Diversity, composition, and biogeography of trees in tropical mountain forests of Sulawesi, Indonesia

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I should describe it rather as an intense interest in the mere variety of living things, the variety that catches the eye of the observer even among those which are very much alike, but which are soon found to differ in several distinct characters [...] we became travellers, collectors, and observers, in some of the richest and most interesting portions of the earth; and we thus had forced upon our attention all the strange phenomena of local and geographical distribution

Alfred Russel Wallace

Contents

Abstract

Human activities are increasingly threatening the integrity of Earth's ecosystems. For successful conservation measures, one necessary prerequisite is an adequate level of understanding about the ecosystems and their constituting organisms. Currently, however, there are considerable deficits in our knowledge about which and how many species exist (Linnean shortfall), where these species are distributed geographically (Wallacean shortfall) and ecologically (Hutchinsonian shortfall), how abundant they are (Prestonian shortfall), and their evolutionary histories (Darwinian shortfall), among others. Many methods are available to fill these existing knowledge gaps but one of the undoubtedly crucial approaches is work on the ground in tropical hinterland regions, where high levels of biodiversity, important knowledge gaps, and often imminent threats to natural habitats coincide. One example for such a hinterland region is the Indonesian island of Sulawesi in the centre of the Malesian archipelago, whose large portions of relatively undisturbed tropical mountain forests harbour a rich and biogeographically unique, yet poorly known flora. With his thesis, I aim to contribute to a better understanding of the ecology of Sulawesi's tropical mountain forest and its tree flora in relation to environmental factors and evolutionary history. To do so, I conducted extensive plot-based field work in the Lore Lindu National Park in Central Sulawesi, putting special emphasis on rigorous species identification. In the different chapters, I address the specific knowledge gaps or shortfalls outlined above.

In an attempt to deal with the Linnean shortfall, I describe seven new endemic tree species from Sulawesi (Chapters 1–3), including information of their distribution, ecology, and conservation status. The species descriptions furthermore provide the necessary foundation for analyses carried out in later chapters. Chapter 1 contains the description of *Magnolia sulawesiana* (Magnoliaceae), a new *Magnolia* species from upper montane forests of Sulawesi, as well as an identification key for all ten species of the genus native to the island. Another montane species, *Elaeocarpus firdausii* (Elaeocarpaceae) of the species-rich and predominantly Australasian genus *Elaeocarpus*, is described in Chapter 2. In the third chapter, I propose five new species of *Syzygium* (Myrtaceae), one of the largest genera of woody plants worldwide. Although the genus is widespread, diverse, and often dominant, the taxonomy of *Syzygium* in Sulawesi is largely unresolved and taxonomic work on the genus is urgently needed. The newly proposed species are *Syzygium balgooyi*, *Syzygium contiguum*, *Syzygium devogelii*, *Syzygium eymae*, and *Syzygium galanthum*.

In Chapter 4, I investigate patterns of tree species diversity, endemism, and composition along gradients of elevation and soil properties. I show that species diversity in Sulawesi at the plot level is similar to other Malesian regions and that it monotonically declines with elevation. Over 25% of the recorded tree species are new occurrence-records for (Central-) Sulawesi or undescribed species, highlighting how underexplored the region is. Levels of endemism found in this study clearly exceed estimates from previous studies, especially in high-elevation forests. The forest communities are mostly determined by elevation and can be grouped into three floristically distinct elevational belts whereas soil characteristics play only a minor role. I take a closer look at understorey trees species, a guild that is often neglected in standard forest or biodiversity inventories and highlight the important contribution of these understorey tree species to local species diversity.

Given Sulawesi's geographical position and geological history, the island's tree flora needs to be viewed in a wider spatial and temporal context that includes Asia and Australia. I therefore widen the scope in Chapter 5 to address the Darwinian shortfall, which is defined as the lack of knowledge about the evolutionary history of Malesian tree species. The central part of Malesia only formed in the last 23 My and in that timespan, plants have colonized Malesia from Asia and Australia in a process termed the Malesian Floristic Interchange. I used my dataset from Central Sulawesi and published studies from other Malesia subregions and inferred the geographical origin of the tree lineages in the dataset based on phylogenetic and fossil information. I then related the relative abundance of Asian versus Australian trees per plot to environmental parameters to show that the colonization success of tree lineages in Malesia is strongly determined by habitat. The results showed a higher proportion of Australian tree species and individuals at higher elevations, over ultramafic bedrock, and east of Wallace's line. The trend is stronger for tree individuals than for species meaning that montane forests and those on poor soils in Malesia are mainly dominated by Australian tree-lineages. These patterns are a consequence of the climatic and biogeographical history of Malesia and indicate that environmental similarities between source and sink habitats have largely determined the colonization success during the Malesian floristic interchange.

In conclusion, I show that the rain forests of Sulawesi harbour a species-rich and unique tree flora, characterized by high proportions of small understorey trees and endemic species, many of which remain to be discovered and formally described. The biogeographical history changes from sub-montane communities dominated by Asian tree lineages to upper montane forests composed of mainly Australian lineages and many endemics. Although less-diverse than lowland rain forests, these upper montane communities therefore have high conservation values. At the same time, they remain among the least-studied ecosystems in Malesia. While with this thesis I hope to have bridged some knowledge gaps regarding Sulawesi's trees and forests, repeated biodiversity inventories including phylogenetic and trait-based approaches will be indispensable to improve our baseline knowledge about plant diversity patterns in Sulawesi.

Zusammenfassung

Menschliche Aktivitäten bedrohen zunehmend die Unversehrtheit der Ökosysteme auf der Erde. Eine wichtige Voraussetzung für erfolgreiche Naturschutzmaßnahmen ist ein angemessenes Verständnis der einzelnen Ökosysteme und der sie ausmachenden Organismen. Bisher bestehen jedoch beträchtliche Wissenslücken, unter anderem darüber wie viele Arten existieren und wie diese heißen (Linnéisches Defizit), wie diese Arten geographisch (Wallaceisches Defizit) und ökologisch (Hutchinsonisches Defizit) verbreitet sind und wie häufig die Arten sind (Prestonisches Defizit) sowie über ihre evolutionäre Geschichte (Darwinisches Defizit). Zahlreiche Methoden stehen zur Verfügung um diese Wissenslücken zu füllen; ein zweifellos entscheidender Ansatz ist Feldforschung in tropischen Hinterlandregionen, wo reiche Biodiversität, große Wissenslücken, und oft auch unmittelbar bevorstehende Bedrohungen der natürlichen Habitate zusammenfallen. Die indonesische Insel Sulawesi im Zentrum des malesichen Archipels ist ein Besipiel für solche Hinterlandregionen. Ihre großen und relativ ungestörten tropischen Bergwaldgebiete beherbergen eine reiche und biogeographisch einzigartige, gleichzeitig aber schlecht erforschte Flora. Mit dieser Dissertation beabsichtige ich zu einem besseren Verständnis über die Ökologie von Sulawesi’s tropischen Bergwäldern und ihrer Baumflora im Kontext von Umweltfaktoren und evolutionärer Geschichte beizutragen. Dafür habe ich umfangreiche plotbasierte Feldarbeiten im Lore Lindu Nationalpark in Zentralsulawesi durchgeführt und dabei besonderes Augenmerk auf die gründliche Bestimmung der gefundenen Baumarten gelegt. In den einzelnen Kapiteln befasse ich mich mit den oben genannten Wissenslücken oder Defiziten.

In den Kapiteln 1–3 versuche ich das Linnéische Defizit zu verringern indem ich sieben neue, für Sulawesi endemische Baumarten beschreibe und Information über deren Verbreitung, Ökologie und Gefährundsstatus beisteuere. Die Artbeschreibungen liefern darüber hinaus die notwendige Basis für die weiterführenden Analysen der späteren Kapitel. Kapitel 1 enthält die Beschreibugn von *Magnolia sulawesiana* (Magnoliaceae), eine neue Magnolienart aus den hochmontanen Bergwäldern Sulawesis, sowie einen Bestimmungsschlüssel für alle zehn Arten der Gattung, die auf der Insel vorkommen. Eine weitere montane Art, *Elaeocarpus firdausii* (Elaeocarpaceae) aus der artenreichen und hauptsächlich australasiatischen Gattung *Elaeocarpu*s wird in Kapitel 2 beschrieben. Im dritten Kapitel, schlage ich fünf neue Arten der Gattung *Syzygium* (Myrtaceae) vor, einer der größten Gattungen holziger Pflanzen weltweit. Obwohl die Gattung weit verbreitet, artenreich und often ökologische dominant ist, bestehen beträchtliche Lücken in der Taxonomie von *Syzygium* auf Sulawesi; pflanzensystematische Arbeit ist daher dringend geboten. Die fünf neuen Arten sind *Syzygium balgooyi*, *Syzygium contiguum*, *Syzygium devogelii*, *Syzygium eymae*, and *Syzygium galanthum*.

In Kapitel 4 untersuche ich die Muster von Baumartendiversität, -endemismus und -zusammensetzung entlang von ökologischen Gradienten (Meereshöhe und Bodeneigenschaften). Ich zeige, dass die Artenvielfalt in Sulawesi zumindest auf Plotebene der anderer Regionen in Malesien ähnlich ist und dass sie linear mit der Meereshöhe abnimmt.

Über 25% der gefundenen Baumarten sind Neufunde für (Zentral-) Sulawesi oder unbeschriebene Arten; ein klarer Hinweis auf die mangelnde botanische Kenntniss über die Region. Der in dieser Studie gefundene Anteil endemischer Arten ist deutlich höher als Schätzungen vorheriger Arbeiten, vor allem in den höher gelegenen Waldgesellschaften. Die Waldgeschellschaften werden vor allem durch die Meereshöhe bestimmt und können in drei floristisch-verschiedene Höhenzonen eingeteilt werden; Bodeneigenschaften spielen im Vergleich zu Meereshöhe eine untergeordnete Rolle. Ich lege besonderes Augenmerk auf kleine, im-Unterstand-wachsende Baumarten; eine Gruppe, die in den meisten forstlichen oder botanischen Inventuren vernachlässigt wird, und hebe den bedeutenden Beitrag dieser Gruppe zum lokalen Baumartenpool hervor.

