5-(8)	U	(175)-500-(900)	?	(10)-13-(14)	?	He	–	+
D. salicifolia	RBHw13375	RM(2-4), (S)	(50)-70-(80)	(5)-10-(10)	?	A	3–4	T-T	?	B1,S	(3)-4-(5)	U-M	(200)-330-(500)	(325)-430-(650)	(6)-7-(7)	(5)-6-(7)	He	–,C	–,C
D. samoensis	RBHw13413	S, RM(2-4)	(50)-60-(70)	(5)-10-(15)	(335)-395-(455)	A(O)	3–4	T-(T)	(860)-970-(1080)	IB(1-2),S-V	(3)-4-(6)	U	(185)-430-(675)	?	(16)-18-(19)	?	He	–	+,C

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. sandwicensis	Tw35938	S, RM(2-4(5))	(30)-50-(70)	(30)-35-(50)	(200)-325-(430)	A(O)	4–7	VT	(540)-760-(1020)	B1(2),S-V	(3)-4-(4)	U-M	(165)-335-(605)	(190)-345-(575)	(7)-10-(12)	(4)-5-(7)	He	+,C	–
D. sanza-minika	WAG0368814	S, RM(2-4)	(50)-110-(150)	(5)-5-(10)	(300)-450-(550)	A	3–4	VT	(900)-1150-(1600)	B1(2),S	(4)-5-(6)	U-(M)	(150)-250-(350)	(150)-350-(500)	(9)-11-(14)	(1)-2-(3)	He	–,C	–
D. saxosa	Tw19693	S, RM(2-4)	(60)-80-(100)	(5)-15-(20)	(200)-420-(560)	A(O)	4–7	T-T	(530)-955-(1460)	(I)D,S	(4)-5-(7)	U	(225)-400-(735)	?	(15)-16-(19)	?	He	–	+
*D. sclerophylla**	RBHw24403	S, RM(2-3)	(35)-60-(85)	(10)-15-(15)	(300)-450-(600)	O(A)	4–7	T-(T)	(1000)-1300-(1700)	B1(2),S	(3)-4-(5)	U-M	(215)-410-(845)	(265)-645-(1070)	(8)-10-(11)	(3)-4-(5)	He	+,C	–
D. sericea	U0077126	S, RM(2-4)	(60)-135-(175)	(5)-10-(15)	(325)-475-(650)	A	6–8	T-T	(800)-1050-(1350)	B1(2),S-V	(4)-4-(5)	U-M	(175)-300-(500)	(150)-350-(525)	(8)-9-(9)	(1)-3-(4)	He	–,C	–
D. setosa	L0087870	RM(2-3(5)), (S)	(50)-80-(110)	(15)-20-(25)	(450)-650-(800)	A(O)	7–8	VT	(700)-950-(1200)	B3(5),S	(2)-5-(8)	U	(75)-150-(250)	?	(10)-11-(13)	?	He	–,C	–
D. siamang	RBHw13029	S, RM(2-3)	(110)-145-(200)	(0)-5-(10)	?	A(O)	4–7	T-T	?	IB1(2),S	(4)-6-(8)	U	(180)-405-(770)	?	(8)-10-(13)	?	He	+	+
D. siamensis	Tw30850	S, RM(2-3)	(60)-110-(150)	(5)-5-(5)	(280)-410-(540)	A(O)	3–4	VT	(420)-915-(1200)	(I)B1(2),(S)-V	(4)-6-(8)	U-(M)	(180)-400-(610)	(370)-510-(780)	(18)-20-(22)	(2)-2-(4)	He	–	+
D. sogeriensis	WAG0368809	S, (RM(2-3(4)))	(60)-140-(200)	(0)-5-(5)	(350)-575-(750)	A(O)	4–7	VT	(900)-1250-(1600)	B1(2),(S)	(3)-4-(6)	U-M	(150)-425-(650)	(200)-475-(825)	(8)-10-(13)	(1)-4-(6)	Ho	+,C	+
D. soubreana	WAG0368808	RM(2-4(8)), (S), (C(4-8))	(50)-80-(125)	(15)-20-(30)	(225)-400-(550)	A	8–10	VT	(750)-950-(1250)	D,(S)	(4)-5-(7)	U-M	(100)-275-(350)	(150)-300-(475)	(7)-8-(10)	(3)-5-(7)	Ho	–	+
D. spectabilis	RBHw13380	RM(2-3(5)), (S)	(30)-55-(80)	(15)-20-(25)	(180)-295-(400)	A(O)	4–7	T-T	?	IB1,S-V	(3)-4-(4)	U-M	(150)-340-(480)	(180)-390-(670)	(6)-9-(10)	(3)-3-(5)	He	–,C	–,C
D. spinescens	L0967372	S, RM(2-7)	(30)-50-(70)	(50)-80-(105)	(220)-335-(440)	A(O)	4–7	VT	(650)-870-(1070)	I(B)1(2),S	(3)-4-(6)	U	(135)-420-(1015)	?	(13)-15-(19)	?	He	–	+,C
*D. squamosa**	RBHw24404	S, (RM((2)3-6)), (C(4-6))	(25)-65-(80)	(5)-10-(15)	(250)-610-(1000)	A(O)	3–4	T-(T)	(775)-1075-(1350)	B1(2),S-V	(4)-4-(5)	U	(275)-540-(860)	?	(13)-16-(18)	?	He	+	+
*D. squarrosa**	Tw66375	S, RM(2-4)	(40)-55-(80)	(10)-20-(25)	(350)-400-(550)	A(O)	3–4	VT	(500)-850-(1100)	B1(2),S	(3)-4-(4)	U-M	(200)-300-(450)	(150)-280-(450)	(7)-9-(11)	(1)-3-(5)	He	–,C	+
D. styraciformis	RBHw13065	S, RM(2-3(5))	(45)-90-(125)	(0)-5-(10)	?	A(O)	4–7	T-T	?	B(1-2),S	(4)-6-(7)	U	(250)-700-(1400)	?	(7)-12-(15)	?	He	–	+

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. suaveolens	Tw14487	S, (RM2-5)	(15)-45-(60)	(5)-10-(10)	(150)-400-(550)	A	3–4	T-T	(900)-1250-(1500)	B2(3),S	(2)-4-(5)	U-(M)	(250)-500-(750)	(200)-350-(500)	(17)-19-(22)	(1)-2-(4)	He	–,C	–
D. subrhomboidea	L0087872	RM(2-5), (S), (C(3-8))	(25)-70-(100)	(20)-25-(40)	(300)-550-(800)	A	3–4	VT	(700)-1200-(1700)	IB1-3,S	(3)-4-(5)	U	(200)-300-(530)	?	(24)-26-(28)	?	Ho	–,C	+
D. subtruncata	L0087873	S, (RM2-3)	(110)-130-(160)	(0)-0-(5)	(500)-550-(600)	A	5 to 8	T-T	(900)-1400-(1900)	B1,S	(3)-4-(5)	U-M	(300)-400-(500)	(350)-500-(900)	(4)-5-(6)	(3)-5-(9)	He	–	+
D. sumatrana	L0967376	S, RM(2-3), (C(3-9))	(65)-105-(125)	(5)-10-(15)	(550)-695-(870)	A(O)	3–4	T-T	(1100)-1370-(1600)	B1(2),S	(3)-4-(5)	U-(M)	(250)-610-(1070)	(220)-515-(1020)	(9)-12-(16)	(1)-2-(4)	He	+,C	+,C
D. sundaica	RBHw13010	RM(2-4), (S)	(35)-85-(120)	(15)-20-(30)	(380)-480-(700)	A(O)	3–4	VT	?	(I)B1(2),S	(3)-4-(4)	U	(210)-345-(530)	?	(12)-14-(16)	?	He	–	–,C
D. sylvatica	Tw46633	S, RM(2-6(9))	(35)-70-(110)	(15)-20-(25)	(260)-405-(500)	O(A)	4–7	VT	(680)-1070-(1590)	B1(2),S	(3)-4-(4)	U	(255)-385-(790)	?	(19)-20-(20)	?	He	–	+
D. tenuiflora	U0077108	S, (RM(2-5(7))), (C(2-7))	(40)-70-(100)	(5)-10-(15)	(300)-575-(750)	A	4–7	T-(T)	(900)-1100-(1400)	B1(2),(S)	(3)-4-(5)	U	(200)-550-(1100)	?	(15)-17-(19)	?	Ho	–,C	–,C
D. tetrandra	U0077109	S, RM(2-4)	(40)-90-(150)	(5)-5-(10)	(400)-550-(650)	A	3–4	VT	(1000)-1300-(1500)	B1(2),S	(3)-4-(4)	U-M	(200)-400-(650)	(200)-500-(1000)	(8)-11-(16)	(1)-3-(5)	He	–	–,C
D. tetrasperma	RBHw13431	S, RM(2-5(7))	(40)-70-(110)	(10)-15-(15)	?	A(O)	3–4	T-(T)	?	IB1(2),S	(3)-4-(4)	U-M	(175)-325-(675)	(250)-450-(950)	(6)-8-(10)	(5)-5-(6)	He	–,C	–,C
D. texana	Tw18261	S, RM(2-3)	(25)-40-(50)	(60)-75-(80)	(550)-640-(770)	O(A)	3–4	T	(550)-640-(770)	D,S	(3)-5-(8)	U-M	(50)-130-(200)	(150)-210-(450)	(8)-9-(10)	(7)-8-(10)	He	–,C	+
D. thomasii	RBHw13281	RM((2)3-4), (S), (C(6-8))	(30)-60-(80)	(5)-15-(25)	(400)-725-(1130)	A(O)	3–4	VT	?	B1,S	(3)-4-(4)	U	(250)-660-(1210)	?	(11)-13-(16)	?	He	–,C	–
D. thwaitesii	Tw31756	S, RM(2-3(5))	(75)-125-(185)	(5)-5-(5)	(240)-410-(620)	O(A)	3–4	T-T	(510)-1065-(1380)	B1,S	(3)-4-(5)	U-(M)	(280)-375-(460)	(280)-400-(480)	(8)-11-(12)	(3)-4-(4)	He	–	+
D. toposia	RBHw13133	S, RM(2-3)	(105)-150-(205)	(5)-5-(10)	(300)-575-(760)	A(O)	4–7	VT	?	B1(2),S-V	(4)-5-(7)	U-M	(230)-405-(700)	(320)-440-(780)	(11)-14-(16)	(2)-2-(4)	He	–	–
*D. toxicaria**	Tw66406	S, RM(3-10)	(25)-50-(100)	(10)-20-(35)	(300)-475-(900)	A	4–7	VT	(800)-1175-(1400)	B1(2-3),S	(2)-4-(4)	U-M	(150)-350-(700)	(200)-300-(500)	(6)-9-(12)	(2)-3-(4)	He	–,C	+
D. transita	L0087880	S, RM(3-4(7)), (C(5-8))	(50)-100-(150)	(5)-10-(15)	(300)-500-(700)	A(O)	4–7	T-(T)	(450)-850-(1400)	(I)B1(2),(S)	(3)-4-(6)	U-M	(100)-350-(550)	(275)-550-(900)	(4)-6-(8)	(5)-6-(7)	He	–	+,C