Angesichts von Sulawesi's geographischer Lage und geologischer Geschichte muss die Baumflora der Insel in einem weiteren räumlichen und zeitlichen Kontext betrachtet werden, der Asien und Australien beinhaltet. Daher weite ich den Blickwinkel in Kapitel 5 und betrachte das Darwinische Defizit, das unzureichende Wissen über die Evolutionsgeschichte der Baumarten Malesiens. Der zentrale Teil Malesien entstand in den letzten 20–25 Millionen Jahren und erst seitdem haben Pflanzenarten Malesien von Asien und von Australien aus besiedelt. Dieser Vorgang wird malesischer floristischer Austausch (Malesian Floristic Interchange) genannt. Ich habe meine Daten aus Zentralsulawesi und solche von publizierten Studien aus anderen malesischen Gebieten verwendet und die geographische Herkunft der Abstammungslinien aller Bäume in dem vereinten Datensatz mithilfe von phylogenetischen Studien und Fossilfunden ermittelt. Anschließend habe ich die relative Abundanz der aus Asien bzw. Australien stammenden Bäume pro Plot mit Umweltfaktoren in Verbindung gesetzt um zu zeigen, dass der Besiedlungserfolg malesicher Bäume stark von den zur Verfügung stehenden Habitaten bestimmt wird. Die Ergebnisse zeigen einen höheren Anteil australischer Baumarten und -individuen mit steigender Meereshöhe, auf ultrabasichem Gestein, und östlich der Wallace-Linie. Der Zusammenhang ist für Individuen stärker ausgeprägt, so dass montane Wälder und solche auf ärmeren Böden in Malesien meist von aus-Australien-stammenden Baumarten dominiert werden. Diese Muster stehen im Zusammenhang mit der klimatischen und biogeographischen Geschichte Malesiens und zeigen, dass Ähnlichkeiten der Umweltfaktoren von Quellen- und Senkenhabitaten zu einem großen Teil den Besiedlungserfolg während des malesischen floristischen Austausches bestimmt haben.

Zusammengefasst zeige ich, dass die Regenwälder Sulawesis eine artenreiche und einzigartige Baumflora aufweisen, die durch einen hohen Anteil im-Waldesinneren-wachsender, kleinwüchsiger Arten und Endemiten geprägt ist, von denen viele noch nicht entdeckt und beschrieben worden. Submontane Waldgesellschaften warden von asiatischen Baumabstammungslinien dominiert während die hochmontane Wäldern vor allem aus Bäumen australischen Abstammungslinien und vieler endemischer Arten zusammengesetzt sind. Obwohl diese hochmontanen Waldgesellschaften weniger artenreich als Tieflandregenwälder sind, haben sie daher einen hohen Wert für den Naturschutz. Gleichzeitig gehören sie nach wie vor zu den am wenigsten erforschten Ökosystemen in Malesien. Ich hoffe, dass ich mit dieser Dissertation unsere Wissenslücken über Sulawesi's Bäume und Wäldern verkleinern konnte, weise aber darauf hin, das seine systematische Inventur der Pflanzenarten sowie ihrer funktionellen Merkmale und phylogenetischen Verwandschaftsverhältnisse unabdingbar ist um unser grundlegendes Verständnis über biologische Diversitätsmuster in Sulawesi zu verbessern.

General Introduction

Threats and conservation of biological diversity

In the last century, human impact on the Earth has risen dramatically. There is increasing evidence that the effects of human activities are functioning at the same scale as geophysical forces and that these activities are driving the planet beyond planetary boundaries that have maintained stable conditions throughout the Holocene, i.e. the time in which human civilizations have developed (Steffen et al. 2011, Pachauri et al. 2015, Zalasiewicz et al. 2017). Now, in the Anthropocene, there is a real risk of passing planetary thresholds that would likely induce even more dramatic and potentially irreversible changes to Earth's biogeochemical cycles and ecosystems and severely affect human well-being (Rockström et al. 2009, Barnosky et al. 2012, Ripple et al. 2017, Steffen et al. 2018). Among the most important and threatened proposed planetary boundaries is biosphere integrity, the diversity of biological organisms and their functions, which ensures the continued functioning of ecosystems under changing conditions (Steffen et al. 2018). The present decline of biodiversity due to human activities occurs across taxa and biomes (May 2010, Maxwell et al. 2016, Ceballos et al. 2017, Lister and Garcia 2018, Sánchez-Bayo and Wyckhuys 2019). Analogous to other catastrophic periods of rapid biodiversity decline in Earth's history it has been termed the Earth's sixth mass extinction event (Barnosky et al. 2011, Pimm et al. 2014, de Vos et al. 2015, Ceballos et al. 2017). Major factors contributing to this decline are the large-scale destruction of natural habitats, extraction of resources, introduction of alien species, pollution, and climate change (Urban 2015, van Kleunen et al. 2015, Maxwell et al. 2016, Fadrique et al. 2018, Lister and Garcia 2018, Midolo et al. 2019, Sánchez-Bayo and Wyckhuys 2019).

To halt the biodiversity loss, the importance of conservation and sustainable use of existing species and ecosystems has long been acknowledged in multilateral treaties like the Convention on Biological Diversity or, more recently, the Aichi Biodiversity Targets. One of the difficulties to achieve those targets is the incomplete knowledge about biodiversity on Earth (Pimm et al. 2014). Even for a major relatively well-studied clade in the tree of life like the vascular plants, considerable knowledge gaps remain regarding the total number of plant species, their geographical distribution, population dynamics, and extinction threats (Brummitt et al. 2015, Meyer et al. 2015, Pimm and Joppa 2015, Pimm and Raven 2017). Large-scale efforts by the scientific community are underway to synthesize the scattered available information and make it publicly available in online databases (Kattge et al. 2011, Enquist et al. 2016, König et al. 2019, POWO 2019, The Plant List 2019, WCSP 2019, Weigelt et al. 2019, World Flora Online 2019). In addition, increasingly complex statistical models are able to deal with data gaps and still provide meaningful results about biodiversity patterns and species distributions (Kier et al. 2005, 2009, Raes et al. 2009, Jetz et al. 2012, Meyer et al. 2015, Keil and Chase 2019). Despite these efforts, real and problematic data gaps remain and these need to be tackled through interdisciplinary collaborations by taxonomists and plant ecologists (Gotelli 2004). For example, an estimated

15% of all plant species remains undescribed (Pimm and Raven 2017), calling for accelerated alpha-taxonomical work in herbaria (Bebber et al. 2010) and extensive field work, especially in underexplored regions (Wilson 2017).

Tropical hinterland regions as frontiers of biodiversity research

Plant diversity is not uniformly distributed across the globe. Most of it is concentrated in the tropics (Myers et al. 2000, Brummitt and Lughadha 2003, Kier et al. 2009, Pimm and Joppa 2015) and, in provides numerous essential contributions to the well-being of human populations from local to global levels (Díaz et al. 2018, Rasolofoson et al. 2018). At the same time, some of the biodiversity threats are also most severe in tropical regions due to rapid population growth and economic development (Sodhi et al. 2004, Maxwell et al. 2016, Nellemann et al. 2016, Ripple et al. 2017, Sánchez-Bayo and Wyckhuys 2019). Consequently, the majority of proposed global hotspots for the conservation of biodiversity are located in tropical regions (Myers et al. 2000). Unfortunately, biodiversity knowledge gaps are also most pronounced in the tropics. For example, most of the still undescribed plant species grow in tropical biodiversity hotspots (Joppa et al. 2011). More precisely, they are located in relatively inaccessible and therefore less-disturbed tropical forests (Giam et al. 2012, Tyukavina et al. 2015). As these tropical hinterland regions are being fragmented and degraded (Potapov et al. 2017), a large portion of the species inhabiting them will disappear before being known to science (Pimm et al. 2014). Tropical mountain forests (TMF) are among these biodiverse, yet least known ecosystems in the tropics (Myers et al. 2000, Homeier et al. 2010, Takeuchi 2010, Hoorn et al. 2013, Merckx et al. 2015, Peters et al. 2016). Both climate and soil conditions change markedly along mountain slopes, making them preferred objects of research on the drivers of plant diversity (Ohsawa et al. 1985, Aiba and Kitayama 1999, Culmsee and Pitopang 2009, Homeier et al. 2010, Culmsee et al. 2011, Culmsee and Leuschner 2013, Merckx et al. 2015). The close proximity of different habitats and organismic communities along the environmental gradients result in high levels of beta diversity, so that TMF also constitute some of the botanically richest landscapes on earth and have exceptionally high conservation values (Aldrich et al. 1997, Brummitt and Lughadha 2003, Richter 2008, Merckx et al. 2015).

Knowledge gaps about earth's biodiversity have been classified in seven main shortfalls, related to taxonomy (Linnean shortfall), geographical distribution (Wallacean), abundance and population dynamics (Prestonian), evolutionary relationships (Darwinian), ecological functions (Raunkiæran), tolerances to abiotic conditions (Hutchinsonian), and biotic interactions (Eltonian; Hortal et al. 2015). All of these shortfalls apply to varying degrees to TMF. In fact, besides being hotspots of diversity, the latter are also hotspots of botanical knowledge gaps. Therefore, biodiversity field studies in underexplored TMF are needed to fill crucial knowledge gaps about plant diversity (Wilson 2017).

Sulawesi – an understudied tropical region

Sulawesi, part of the island-nation Indonesia, is the world's 11th-largest island. It is located in the centre of the Indo-Australian Archipelago (Wallace 1863), usually referred to as Malesia in botanical research (Zollinger 1857, Raes and van Welzen 2009). The complex geological history of Sulawesi (Hall 2013, Nugraha and Hall 2017) has resulted in the islands particular shape, rugged topography (7% of the island's area lie above 1500 m; Culmsee and Leuschner 2013) and variety of different habitats. Since the initial studies of Alfred Russel Wallace (1869), Sulawesi has received attention by researchers because of its diverse fauna with a strong endemic element (e.g. Musser 1987, Michaux 2010, Stelbrink et al. 2012). The peculiar fauna reflects the island's position in the transition zone between Asian and Australian zoogeographical regions (Wallace 1876a, Kreft and Jetz 2013), called Wallacea. Wallacea, also including the Maluku Islands to the east and Lesser Sunda Islands (except Bali) to the south of Sulawesi, was included in the list of global biodiversity hotspots where conservation measures should be prioritized to minimize species loss (Myers et al. 2000). The hotspot is threatened by habitat loss due to mining activities and intensifying deforestation and Sulawesi is no exception (Hansen et al. 2013, Margono et al. 2014). However, Sulawesi still contains the largest tracts of relatively undisturbed forests in Wallacea, especially in mountain areas where access is more difficult (Cannon et al. 2007, Tyukavina et al. 2015).