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. transitoria	L0967368	S, RM(3-6(7)), (C(3-11))	(45)-65-(75)	(15)-25-(40)	(290)-445-(570)	A(O)	4–7	T-T	(860)-1110-(1500)	B1(2),S	(4)-4-(4)	U	(110)-410-(760)	?	(17)-19-(22)	?	He	–	+
D. trichophylla	RBHw17902	RM((2)3-4), (S))	(50)-75-(95)	(10)-15-(20)	(350)-595-(850)	A(O)	3–4	T-T	?	B1(2),S	(4)-5-(7)	U	(250)-435-(860)	?	(11)-12-(13)	?	Ho	–,C	–
D. tristis	RBHw13173	RM(2-4), (C(3-6))	(50)-100-(135)	(5)-5-(10)	(240)-465-(640)	A(O)	3–4	T-T	?	B1(2),S	(3)-4-(5)	U	(170)-465-(740)	?	(11)-13-(15)	?	He	–	–
*D. tropophylla**	Tw66448	RM(4-8(12)), (S)	(10)-40-(55)	(100)-125-(240)	(200)-300-(400)	A	4–7	T-T	(400)-700-(900)	B1(2),S	(3)-4-(6)	U	(120)-250-(350)	?	(14)-16-(19)	?	He	–,C	–
D. truncata	RBHw13015	S, RM(2-3)	(40)-95-(135)	(5)-5-(10)	(360)-515-(770)	A(O)	3–4	T-T	?	B1,S-V	(4)-5-(6)	U-M	(300)-450-(800)	(370)-565-(780)	(5)-6-(7)	(4)-6-(8)	He	–,C	–
*D. tsaratananensis**	Tw66498	S, (RM2-4(9))	(10)-25-(35)	(80)-100-(120)	(300)-400-(500)	A	4–7	VT	(800)-1000-(1100)	B1(2),S	(3)-4-(5)	U-(M)	(150)-300-(450)	(200)-350-(500)	(7)-8-(10)	(1)-3-(5)	He	–,C	+
D. undulata	RBHw13068	S, RM(2-3)	(80)-120-(150)	(5)-5-(10)	?	A(O)	3–4	T-T	?	B1(2),S	(3)-4-(5)	U-M	(310)-440-(680)	(370)-770-(1040)	(6)-8-(9)	(3)-4-(5)	He	–,C	–
D. variegata	RBHw13058	S, RM(2-3(4))	(35)-85-(130)	(10)-15-(20)	(210)-405-(620)	O(A)	4–7	VT	?	B1(2),S	(2)-3-(5)	U-M	(100)-315-(760)	(180)-285-(370)	(4)-6-(9)	(4)-7-(8)	Ho	–	–,C
*D. velutipes**	Tw66394	S, RM(2-6(8))	(50)-80-(110)	(40)-55-(70)	(210)-390-(540)	A	4–7	VT	?	B1(2-3),S-V	(3)-5-(8)	U	(140)-370-(750)	?	(9)-10-(11)	?	He	–,C	–
D. venosa	RBHw13238	S, RM(2-4)	(50)-110-(150)	(0)-5-(5)	?	A(O)	3–4	T-T	?	IB1(2),S	(2)-4-(6)	U-M	(275)-550-(925)	(350)-570-(1000)	(6)-9-(11)	(3)-5-(6)	He	–	+
D. verae-crucis	RBHw13423	S, RM(2-3), (C(6))	(55)-100-(120)	(5)-10-(15)	(330)-455-(700)	A(O)	4–7	T-T	?	B1(2),S-V	(2)-4-(5)	U-M	(190)-365-(470)	(300)-505-(800)	(5)-7-(10)	(2)-5-(9)	He	–,C	–,C
D. verrucosa	U0076835	RM(2-5(9)), (S), (C(3-7))	(20)-50-(80)	(75)-95-(115)	(300)-375-(500)	A	4–7	VT	(500)-850-(1100)	(I)B1(2),(S)	(3)-4-(4)	U	(100)-250-(400)	?	(9)-12-(15)	?	He	–,C	–
*D. vescoi**	RBHw24508	S, RM(2-3)	(25)-50-(70)	(20)-25-(25)	(280)-350-(450)	A	4–7	VT	(860)-990-(1240)	B(1-3),S-V	(2)-3-(4)	U-M	(140)-475-(920)	(250)-610-(1420)	(17)-18-(20)	(2)-3-(4)	He	–,C	–
D. vignei	WAG0368902	S, RM(2-5), (C(3-5))	(20)-50-(80)	(15)-20-(30)	(300)-600-(900)	A(O)	3–4	VT	(700)-1250-(1600)	B1(2),(S)	(2)-3-(4)	U	(225)-400-(550)	?	(10)-13-(14)	?	He	–,C	–
D. virginiana	Tw19293	S, RM(2-4)	(50)-110-(160)	(5)-10-(15)	(910)-1150-(1320)	O(A)	3–4	T-(T)	(910)-1150-(1320)	IB1, D,S	(4)-8-(10)	U-M	(50)-195-(300)	(200)-275-(300)	(4)-6-(6)	(7)-7-(8)	He	–,C	–

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
D. viridicans	Tw41625	S, RM(2-3)	(50)-90-(115)	(5)-5-(10)	(260)-305-(380)	A(O)	6–8	T-(T)	(700)-995-(1340)	B1(2),S	(4)-5-(7)	U-M	(230)-305-(425)	(240)-330-(425)	(3)-4-(5)	(7)-8-(9)	He	+,C	–
D. vitiensis	RBHw13417	S, RM(2-6), (C(4-6))	(30)-60-(70)	(10)-15-(25)	?	A(O)	3–4	T-T	?	B1,S	(3)-4-(4)	U	(205)-385-(670)	?	(12)-13-(15)	?	He	–	+
D. walkeri	RBHw17903	S, RM(2-3(4))	(45)-70-(85)	(5)-5-(15)	?	A(O)	3–4	T-T	?	B1,S-V	(3)-4-(5)	U	(250)-540-(780)	?	(11)-13-(15)	?	Ho	–	+
D. wallichii	RBHw13151	S, RM(2-3), (C(4-7(10)))	(55)-130-(160)	(5)-5-(10)	?	A(O)	6–8	T-T	?	(I)B1(2),S	(2)-4-(5)	U-(M)	(300)-475-(850)	(150)-475-(900)	(8)-10-(11)	(1)-2-(2)	He	+	+,C
D. yeobi	RBHw13135	S, RM(3-4)	(70)-90-(105)	(5)-10-(15)	(380)-625-(800)	A(O)	3–4	VT	?	B1,S	(3)-4-(5)	U	(210)-455-(630)	?	(15)-18-(20)	?	He	–	+
D. zenkeri	RBHw13287	S, RM(2-3)	(35)-50-(60)	(15)-20-(20)	?	A(O)	3–4	T-T	?	B1(2),S	(4)-5-(6)	U	(175)-580-(1200)	?	(12)-14-(15)	?	He	–,C	–
Euclea divinorum	Tw28287	S, RM(2-4)	(25)-40-(50)	(25)-30-(40)	(200)-290-(380)	A(O)	3–4	VT	(700)-875-(980)	IB1, D,S	(3)-4-(5)	U-M	(150)-420-(1200)	(300)-585-(1300)	(6)-9-(10)	(3)-4-(6)	He	–	–
E. lanceolata	Tw39136	S, RM(2-4)	(40)-60-(80)	(5)-9-(12)	(350)-415-(470)	A(O)	3–4	T-T	(850)-1120-(1280)	IB1(2)-D, S-V	(3)-4-(5)	U-M	(100)-340-(600)	(300)-430-(600)	(7)-8-(9)	(3)-4-(5)	He	–	+
E. natalensis	RBHw17817	S, RM(2-4)	(35)-50-(65)	(10)-20-(30)	(315)-375-(435)	A(O)	3–4	T-T	(755)-825-(900)	IB(1-2), D,S	(4)-4-(4)	U-M	(220)-350-(480)	(260)-330-(420)	(4)-4-(4)	(6)-7-(7)	He	+,C	–
E. schimperi	Tw 33870	RM(2-5(10)), (S)	(90)-80-(110)	(10)-13-(17)	(270)-345-(480)	A(O)	3–4	T-T	(810)-1020-(1110)	IB(1-2)-D, S-V	(3)-4-(5)	U-M	(200)-350-(650)	(350)-660-(950)	(4)-5-(7)	(5)-6-(7)	He	+	+