While Sulawesi's fauna is reasonably well-known, botanical research has been lagging behind. Botanical exploration of the island started in the early 19th century mostly in the Minahasa region at the tip of the northern peninsula (Koorders 1898, Koorders-Schumacher 1914) and the region around Makassar in the southwest (Reinwardt and de Vriese 1856, Teijsmann 1879). In the 20th century, extensive collection trips all over Sulawesi were carried out by the Forest Research Institute ('Boschbouwproefstation') in Bogor (e.g. Bloembergen 1940, Eyma 1940) as well as others (Schlechter 1925, Kjellberg and Christensen 1933) . Renewed interest in the 1970s lead to botanical expeditions in the central part of the island (Meijer 1983, Balgooy and Tantra 1986). Since then, several botanical expeditions by Herbarium Bogoriense, Kebun Raya Bogor, and international partner institutions have increased the number of collected specimens but only part of the material has been studied in detail (e.g. Powling et al. 2016). The first plot-based plant inventories were conducted by different botanists within the framework of the Indonesian-German interdisciplinary research project STORMA in the area of Lore Lindu National Park (LLNP) in Central Sulawesi (Pitopang et al. 2004, Kessler et al. 2005, Culmsee and Pitopang 2009, Cicuzza et al. 2010, Culmsee et al. 2011, Willinghöfer et al. 2011, Culmsee and Leuschner 2013), providing quantitative, spatially explicit data including species abundance and allowing more general conclusions about diversity patterns on the island. Nevertheless, Sulawesi remains one of the most underexplored tropical regions worldwide today resulting in insufficient knowledge about its flora (Vogel 1989, Cannon et al. 2007, Culmsee and Pitopang 2009, Culmsee et al. 2011) Particularly, there is still a lack of quantitative data including species' distributions, abundances and functions. Also, despite the large proportion of montane habitats in Sulawesi, there has never been a concerted effort to study the montane flora and vegetation as for example in Borneo (Beaman and Beaman 1990, Beaman et al. 1992, Kitayama 1992, 1992, Aiba and Kitayama 1999, Merckx et al. 2015) or New Guinea (Richards and Suryadi 2002, Richards 2007, Utteridge and Edwards 2009, Takeuchi 2010, Richards and Gamui 2011).

Study outline

With this thesis, I aim to contribute to a better ecological understanding of the TMF in Sulawesi by closing knowledge gaps about their tree species diversity, composition, endemism, and biogeographic context. The study builds on previous research on plant ecology and diversity in Central Sulawesi's Lore Lindu National Park (Keßler et al. 2002, Kessler et al. 2005, Culmsee 2008, Culmsee and Pitopang 2009, Culmsee et al. 2010a, Berg and Culmsee 2011, Culmsee et al. 2011) and is mainly based on field work using plot-based tree inventories. Other important methods used were the morphology-based identification of plant specimens with taxonomic literature and reference collections in herbaria and an extensive literature survey on the evolutionary history of Malesian tree species. Each of the five chapters of this thesis aims to bridge specific shortfalls of biodiversity knowledge, as defined by Hortal et al. (2015):

Chapters 1–3 tackle the Linnean shortfall, the insufficient taxonomic knowledge about Earth's species, by proposing and describing seven new tree species in three families from Sulawesi based on material collected during the plot-based tree inventories. Correct species identification provides the basis for analyses of different dimensions of biodiversity. While for some measures (e.g. taxonomic alpha diversity and species composition), naming of species is not a necessity, the usefulness of un- or incompletely named datasets is limited. Correctly assigned species names allow to connect the individuals of a study to the accumulated information of previous and future work, including data on distribution, ecology, traits, and biotic interactions while incorrect or missing identifications may distort found diversity patterns (Dexter et al. 2010, Baker et al. 2017). The description of new species may therefore be a necessary precursor to further research on ecology and biogeography, as presented in Chapters 4–5. In particular, in Chapter 1 I describe a species of *Magnolia* endemic to montane forest of Sulawesi and belonging to the relatively well-studied and economically important family Magnoliaceae. I also provide a field identification key to the ten *Magnolia*-species occurring on Sulawesi. Chapter 2 includes the description of the new species *Elaeocarpus firdausii* (Elaeocarpaceae), also endemic to high mountain forests. Chapter 3 deals with the extremely species-rich and often ecologically dominant genus *Syzygium* (>1200 species). Only about 15% of *Syzygium* species expected to occur in Sulawesi have been formally described (Syzygium Working Group et al. 2016). I propose five new species of *Syzygium*, all endemic to the island.

In Chapter 4, I deal with the Wallacean, Prestonian, and Hutchinsonian shortfalls, i.e. the inadequate knowledge about species' geographic distributions and abundances, and abiotic tolerances by investigating patterns of tree species diversity, composition, and endemism along gradients of elevation and soil properties in TMF of Central Sulawesi. I put special emphasis on understorey trees species, a guild that is often neglected in standard forest or biodiversity inventories. More than one quarter of the reported tree species present new occurrence-records for (Central-) Sulawesi or undescribed species. I show that forest communities are mostly determined by elevation and can be grouped into three floristically distinct elevational belts whereas soil characteristics play only a minor role. Furthermore, I demonstrate that the diversity of tree communities in Sulawesi's forest harbour is comparable to that of other Malesian regions and that diversity declines with elevation while higher elevation forests contain higher proportions of endemic species. Lastly, I highlight the important contribution of understorey tree species to local species diversity.

In Chapter 5, I widen the scope beyond Sulawesi to address the Darwinian shortfall, the incomplete insight into the evolutionary history of species. Sulawesi belongs to Wallacea, the transition zone between the Asian flora to the west and the Australian flora in the southeast. The region was only formed in the last 23 My as a result of the collision of the Asian and Indo-Australian tectonic plates and plants have colonized Wallacea since then from either of the two continents in a process termed the Malesian Floristic Interchange. As the rest of Malesia, Wallacea is considered to have a predominantly Asian flora, indicating asymmetric colonization, but this assumption is based on studies with coarse datasets that have mostly not taken into account species' abundances and differing environmental conditions. I combine my dataset from Central Sulawesi with other published studies along environmental gradients in Malesia and conduct an extensive literature review to infer the geographic origin of the lineages of all tree individuals in the combined dataset based on phylogenetic and fossil information. Afterwards, I relate the relative abundance of Asian versus Australian trees to environmental parameters and geographic location to show that proportionally more Australian tree species and individuals occur in Malesia (1) at higher elevations, (2) on sites over ultramafic parent material, and (3) closer to their source region Australia with a significant drop at Wallace's line. The trend is stronger for tree individuals than for species meaning that montane forests and those on poor soils in Malesia are mainly dominated by Australian tree-lineages. I discuss these pattern in the context of the climatic and biogeographic history of Malesia and highlight that environmental similarities between the source and sink habitats have largely determined the colonization success during the Malesian floristic exchange, a pattern that has also been suggested for the mixing of North and South American biotas during the Great American Biotic Interchange.

1 *Magnolia sulawesiana* described, and a key to the species of *Magnolia* (Magnoliaceae) occurring in Sulawesi

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1.1 Abstract

Magnolia sulawesiana is described as new species and a modified key of *Magnolia* subsect. *Elmerrillia* is included. In addition, a new key of the eleven *Magnolia* species occurring in Sulawesi is provided based on vegetative characters for easy identification in the field.

1.2 Introduction

Currently, 36 species of *Magnolia* are known to occur in Malesia, 25 of which are endemic to the region (WCSP 2019). The family has been thoroughly studied in Malesia in comparison with many other tree families (Keng 1978a, Nooteboom 1985, 1987, 1988, Kim et al. 2001). Taxonomic and phylogenetic studies using both morphological (Keng 1978a, Figlar 2000, Li and Conran 2003) and molecular data (Shi et al. 2000, Azuma et al. 2001, Kim et al. 2001, Nie et al. 2008) have challenged traditional generic concepts and relationships and modified the positions and circumscriptions of many taxa within the subfamily *Magnolioideae*. As a result, former segregate genera like *Manglietia*, *Michelia* and *Elmerrillia* have been reduced to taxa at infrageneric level in broadened *Magnolia* (Figlar and Nooteboom 2004) reflecting phylogenetic relationships. The former genus *Elmerrillia* Dandy, which was initially reduced to a section of the genus *Magnolia* by Figlar (2000), is currently treated as a subsection in *Magnolia* section *Michelia* (L.) Baill., based largely on its morphological characters – flowers that usually arise terminally on brachyblasts as in *Michelia* sensu stricto –, but differs slightly by its sessile gynoecium and introrse anther dehiscence. However, recently both nuclear and cpDNA sequences have shown subsection *Elmerrillia* taxa to be embedded within the *Michelia* sensu stricto clade (Azuma et al. 2001, Kim et al. 2001, Nie et al. 2008) rather than forming a separate sub-clade. Thus, the subsectional status for this group is now in doubt.

Sulawesi is the largest island of the geologically complex insular region termed Wallacea. While levels of biodiversity and endemism are high (Myers et al. 2000), Sulawesi's flora remains poorly known and botanical collections are sparse compared to the other major Malesian islands (Frodin 2001). The results of recent intensive tree inventories for ecological studies in montane areas of Central Sulawesi have highlighted the deficiencies in the taxonomic and distribution data for Sulawesi (Culmsee and Pitopang 2009, Berg and Culmsee 2011, Culmsee et al. 2011). Due to their size, valuable timber and the potential use as ornamentals, Magnolias are likely to be well represented in botanical collections. However, only recently *Magnolia utilis* (Dandy) V.S.Kumar, a species otherwise known to occur in Continental Southeast Asia and Borneo, was recorded in Sulawesi's Southeast Peninsula for the first time (Wen & Kartonegoro 10261, 10276; BO, US). In the course of our above-mentioned tree inventory studies in montane forests of Sulawesi, we now discovered a new *Magnolia* species of subsection *Elmerrillia*, which is – to our present knowledge – endemic to the island. Here, we describe the new species and place it in existing keys. In addition, we provide a new key of the eleven known *Magnolia* species of Sulawesi based on vegetative characters for easy identification in the field. For the construction of the keys, in addition to our own observations and specimens from Sulawesi, herbarium specimens were studied in the National Herbarium of the Netherlands (L, U), Herbarium Bogoriense (BO) and Herbarium Celebense (CEB).

1.3 Species description

Magnolia sulawesiana Brambach, Noot. & Culmsee, sp. nov*.*

urn:lsid:ipni.org:names:77135717-1 Figures 1.1, 1.2

Prope *M. tsiampacca* (L.) Figlar & Noot. et *M. platyphyllam* (Merr.) Figlar & Noot. subsectionis *Elmerrillia* (Dandy) Figlar & Noot. speciebus ceteris in petioli sulco superiore tantum pilis villosis plus minusve persistentibus et folii pagina inferior in lineis angustis proxime iuxta costae utrinque laterem, gynoecio 8--12 carpellis differt. – Type: *Brambach et al. 1334* (flowers; holo L 3 sheets; iso BO, CEB), Indonesia, Province of Central Sulawesi (Sulawesi Tengah), Poso Regency, Lore Tengah District, Lore Lindu National Park, Mount Dali (S 01.700°, E 120.150°), 1950 m, 23 Jan 2012.

Evergreen *trees* of tropical montane rain forest, up to 35 m tall and 100 cm diameter. *Bark* grey-brown, fissured, lenticellate, of mealy texture, flaking off in large, irregular plates on older trees, inner bark yellow, turning orange upon contact with air.