Table A1.
(Continued.)

Species	*Xylarium* specimen	VG	VDia	VDen	VEL	IVPa	IVPl	FWT	FL	APd	NrAP	RW	URH	MRH	URD	MRD	RC	CAP	CR
Lissocarpa bentami	Tw36617	S, RM(2-3)	(70)-110-(80)	(5)-10-(10)	(450)-740-(950)	A(O)	4–7	VT	(1500)-1850-(2100)	B(1)2,S	(4)-5-(7)	U-M	(200)-270-(450)	(650)-950-(1500)	(2)-3-(4)	(5)-6-(8)	Ho	–	–
L. guianensis	Tw23381	S, RM(2-4), (C(3-7))	(40)-80-(120)	(10)-15-(20)	(850)-1150-(1450)	A(O)	4–7	VT	(1900)-2225-(2550)	B(1-2),S	(5)-7-(9)	U-M	(350)-570-(1050)	(550)-1410-(2300)	(2)-2-(3)	(7)-8-(10)	He	–	–
Royena glabra	RBHw17909	S, RM(2-9)	(40)-55-(70)	(35)-45-(55)	(275)-335-(395)	A(O)	3–4	T	(715)-850-(985)	IB(1-2),S-V	(3)-4-(4)	U-M	(150)-305-(460)	(130)-655-(1180)	(4)-7-(11)	(2)-5-(9)	He	–	–
R. lucida	Tw21536	RM(2-10), (S), (C(3-12))	(25)-50-(70)	(30)-35-(45)	(200)-430-(620)	A(O)	3–4	T	(770)-1030-(1210)	IB1, D,S	(3)-4-(4)	U-M	(200)-350-(450)	(200)-535-(1000)	(2)-4-(7)	(3)-5-(6)	He	–	+
R. lycioides	RBHw3447	RM(2-6(15))	(30)-70-(100)	(45)-65-(80)	(140)-250-(450)	A(O)	3–4	T	?	IB(1-2), D,S	(3)-4-(4)	U	(150)-575-(1450)	(410)-715-(1150)	(11)-12-(13)	(3)-4-(5)	He	–	+
R. pallens	Tw28101	S, RM(2-6)	(45)-65-(95)	(10)-15-(20)	(140)-335-(520)	A(O)	4–7	VT	(390)-980-(1420)	IB1,S	(3)-4-(8)	U-(M)	(220)-380-(590)	(350)-465-(610)	(9)-12-(14)	(1)-2-(2)	He	–	+

VG, Vessel grouping (S, solitary; RM, radial multiples; C, clusters); VDia, Vessel diameter (µm); VDen, Vessel density (per mm^2); VEL, Vessel element length (µm); IVPa, intervessel pit arrangement (A, alternate; O, opposite); IVPl, (horizontal) length of intervessel pits (µm); FWT, Fibre wall thickness; FL, Fibre length (µm); APd, Axial parenchyma distribution (B, banded; IB, interrupted bands; D, diffuse-in-aggregates; S, scanty paratracheal parenchyma; S-V, scanty to vasicentric paratracheal parenchyma; V, vasicentric paratracheal parenchyma); NrAP, Number of axial parenchyma cells per strand; RW, Ray width; URH, Uniseriate ray height (µm); MRH, Multiseriate ray height (µm); URD, Uniseriate ray density (number per mm in tangential section); MRD, Multiseriate ray density (number per mm in tangential section); RC, Ray composition (He, heterocellular rays, Ho, homocellular rays); CAP, Prismatic crystals in axial parenchyma (C, prismatic crystals in chambered axial parenchyma cells); CR, Prismatic crystals in ray cells (C, prismatic crystals in chambered ray cells). Values in parenthese are either extreme (minimum or maximum) values or represent rare measurements. Species with * are from Madagascar.

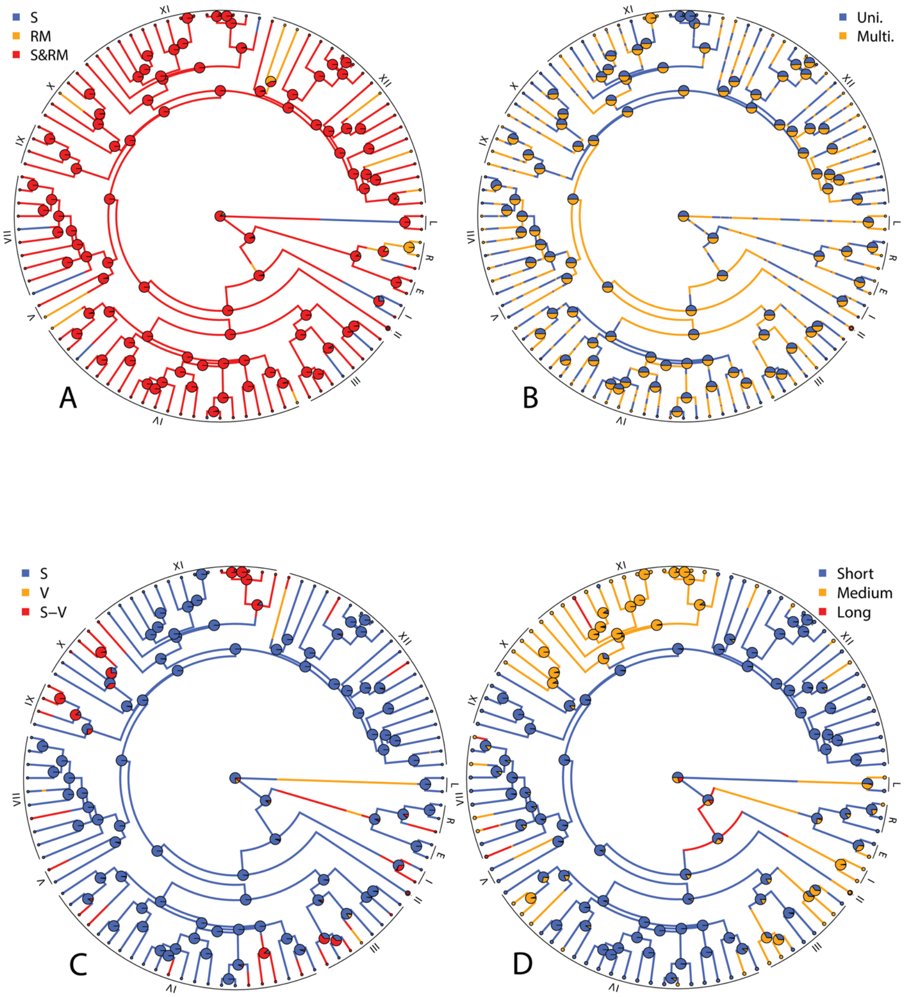

Figure A2. Ancestral state reconstructions of selected wood anatomical characters from stochastic character mapping analyses. (A) Vessel grouping (predominantly solitary, predominantly in radial multiples, solitary and in radial multiple). (B) Ray width (predominantly uniseriate, uniseriate, and multiseriate). (C) Paratracheal parenchyma (scanty, scanty to vasicentric, and vasicentric). (D) Uniseriate rays height (short, medium, and long).