Twigs monopodial, proleptic, glabrous, c. 2–3 mm in diameter in the distal internodes; slightly flattened, more so at the nodes, innovations glossy green (reddish brown when dry), soon becoming darker green (darker brown when dry), with dispersed, conspicuous white lenticels; bark on older twigs silver-grey with fine longitudinal cracks.

Stipules amplexicaul, free from the petioles, yellowish green (reddish brown when dry), glabrous, cigar-shaped, flattened and usually twisted, becoming up to 6 cm long, caducous, leaving white contrasting annular scars.

Leaves glabrous except for a line of brown (pale when dry), erect, villous hairs running through the adaxial petiole groove to about the middle of the abaxial side of the leaf blade on both sides of the midrib, conspicuous in young leaves, glabrescent but often some hairs persistent; spirally arranged, usually oblong, elliptic or (narrowly) obovate (rarely narrowly ovate), the midrib arching downwards, V-shaped in cross section (midrib usually distorted when dry), (5–)6–9(–11) by (2.5–)3–4.5(–6.5) cm, ratio (1.6–)1.9–2.2(–2.4), margin entire, revolute, not thickened; base rounded to obtuse (to acute), slightly asymmetric, apex rounded to obtuse (to acute), with a short triangular, usually contorted acumen (c. 1–3 mm); coriaceous shiny green above (pale greenish-brown to reddish-brown when dry), paler beneath, (darker, golden-brown to chestnut when dry); midrib flat and narrow above, round and strongly prominent beneath, yellowish-green on both sides (concolorous with leaf blade above, chestnut and darker than leaf blade beneath when dry), running up to the very tip, there often forming a tiny, inconspicuous mucro; lateral veins (13–)15–18(–20) per side, not very conspicuous, diverging at moderate to wide angles, running straight, ± parallel, rarely branching, intersecondary veins rarely present, irregularly looping near the margin, concolorous and slightly impressed above, the surface minutely bullate, contrasting darker green and not prominent beneath (concolorous and clearly prominent on both surfaces when dry); 3rd order venation subscalariform to reticulate, not very distinct from the reticulate 4th order venation, colour and prominence similar to lateral veins but slightly less prominent. Petioles (0.9–)1.1–1.7(–2.1) cm long, tapering towards the apex, concolorous with the young twigs, on the adaxial side a narrow groove with brown (pale when dry) hairs.

Flowers bisexual, glabrous, solitary, terminal on brachyblasts. Brachyblasts sylleptic in the axils of normal foliage leaves (or leaves vestigial); 40–55 by 1–2 mm at anthesis, clavate, in colour and texture similar to young twigs; consisting of three internodes, the proximal two of which of ± equal length, the distal one reduced, so the flower sessile; one spathaceous bract at each node, adnate to vestigial, inconspicuous petioles, outside concolorous with the brachyblast, withering yellowish-brown and splitting in two before being shed, inside golden brown when dry (not seen fresh). Tepals 12, free, spathulate, white (dry: chestnut), subequal, in two whorls: outer 3 similar, c. 20 by 7 mm, inner 9 successively becoming narrower, innermost ones c. 18 by 3 mm. Stamens c. 12, filaments c. 1mm long, anthers creamy-yellow (chestnut when dry), linear, bifacially flattened, arching inwards, c. 8 mm long, bisporangiate, introrse, opening by two longitudinal slits along their whole length, connective rounded to subacute, c. 0.5 mm long. Gynoecium sessile, covered by the stamens at anthesis, carpels 8–11, spirally arranged on the receptacle, ± ovoid, fresh green with white lenticels (dry: black), the styles minutely curved outwards.

Fruit irregular, 1–2.5 cm long, fruiting carpels concrescent in developing fruit, finally free, only 2–3 of them developing seeds, dehiscing along the dorsal suture, falcate midrib sometimes persistent. Seeds not seen.

1.3.1 Additional specimens

Brambach et al. 0109 (from same tree as type, flower buds and fruits; BO 2 sheets; CEB 2; GOET 2; K 2; L 2), Indonesia, Province of Central Sulawesi (Sulawesi Tengah), Poso Regency, Lore Tengah District, Lore Lindu National Park, Mount Dali (S 01.700°, E 120.150°), 1950 m, 27 – 31 Mar 2011.

Culmsee 2581 (flower buds and young fruits; CEB 2, GOET, L); *Culmsee 2945* (sterile; CEB, GOET); *Culmsee 3153* (sterile; GOET); *Culmsee 3154* (sterile; L), all from: Indonesia, Province of Central Sulawesi (Sulawesi Tengah), Sigi Regency, Nokilalaki District; Lore Lindu National Park, Mount Nokilalaki (S 01.243°, E 120.153°), 1900 m, Aug 2007.

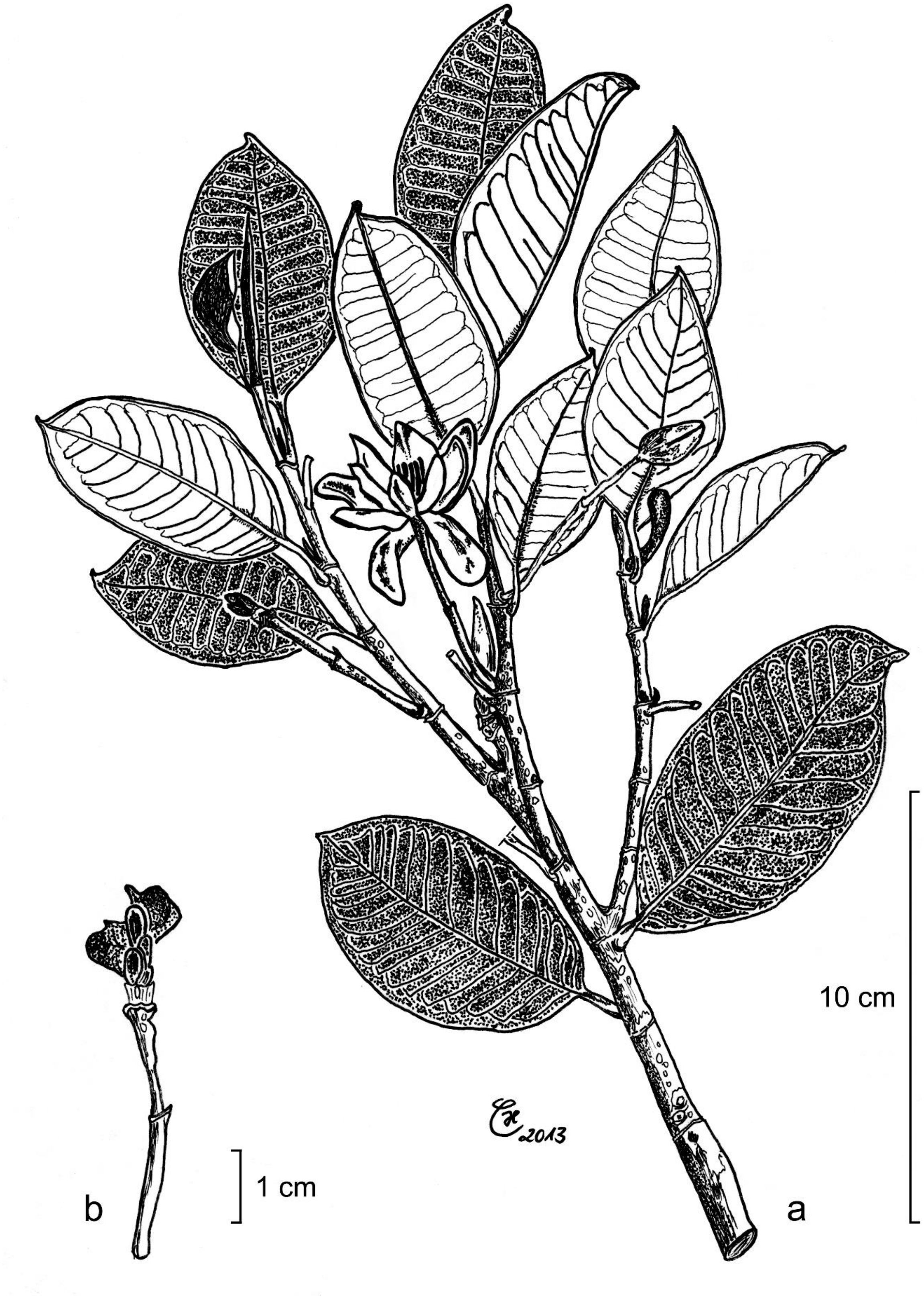

Figure 1.1 *Magnolia sulawesiana* Brambach, Noot. & Culmsee. **a**. Leafy twig with flowers in four different development stages: flower buds (1st and 2nd to the right), open flower (middle) and young fruit after petals shed (left); **b**. ripe fruit (a. *Brambach et al.1334*, b. *Brambach et al. 0109*).

Netherland Indies Forest Service (NIFS) bb 23355 (sterile; L, BO), Indonesia, Province of South Sulawesi (Sulawesi Selatan), Masamba Regency, Boschafdeeling Salotoradja, ± 2200 m, 21 Oct 1937.

Sabir et al. B2 109 (sterile; CEB), Indonesia, Province of Central Sulawesi (Sulawesi Tengah), Sigi Regency, Nokilalaki District, Lore Lindu National Park, Mount Nokilalaki, 1600 m, Apr – May 2008.

1.3.2 Distribution

Endemic to Sulawesi according to the present state of knowledge; recorded from the central part of Sulawesi (Provinces of Central Sulawesi and South Sulawesi) between elevations of 1600–2200 m. In Lore Lindu National Park it has been found at two sites, Mount Nokilalaki (at 1600 and 1900 m a.s.l.) and Mount Dali (at 1950 m a.s.l.). The third collection site is located in the Regency of Masamba at 2200 m a.s.l. (exact location unknown). The known area of distribution spans a range of c. 100 km in N–S direction (Figure 1.2).