Lissocarpa (*based on L. bentami Tw36617 and L. guianensis Tw23381*)

Growth ring boundaries absent. Wood diffuse-porous. Tangential diameter of vessels (40)-80-110-(180) µm, vessel elements (450)-740-1150-(1450) µm long. Vessels (7)-10-15-(22)/mm², usually in radial multiples of 2–4 (Fig. A1D), less frequently solitary or in vessel clusters of 3–7. Vessel outline circular. Vessel perforation plates usually simple, sporadically scalariform with up to 30 bars (Fig. A1E). Intervessel pits alternate to opposite but

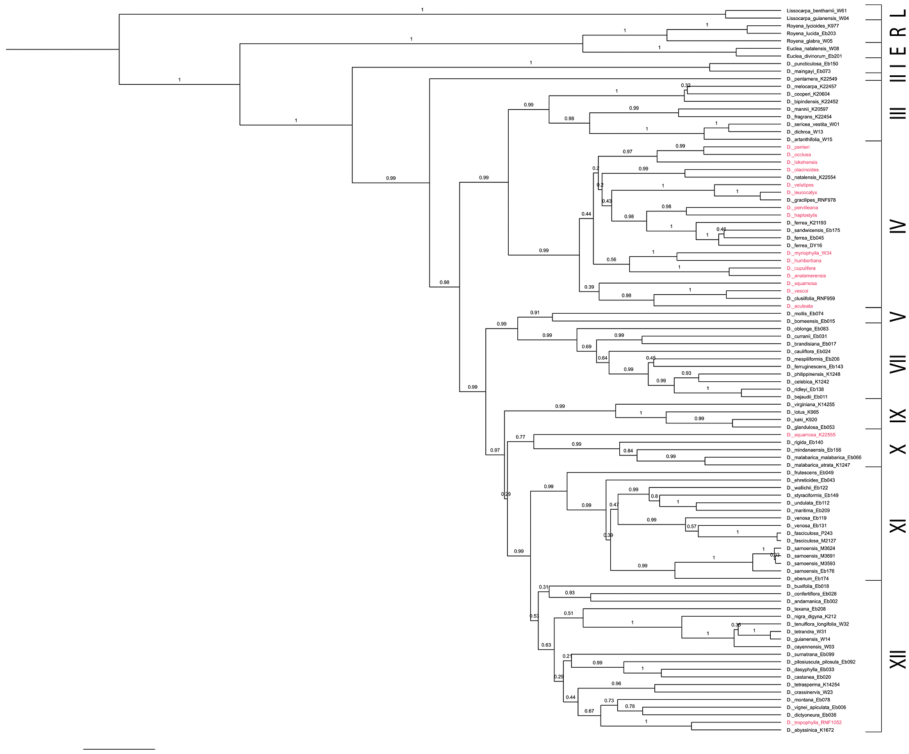

Figure A3. Phylogenetic tree resulting from Bayesian inference analyses of data from four markers (*rbcL*, *atpB*, *trnS-G*, and *matK-trnK*), with posterior probabilities shown above branches. The taxa from Madagascar are shown in red.

Table A2.
DNA sequence alignment statistics of four plastid regions analysed with BEAST.

Plastid DNA region	Sequence length	Min sequence length	Max sequence length	Pairwise identity (%)	Identical sites (%)	GC (%)	Best model (AIC)
atpB	1435	1321	1434	99.3	88.9	42.6	TIM1+I+G
rbcL	1516	1354	1483	98.3	62.5	43.1	TVM+I+G
matK-trnK	2602	2352	2479	97.9	67.3	33.2	TVM+I+G
trnS-trnG	850	528	676	92.8	34.6	28.2	GTR+G

the alternate type often dominates, 4–6 μm in horizontal diameter. Vessel-ray pits alternate to opposite 4–6 μm in horizontal diameter. Tracheids absent. Non-septate fibres with simple to minutely bordered pits concentrated in radial walls, thick- to very thick-walled, (1500)-1850-2220-(2550) μm long. Axial parenchyma in bands of 1 to 2 cells wide, paratracheal parenchyma scanty, 2–4 cells per strand. Uniseriate rays always present but less

Table A3.
Diospyros/*Euclea* fossil calibration point priors based on a recently described pollen fossil treated as a minimum age constraint (56 Mya) for the split between *Diospyros* and *Euclea* (Linan *et al.*, 2019).

Distribution	log-normal
Mean	1.5
Standard deviation	0.7
Offset	56

Table A4.
Molecular clock priors for *ucld.stdev* analyses.

ucld.stdev		ucld.mean	
Distribution	log-normal	diffuse gamma	
Mean (in real space)	0.9	Alpha	0.001
Standard deviation	1	Beta	1000
Initial value	0.5	1	

frequent than multiseriate rays (Fig. A1F), (200)-270-570-(1050) µm high, consisting of procumbent or square cells, 2–4 rays/mm. Multiseriate rays 2–3-seriate, (550)-950-1410-(2300) µm high, 5–10 rays/mm, consisting of procumbent body ray cells, and 1–4 rows of upright marginal ray cells. Sheath cells absent. No mineral inclusion observed.

Table A5.
Log-likelihoods ratio test results from the equal rates (ER), all rates different (ARD) and symmetrical (SYM) models.

Trait	ER	SYM	ARD	ER vs SYM	ER vs ARD	SYM vs ARD	p_val ER vs SYM	p_val ER vs ARD	p_val SYM vs ARD
Perforation plate	−4.02	−4.02	−9.03	0	10.02	10.02	1	0.07	0.01
Vessel grouping	−65.86	−66.04	−58.91	0.36	13.9	14.26	0.95	0.02	0
Storied structures	−5.9	−5.9	−5.86	0	0.06	0.06	1	1	0.97
Apotracheal parenchyma distribution	−67.4	−65.71	−62.48	3.38	9.84	6.46	0.34	0.08	0.04
Ray width	−64.84	−64.84	−64.78	0	0.11	0.11	1	1	0.95
Mineral inclusion	−118.07	−103.29	−100.86	29.56	34.42	4.86	0	0	0.09
Paratracheal parenchyma distribution	−73.34	−60.47	−57.8	25.74	31.08	5.34	0	0	0.07
Uniseriate ray height	−87.23	−71.23	−70.12	32	34.22	2.23	0	0	0.33
Multiseriate ray height	−86.49	−70.31	−69.4	32.36	34.19	1.83	0	0	0.4

Table A6.
Marginal probability of the root state as estimated with RJMCMC, ACE and SCM (ER model).

Character	RJMCMC (BT)					SCM (SIMMAP)					ML (ACE)				
	State 0	State 1	State 2	State 3	State 4	State 0	State 1	State 2	State 3	State 4	State 0	State 1	State 2	State 3	State 4
Apotracheal parenchyma (0 = Banded, 1 = Irregular banded, 2 = Diffuse-in-aggregates)	0.51	0.28	0.21	–	–	0.81	0.04	0.15	–	–	0.70	0.11	0.19	–	–
Mineral inclusion (0 = No crystal, 1 = Crystals in axial parenchyma, 2 = Crystals in axial parenchyma and rays, 3 = Crystals in rays, 4 = Silica body)	0.20	0.20	0.20	0.20	0.20	0.05	0.39	0.22	0.30	0.04	0.22	0.32	0.12	0.18	0.16
Multiseriate ray height (0 = short, 1 = medium, 2 = long)	0.36	0.32	0.32	–	–	0.68	0.29	0.03	–	–	0.53	0.38	0.09	–	–
Paratracheal parenchyma (0 = scanty, 1 = scanty to vasicentric, 2 = vasicentric)	0.48	0.26	0.26	–	–	0.79	0.01	0.20	–	–	0.78	0.11	0.12	–	–
Perforation plate (0 = Exclusively simple, 1 = Simple and scalariform)	0.05	0.95	–	–	–	0.96	0.04	–	–	–	0.83	0.17	–	–	–
Ray type (0 = Predominantly uniseriate, 1 = Predominantly multiseriate)	0.50	0.50	–	–	–	0.50	0.50	–	–	–	0.50	0.50	–	–	–
Storied structures (0 = Absent, 1 = Present)	0.94	0.06	–	–	–	0.96	0.04	–	–	–	1.00	0.00	–	–	–
Uniseriate ray height (0 = Short, 1 = Medium, 2 = Long)	0.34	0.33	0.33	–	–	0.66	0.31	0.02	–	–	0.76	0.17	0.06	–	–
Vessel grouping (0 = Solitary, 1 = Radial multiples, 2 = Solitary and radial multiples)	0.33	0.33	0.34	–	–	0.04	0.07	0.89	–	–	0.07	0.07	0.86	–	–