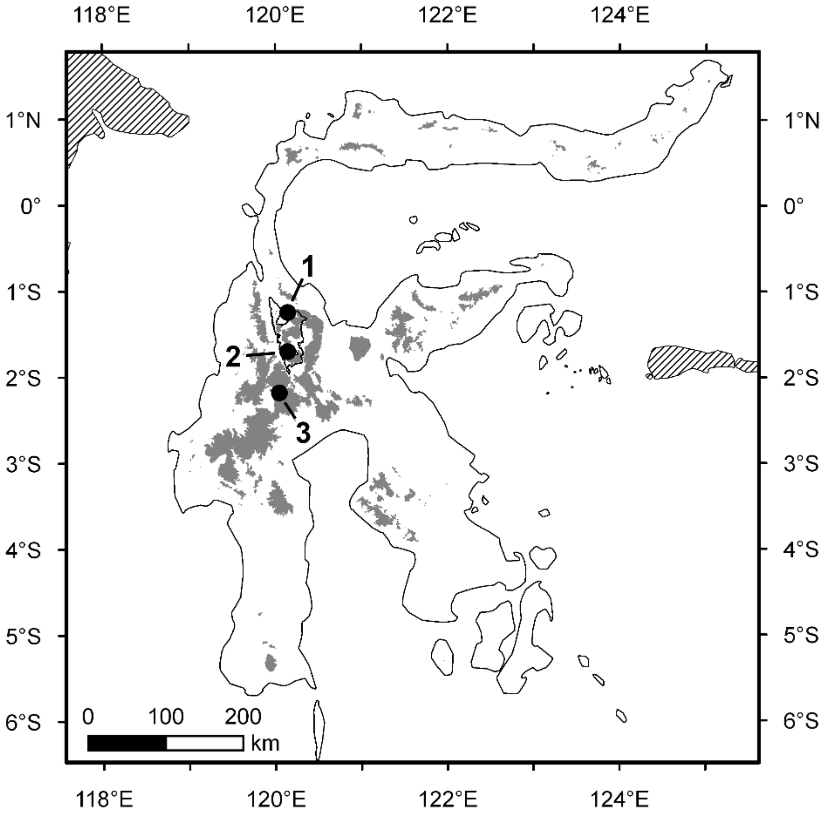

Figure 1.2 Map of the known occurrences of *Magnolia sulawesiana* Brambach, Noot. & Culmsee in the central part of Sulawesi. 1. *Culmsee 2581*, *2945*, *3153*, *3154*; 2. *Brambach et al. 0109*, *1334*; 3. *NIFS bb 23355* (approximate location). Collection sites 1 and 2 are located within Lore Lindu National Park (bold black line). Grey areas indicate montane elevations ≥1500 m a.s.l.

1.3.3 Ecology

Large, canopy forming trees of primary, ever-wet, montane forests growing on gently sloping ridges over granite-derived soils. At Mount Nokilalaki (1900 m a.s.l.), *M. sulawesiana* is co-dominant in a *Fagaceae* and *Myrtaceae* forest. At Mount Dali, it occurs together with *M. carsonii* Dandy ex Noot. var. *carsonii* (see below for discussion of infraspecific taxonomy). and *M. liliifera* (L.) Baill. var. *liliifera* in a forest dominated by *Fagaceae*, *Myrtaceae* and conifers. Flowering was observed in January, March and August; fruiting in March.

1.3.4 Conservation status

The three collection localities of the species all lie within the mountain range of the central part of Sulawesi. Since the area is little explored botanically, and *M. sulawesiana* can be locally abundant (see Ecology), we expect the species to occur more widely within the mountain range. The land area of Sulawesi lying above 1500 m a.s.l. is ca. 13,600 km² (calculated in Quantum GIS Version 1.8.0 using SRTM data from Jarvis et al. 2008). Forest condition in these upland areas is so far mostly good to old-growth (Cannon et al. 2007), but pressure on the montane forests has increased during recent years where access was possible and is expected to intensify further. Based on these indications we propose a preliminary conservation assessment of Near Threatened (NT).

1.3.5 Notes

M. sulawesiana belongs to subsection *Elmerrillia* and is most similar to *M. tsiampacca* var. *tsiampacca* and *M. platyphylla* from that subsection. It differs from both species by its far fewer carpels (8–11 vs. > 20). It can also be distinguished from the sympatric *M. tsiampacca* var. *tsiampacca* by its usually smaller, oblong leaves which, as the rest of the tree, are completely glabrous except for the distinctive line of hairs that starts in the groove on the upper petiole side and continues on the lower surface of the leaf blade along a narrow line on each side of the midrib. The leaves of *M. platyphylla* are completely glabrous, much larger and do not have the close reticulation of *M. sulawesiana*. The species is also superficially similar to *M. carsonii* Dandy ex Noot. var. *drymifolia* Noot. of subsection *Maingola* because of its small, coriaceous, densely reticulate leaves. The former can be distinguished from the latter by the flowers with narrow white tepals on axillary brachyblasts (vs. terminal flowers with oblong tepals, the outer ones green, the inner ones yellow), its almost complete glabrousness, and the leaves with green lower surfaces (vs. glaucous) and more numerous lateral veins (13-20 vs. 6–12).

The sterile specimen *NIFS bb 23355* (see Additional Specimens) was the only known record of *M. carsonii* var. *drymifolia* from Sulawesi. However, it is clearly a representative of *M. sulawesiana*. The distribution of the former taxon thus now remains restricted to Thailand, Sumatra, Borneo and possibly the Philippines (Palawan).

The name *Magnolia vrieseana* from inventory plot Nokilalaki (N1), published by Culmsee et al. (2011; Appendix species no. 33) is hereby corrected to *Magnolia sulawesiana*.

1.4 Keys to species of *Magnolia* subsection *Elmerrillia* (section *Michelia*)

The species can be accommodated in the key of Nooteboom (1988). Names were adapted according to Figlar & Nooteboom (2004).

1.4.1 Key based on characters of flowers and fruits

1. Tepals 12. Carpels concrescent during development, becoming free at dehiscence.........2
1. Tepals (12–)17. Carpels concrescent during development, remaining that way, forming a syncarp or becoming free at dehiscence.........4

2. Twigs and stipules hairy.........*M. tsiampacca*
2. Twigs and stipules glabrous.........3

3. Leaves large (>20 cm long). Carpels > 20. Plant completely glabrous. Philippines ....*M. platyphylla*
3. Leaves small (<12 cm long). Carpels <12. Plants with hairs in the adaxial petiole grooves and next to the midrib on the lower leaf surfaces. Sulawesi.........***M. sulawesiana***

4. Undersurface of leaves glaucous (sometimes a dense indumentum of adpressed hairs obscuring the glaucousness), hairy (in New Guinea sometimes glabrous: var. *glaberrima).* Fruiting carpels free, dorsally dehiscing. Borneo, Sulawesi, Maluku, New Guinea.........*M. tsiampacca*
4. Undersurface of leaves not glaucous, glabrous or hairy. Fruiting carpels concrescent 5

5. Twigs glabrous or yellowish villous, ± soon glabrescent, rarely pubescent. Nerves in (10–)14–21 pairs. Sulawesi, Maluku.........*M. vrieseana*
5. Twigs densely fulvously pubescent or tomentose, later glabrescent. Nerves in 20–24 pairs. Philippines (Mindanao).........*M. pubescens*

1.4.2 Key based on fruit characters

1. Carpels thickly concrescent, forming a syncarp, ripe carpels shedding their apical parts..2
1. Carpels thinly concrescent, becoming free when ripe and longitudinally dehiscing..........3

2. Young twigs and stipules glabrous or yellowish villous, ± soon glabrescent, rarely pubescent. Nerves in (10–)14–21 pairs. Sulawesi, Maluku.........*M. vrieseana*
2. Twigs densely fulvously pubescent or tomentose, later glabrescent. Nerves in 20–24 pairs. Philippines (Mindanao).........*M. pubescens*

3. Carpels < 12. Sulawesi.........***M. sulawesiana***
3. Carpels > 20.........4

4. Twigs and leaves glabrous. Brachyblast glabrous. Philippines.........*M. platyphylla*
4. Twigs and leaves glabrous or hairy. Brachyblast hairy (except rarely in New Guinea: var. *glaberrima*). Borneo, Sulawesi, Maluku, New Guinea.........*M. tsiampacca*

1.5 Key to the species of *Magnolia* occurring in Sulawesi

The following key does not differentiate between the two varieties of *M. carsonii* found in Sulawesi, *M. carsonii* var. *carsonii* and *M. carsonii* var. *phaulanta* (Dandy ex Noot.) S.Kim & Noot. As Nooteboom (1988) already pointed out, the two are very similar, possibly conspecific, and can only be differentiated by quantitative characters. The difference in leaf size (Kim et al. 2002) could not be confirmed for specimens from Sulawesi and Borneo present in the collections in L and BO, leaving slight differences in flower size (cluster of perianth and stamen scars 2–3 mm vs. c. 1 mm long) as the only separating character. We therefore prefer to treat all collections from Sulawesi as *M. carsonii* var. *carsonii*.

M. angatensis is only known from one, sterile collection on Talaud Island (Lam 3121, L), midway between the north-eastern tip of Sulawesi and the Philippine island of Mindanao. Distinction between the many forms of *M. liliifera* and *M. angatensis* based on sterile material is nearly impossible. We do not treat the latter species separately in the key, because it would key out together with *M. liliifera*.

The key is mostly based on vegetative characters for easy identification in the field. Information on distribution (geography and elevation) is based on available material (from CEB, GOET, L and U). All species known to occur on the island of Sulawesi and surrounding minor islands (e.g. Kabaena, Buton, Sangihe and Talaud) as defined in Brummitt (2001) are included. It is intended to work for specimens from Sulawesi and may not cover intraspecific variation found on other Malesian islands. Leaf measurements are given for mature trees unless indicated otherwise; young trees and adventitious shoots may have larger leaves.

See Appendix 1.1 for complete binomials with author names.

1. Stipules adnate to the petiole. In older or fallen leaves visible by a scar on the upper side of the petiole..2
1. Stipules free. Petioles without a scar on the upper side..6

2. Young twigs, stipules and peduncles glabrous or with minute adpressed hairs (hardly visible with a handlens. Stipule scar about one third to half the length of the petiole. Leaves elliptic to obovate, 9—25 cm long, base cuneate. Flowers terminal on leafy twigs...3
2. Young twigs, stipules and peduncles usually conspicuously hairy (rarely glabrous, but hairs sometimes lost). Stipule scar about half to the full length of the petiole. Flowers terminal on leafy twigs or on axillary short shoots...4

3. Stipule scar clearly less than half the length of the petiole (rarely half the length). Twigs and stipules glabrous or with minute adpressed hairs (hardly visible with a handlens). Stipule scar ¼ to 1/3 of the petiole length. Fruits ellipsoid or ovoid, only slightly longer than wide, Carpels opening first along the ventral suture. Widespread, 1000–1500 m ....*M. sumatrana* var. *glauca*
3. 3. Stipule scar 1/3 to half the petiole length. Fruits cylindrical, 2–3 times as long as broad. Carpels opening first along the dorsal suture. C- and SE-Sulawesi, rare, 800–1200m...*M. utilis*

4. Leaves c. 9–22 cm long, lanceolate, the widest part of the blade always beneath the middle. Petiole base not or only slightly thickened. Young twigs with numerous conspicuous white lenticels. Branching monopodial, internodes evenly spaced, flowers terminal on axillary short shoots. Cultivated, 0–1000 m........*M. champaca* var. *champaca*

4. Leaves c. 9–42 cm long, narrowly elliptic to elliptic (to oblanceolate), the widest part of the blade close to the middle or above it. Young twigs with few, dark, or no lenticels. Branching sympodial, internodes often conspicuously varying in length along twigs. Flowers terminal on normal leafy twigs. Occurring naturally, 0–2000 m............................5

5. Young twigs, stipules and underside of leaf blades woolly hairy, the hairs curled like pigs' tails, coming off in patches, usually ± persistent on midrib and lateral veins of leaf undersurfaces. N peninsula of Sulawesi, once recorded at 150 m........................*M. villosa*
5. Young twigs, stipules and underside of leaf blades glabrous or silky hairy, the hairs, if present, adpressed and straight (sometimes mixed with minute curled hairs), persistent or not. Widespread and variable, 0–2000 m..*M. liliifera* var. *liliifera*

6. Young twigs and stipules hairy on the outside (or twigs glabrous, but then stipules at least hairy outside at the very tip. Most leaves > 15 cm long. Carpels > 40 per flower. Widespread and common, 0–1300 m..7
6. Young twigs and stipules completely glabrous on the outside. Most leaves 3–12 cm long. Carpels < 20 per flower. Central part of Sulawesi, 750--2200 m...8

7. Leaves narrow oblong, narrow ovate or lanceolate (index 2.2–4.2). Leaf undersurface glaucous, densely adpressed hairy (sometimes hairs very small and hardly visible with a handlens). Young twigs and stipules usually with short (≤ 1 mm long), adpressed hairs. Mature fruits with free carpels, each carpel opening by a longitudinal slit. 0–1300 m ....*M. tsiampacca* var. *tsiampacca*
7. Leaves (ob-)ovate to elliptic (index 1.7–2.3, in juveniles often oblanceolate). Leaf undersurface not glaucous, glabrous, with scattered short hairs, or with long, curled hairs. Young twigs and stipules glabrous except for the stipule tip or with long (c. 2 mm), yellow hairs. Mature fruits with carpels united, the outer parts breaking off in irregular masses. 0–1100 m..*M. vrieseana*

8. Leaves completely glabrous, chartaceous to thin-coriaceous, lateral veins 8–15 per side. Young twigs with few or no lenticels. Flowers terminal on leafy twigs, appearing leaf-opposed due to sympodial vegetative growth. 1200–2000 m.......*M. carsonii* var. *carsonii*
8. Leaves with a line of hairs in the adaxial petiole groove and on the leaf undersurface on both sides of the midrib (hairs lost in older leaves), otherwise glabrous, coriaceous, lateral veins 13–20 per side. Young twigs conspicuously lenticellate. Flowers on axillary brachyblasts (rarely terminal). 1600–2200 m...***M. sulawesiana***

2 *Elaeocarpus firdausii* (Elaeocarpaceae), a new species from tropical mountain forests of Sulawesi

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2.1 Abstract

Based on ongoing ecological research in mountain forests of Sulawesi, a new species, *Elaeocarpus firdausii* Brambach, Coode, Biagioni & Culmsee, sp. nov. is described and illustrated from mossy forests at > 2000 m and information provided on the species' distribution, ecology and pollen morphology. *Elaeocarpus firdausii* is similar to *E. luteolignum* Coode but differs from the latter in having glabrous terminal buds, leaves with black gland dots, 4-merous, larger flowers, and more numerous stamens.

2.2 Introduction

Elaeocarpus is the largest genus of the Elaeocarpaceae, comprising approximately 350 species in the Old World tropics and subtropics (excluding mainland Africa), from Madagascar and Mauritius in the west, to Japan in the north, Australia and New Zealand in the south and Polynesia including Hawai'i in the east (Coode 2004, Baba 2013). The greatest number of species is found in the Malesian region and taxonomic work on these is currently under way.

Some progress has been made in understanding infrageneric groupings: Already in the early 20th century, Schlechter (1916) defined several sections for Papuasia, most of which still stand. Raymond Weibel worked on the whole genus, and made suggestions for sectional groupings, mostly in unpublished manuscripts at the Conservatoire in Geneva, copies of which have been put at the disposal of MC. In West Malesia (Sumatra, Peninsular Malaysia, Java, and Borneo), almost all species can be allotted to six major, morphologically defined groups. The "*Polystachyus* group" (Coode 1996c) is endemic to that area, while sect. *Acronodia* (Blume) Mast. (Coode 1996b) extends into the Lesser Sunda Islands. In Central and East Malesia, relationships are much less clear, although four of the groups from West Malesia are also represented here: sect. *Elaeocarpus* (Coode and Weibel 1994, Coode 1996a), sect. *Ganitrus* (Gaertn.) Brongn. & Gris (Coode 2010), sect. *Monocera* Mast. (Coode 2001c, 2007, 2014), and sect. *Coilopetalum* Schltr. (Coode 1978, 2001a).

Coode (1995) published 10 new species for Sulawesi. In this paper he drew attention to the contrast between Sulawesi and neighbouring Borneo: In Sulawesi, fewer species of *Elaeocarpus* are present (c. 70 in Borneo vs. c. 35 in Sulawesi), but they belong to a greater number of groups

(6 in Borneo vs. ≥ 8 in Sulawesi). In addition to the four widespread groups mentioned above, three more with a more Eastern distribution are found: sect. *Dactylosphaera* Schltr. (Coode 1978) , distributed from Sulawesi to New Guinea, sect. *Fissipetalum* Schltr. (Coode 1978, 2001b), from Sulawesi to Australia, and sect. *Oreocarpus* Schltr. (Coode 1978, 1984), which extends from the Philippines to Australia. Yet other species appear to be endemic, although their placement in any of the groups based on morphology has so far not been achieved. Coode (1995) suggested that some of these species from Sulawesi might be related to the *Polystachyus* group in Borneo.

Work on DNA samples at the Australian Tropical Herbarium (ATH), James Cook University in Cairns (e.g. Baba 2013), has established a molecular phylogenetic framework, within which, well-supported species-level relationships are beginning to emerge (Darren Crayn, ATH, personal communication).

Many of the recently described *Elaeocarpus* species from Sulawesi grow in montane forests above c. 1500 m (Coode 1995, 1996a, 2001a). Lore Lindu National Park (LLNP) is the protected area covering the largest portion of montane environments on the island. It is located within the large, contiguous upland area that occupies most of the central part of Sulawesi roughly between the city of Palu and the central part of the Southern peninsula (Fig. 1). We will refer to this area as Central Sulawesi Mountains (CSM) throughout the manuscript.

Recent research on tree diversity and composition in LLNP (Culmsee and Pitopang 2009, Culmsee et al. 2011) has improved our knowledge of the flora and vegetation of Sulawesi's mountain forests. The continued research and new fieldwork in 2011–2012 have yielded material for 17 species of *Elaeocarpus*. One of them could not be assigned to any previously published species and is therefore proposed as new here.

2.3 Methods

2.3.1 Morphological observations

The relevant published identification keys for *Elaeocarpus* (Coode and Weibel 1994, Coode 1995, 1996a, 1996c, 2001a, 2001b, 2007) have been consulted, as well as herbarium collections of B, BO, GOET, K and L (herbarium acronyms follow Thiers (continuously updated): http://sweetgum.nybg.org/science/ih/) and online databases of digitized herbarium specimens (JSTOR 2015, RBG Kew 2015, Wieringa 2015). We also recorded the character states of our specimens in a DELTA matrix (Dallwitz et al. 2010) for *Elaeocarpus* in Malesia developed and maintained by MC. Most specimens of *Elaeocarpus* from the Malesian region in K and L have been seen by MC during his work on the genus over the last decades, so relatively few specimens remain unnamed. Our description is based solely on the material gathered during our (FB and HC) fieldwork in Central Sulawesi in 2011–2012, as no further matching specimens were found in herbaria. All our specimens were collected from permanently tagged trees in inventory plots. Duplicates of relevant specimens, including the type, were deposited in the

Indonesian herbaria BO and CEB. All specimens seen by us for the description of the new species are marked with an exclamation mark in the present paper.

For the description, we boiled up flowers in dilute detergent for 5 minutes and dissected them afterwards. Dimensions were measured using a ruler with 0.5 mm accuracy. All colours and measures given refer to dried and pressed material unless stated otherwise. Photographs were taken in the field using a Canon EOS 500D camera with a Tamron AF 18-200mm f/6.2-38 lens.

Wood density (oven-dry mass per fresh volume) was determined from three wood cores extracted with increment borers and belonging to the specimens Brambach et al. 0721, 0973, and 2041, respectively. The samples' fresh volume was measured by Archimedes' principle and weight was noted from the same samples after oven-drying for 48h at 105°C.

2.3.2 Pollen morphology

One closed flower bud (from the specimen Brambach et al. 2041) was processed for the description of the pollen morphology. The pollen grains were treated following standard Erdtman's acetolysis method (Erdtman 1960, Faegri et al. 1989). The samples were mounted on permanent slides with Kaiser's glycerol gelatine and the slides were analysed under a Nikon Eclipse H550L photomicroscope at a magnification of 100×. Descriptions of the pollen grains were compiled following the terminology defined by Punt et al. (2007). The shape was described based on the measurements of the ratio between polar axis (P) and equatorial diameter (E) in equatorial view. Size values are based on a total of 10 grains measured, means are shown with minima and maxima in parentheses.

2.3.3 Conservation Assessment

With only three known collection localities (see "Distribution" below), a meaningful calculation of the extent of occurrence (EOO) and area of occupancy (AOO) (IUCN Standards and Petitions Subcommittee 2017) as basis for the conservation assessment is not feasible. We, therefore, attempted to estimate the extent and location of potential habitats for the proposed species based on its known habitat preferences. For that, we used the CGIAR digital elevation model (Jarvis et al. 2008) in QGIS (QGIS Development Team 2015) to quantify land areas in Sulawesi above the elevation threshold of 2000 m. We defined this threshold based on our field observation of a marked and easily observable transition from mid-montane to upper montane (mossy) forest around this elevation. The proposed new species has so far only been recorded in upper montane forest at > 2000 m elevation (see "Habitat" below). We then assessed the forest condition at elevations ≥ 2000m using data from Cannon et al. (2007) and only used areas classified as "good" or "old-growth" by them for further analysis. As the proposed species has so far been recorded in the CSM and possibly the Eastern peninsula of Sulawesi, we also excluded all upper montane areas from the Northern and Southeastern peninsulas and the tip of the Southern peninsula (Figure 2.1). The resulting potential habitats were used for the calculation of the extent of occurrence (EOO) and area of occupancy (AOO, grid cell size of 2 × 2 km) following the recommendations of IUCN Standards and Petitions Subcommittee (2017).

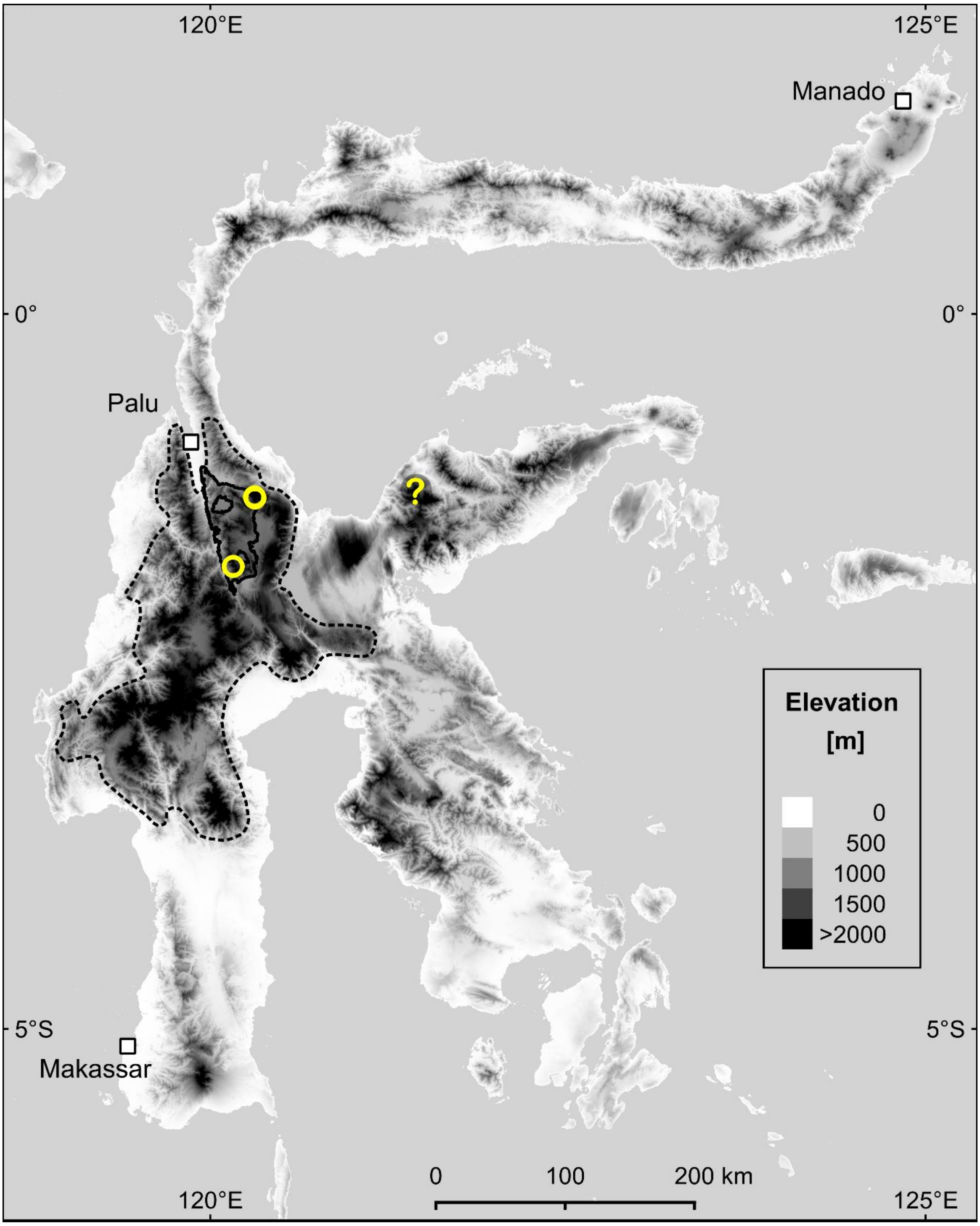

Figure 2.1 Map of known occurrences of *Elaeocarpus firdausii* in Sulawesi. Collecting localities are shown as yellow circles: Mt Rorekautimbu and Mt Malemo, both in Lore Lindu National Park (solid black line). The record on Mt Katopas on the Eastern peninsula (?) is based on a sighting without specimen. Most of the montane environments on the island are concentrated in the Central Sulawesi Mountains (CSM, dashed black line) stretching from near Palu into the Southern peninsula. Areas above 2000 m a.s.l. are shaded black.

2.4 Species description

Elaeocarpus firdausii Brambach, Coode, Biagioni & Culmsee, sp. nov.

urn:lsid:ipni.org:names:77153914-1 Figures 2.1, 2.2, 2.3, 2.4

2.4.1 Diagnosis

Similar to *Elaeocarpus luteolignum* Coode, but differing from that species in glabrous (vs minutely adpressed-hairy) terminal buds and young twigs, leaf blades with black gland dots (vs leaf blades without dots), 5-merous (vs 4-merous) flowers, larger flowers (e.g. sepals 5–8 × 1.5–2.5 vs 3–4 × 1.5 mm) and more numerous stamens (29–31 vs 20).

2.4.2 Type

INDONESIA. Central Sulawesi (Sulawesi Tengah): Lore Lindu National Park, Kabupaten Poso, Kecamatan Lore Utara, 7.7 km NNE of village Sedoa, Mt Rorekautimbu, tree-inventory plot "Bulu Torenali", 1°17.2'S, 120°18.7'E, 2350 m, 21–24 Apr 2012: Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1953 (flowers; holotype: K, 2 sheets, [K000720760]!, [K000720898]!; isotypes: BO (BO 1926842)!, CEB, L [L.2055441]!).

2.4.3 Description

Trees 8–25 m tall, dbh ≤ 40 cm, without buttresses or stilt roots, flowering when full-grown. Outer bark reddish brown, verrucose; inner bark pinkish with white streaks, granular, innermost layer yellow, easily detachable from wood, wood cream to white.

Twigs glabrous, strongly angulate at first, later terete, twig bark longitudinally cracking, forming a net-like pattern, with large conspicuous leaf scars and many prominent lenticels, gummy-resinous where cut, 2.5–4.0 mm thick towards the tip, with gummy-resinous, glabrous terminal buds. Stipules caducous, linear-subulate to narrow-triangular, glabrous, often gummy, 1.5–5.0 mm long, tapering, entire.

Leaves spirally arranged, loosely to ± tightly grouped towards twig tips in older trees, in juveniles often scattered, appearing in flushes, leaves of one flush ± equal in size. Fresh leaves brownish-red when young, later dark green with contrasting paler midrib above, much lighter green and with contrasting darker green venation and the sometimes red midrib beneath, dying red. Petioles 2–14 mm long, 1–3 mm thick, glabrous or almost so, sometimes verrucose when mature, often longitudinally finely striate, usually flat in apical third above, sometimes rounded or slightly channelled above, distinct from or merging into decurrent leaf base (variable within a specimen), pulvinous or not on both ends, without pegs at apex, sometimes with elongate glands at the junction of petiole and lamina-margin, geniculate. Blades chartaceous to coriaceous, mostly oblong-obovate, some oblong-elliptic or obovate, 2.1–4.0 times as long as wide, (5–) 6–13 (–15.5) × 1.5–5.0 (–6.5) cm, acute to obtuse (80–110°) to rounded at apex, the very tip notched and with a (sometimes fused) pair of black glands, cuneate at base or tapering towards a broadly cuneate base (the larger leaves more narrowly cuneate), occasionally rounded, surface sometimes bullate, dull and glabrous above, glabrous or sometimes with some short adpressed hairs on the midrib beneath when young and then soon glabrescent, glabrous and not verrucose beneath when mature, with minute black gland dots on both sides. Midrib darker than lamina, prominent but widened and flattened towards base above, strongly prominent beneath, with 8–16 pairs of main lateral veins, diverging at 60–80° from midrib, straight for most of their length or curved, breaking up 3/4 to 7/8 inside margin, looping forward and mostly joining up; usually with intermediate veins in between, ± prominent and of same colour as or paler than lamina above and below, higher-order veins reticulate, obscure or ± clear and raised above and below, of same colour as lamina, areoles squarish, < 2 mm across, domatia absent. Margins ± entire to weakly glandular-serrate, sometimes less serrated in lower half, the teeth 2–11 mm apart, glands present regardless of serration, 0.5 mm long, spindle- or claw-shaped, sometimes elongate along margin, black.

Inflorescences in the axils of current leaves, solitary, racemose, ± of same length as subtending leaf, 3–8 cm long, axis angular, 1.2–1.5 mm thick at about halfway, with sparse, short, straight hairs between adpressed and spreading, 5–9-flowered.

Flowers bisexual, 5-merous (once 6-petalled), spiral or almost whorled on inflorescence, bracts early caducous, not seen, pedicels 6–18 mm long and 0.5–1 mm thick in flower, bent downwards and thickened at apex, buds ovoid, acute at apex. Sepals 5–8 × 1.5–2.5 mm, cream-coloured when fresh, not verrucose and ± pale adpressed-sericeous outside, densely white-velutinous next to the margins inside, otherwise short-sericeous inside but glabrous in the basalmost 1.5 mm, keeled inside for whole length. Petals thick and opaque, ivory-coloured on account of the hairs when fresh, oblong, parallel-sided almost to base, rounded to a narrow (1 mm wide) base, 6.5–7.5 mm long, 2.0–2.5 mm wide at widest point of limb, rounded at apex and divided into 9–12 narrow-triangular apical divisions 0.3–1.0 mm long, divisions unequal in length and grouped into lobes and acute at tip, not verrucose in dried material, densely white-sericeous outside, margins velvety or densely short-hairy throughout, densely short-hairy inside except for glabrous patch near base, with a low, narrow keel inside running for most of limb length, ± flat at midpoint and flat at base, without any infolding of margins. Disk golden when fresh, ± annular, 10-toothed, 0.5–0.8 mm high, densely covered with short, straight, golden hairs. Stamens 29–31, inserted in a ± single ring between disk and ovary; filaments 0.6–1.8 mm long, straight to somewhat incurved tapering from base to apex, glabrous or with a few minute hairs; anthers 1.6–2.5 mm long, khaki when fresh, minutely hairy, with outer tooth clearly much longer than inner and with a beak 0.2–0.5 mm long, beak glabrous or with a few minute hairs without setae at tip. Ovary placed above the disk, shape clearly narrowed at base, 2.0–2.5 mm long, densely short- to medium-hairy, 2–3-locular; ovules 8–12 per locule; style 2.5–3.5 mm long, stout, tapering to a point, glabrous except for the very base.

Fruits unknown.

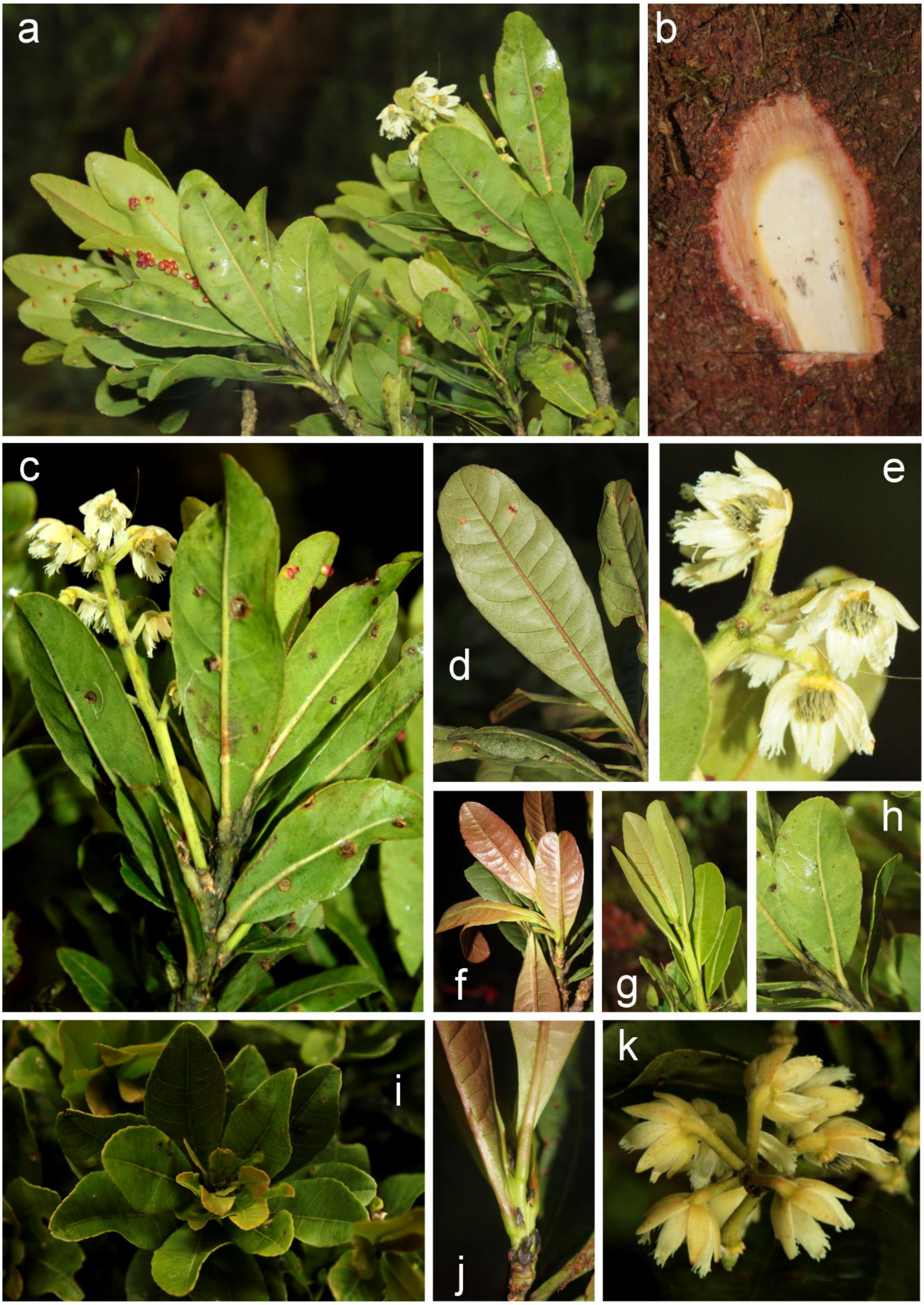

Figure 2.2 *Elaeocarpus firdausii*. **a** branch with leaves and flowers (note red leaf-galls); **b** bark slash; **c** branch apex with inflorescence; **d** underside of mature leaf; **e** flowers with golden disc and grey anthers; **f** reddish-brown young leaves; **g** green young leaves; **h** underside of mature leaf; **i** clustered arrangement of leaves; **j** young twig with stipules; **k** flowers on apically bent pedicels. a, c, e, g–i and k from the type collection (*Brambach et al. 1953*); b, d, f and j from *Brambach et al. 2041*.

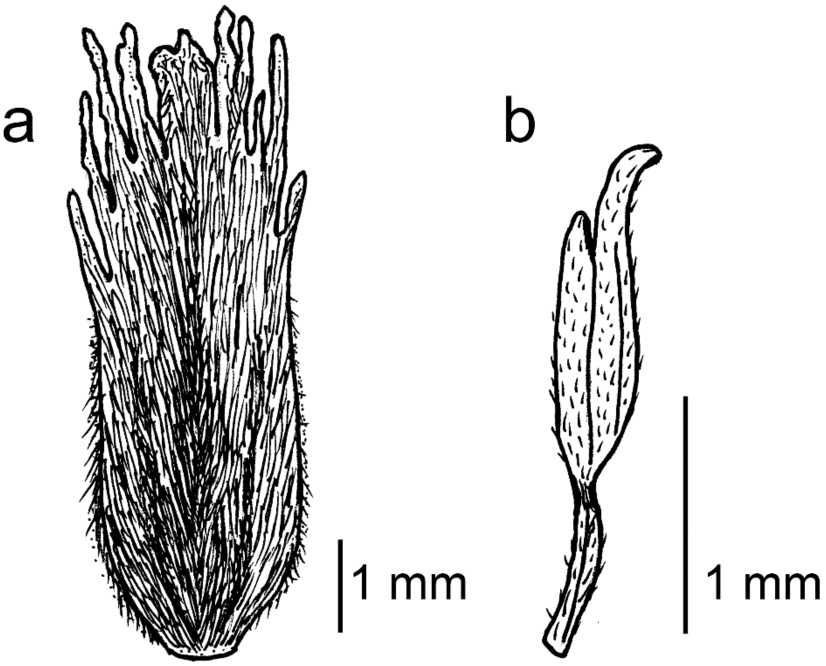

Figure 2.3 Flower details of *Elaeocarpus firdausii*. **a** petal with hairy outer surface and apical divisions; **b** stamen with clearly longer outer anther-tooth to the right. Drawing by Heike Culmsee from Brambach et al. 1953 (isotype, L!).

2.4.4 Phenology

Flowering was observed in April. No fruiting was observed.

2.4.5 Pollen morphology and dimorphism

The pollen of *E. firdausii* is dimorphic as two distinct morphological pollen grains were observed in the sample. The most common one is a 3-aperturate pollen grain, typical of the family Elaeocarpaceae (Coode 2004). The second, less common (4%), type presents a 2-aperturate morphology and it is clearly distinguishable from the first (Figure 2.4). The two pollen types are described as follows:

3-colporate type (Figure 2.4a–b):

Prolate spheroidal to spheroidal pollen grains; outline in polar view (amb) rounded semi angular; psillate; P/E: 1.0 (0.9–1.1); polar axis (P): 12.2 (11.2-13.3) µm; equatorial axis (E): 11.9 (10.4-13.1) µm; apocolpium index 3–4 µm. Colpi 7.1–11.2 × 1–2 µm long with indistinct ends. Endoaperture lalongate, c. 1 µm in diameter. Exine c. 1 µm thick, sexine as thick as nexine.

2-colporate type (Figure 2.4c):

Outline in polar view (amb) circular-elliptical; equatorial axis (E): 11.6 (10.5–12.7) µm. Remaining characteristics as the 3-colporate type.

So far, only one other case of pollen dimorphism has been documented for the genus *Elaeocarpus* (Huang 1972). In *E. firdausii*, the low percentage (ca. 4%) of the 2-colporate type as compared to the 3-colporate suggests the former is an aberrant morphology, possibly associated with hybridism as reported in other species (e.g. Bhowmik and Datta 2012).

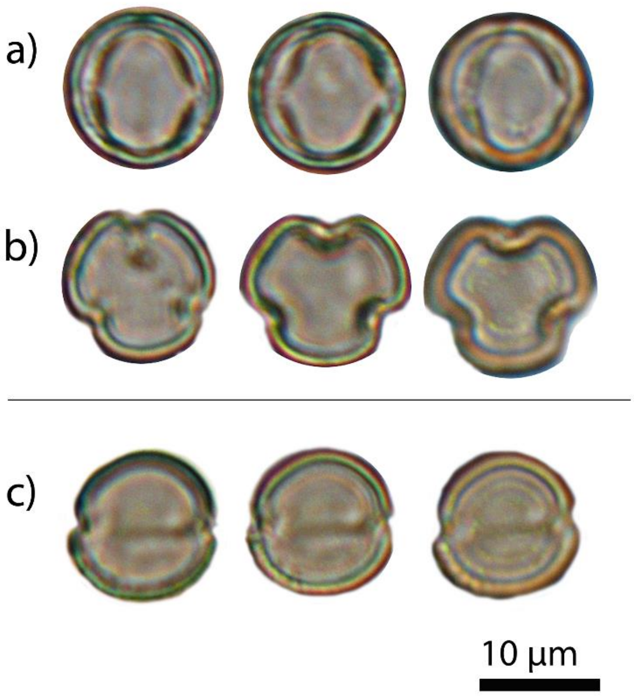

Figure 2.4 Pollen of *Elaeocarpus firdausii*. **a** the 3-colporate pollen type in equatorial view; **b** same in polar view; **c** the 2-colporate pollen type in polar view.

2.4.6 Distribution

Endemic to the central part of Sulawesi. The species is so far recorded with certainty from Mt Rorekautimbu and Mt Malemo at elevations from 2150 to 2400m (Figure 2.1). Both mountains are located within LLNP. During our ecological fieldwork, we recorded *E. firdausii* in all three inventory plots at > 2000 m, although with rather few individuals at each site. Because of its apparent association with a distinct habitat (upper montane or mossy forest above c. 2000 m) and the general lack of information from montane habitats in Sulawesi, we consider it very likely that *E. firdausii* occurs in many of the upper montane forests of the CSM (Figure 2.1).

FB observed a sterile sapling matching all vegetative characters of *E. firdausii* on Mt Katopas, c. 130 km east of the other two sites (1°12.7'S, 121°26.0'E, 2450 m, 6 Sep 2014), indicating a possible occurrence on Sulawesi's Eastern peninsula (Figure 2.1, question mark).

2.4.7 Habitat

Based on the morphological information available *E. firdausii* is a regular component of upper montane (mossy) forests, where its individuals can form part of the canopy. These forests occur from c. 2000 m upwards in the LLNP area and are easily distinguished because of the dominance of conifers (Podocarpaceae, mostly *Dacrycarpus imbricatus* (Blume) de Laub. and *Phyllocladus hypophyllus* Hook.f.). They have a thick layer of epiphytic mosses and ferns on trunks and branches of the trees, ± abundant undergrowth, c. 20 m tall canopies with emergents reaching > 30 m and large amounts of dead wood. The soils are characterized by excess of moisture and heavy accumulation of organic matter. They were classified as Folic Gleysols, Folic Histosols and Folic Cambisols according to the WRB classification (IUSS Working Group WRB 2014). Dominant families besides conifers include Myrtaceae (e.g. *Syzygium* spp., *Xanthomyrtus angustifolia* A.J.Scott), Fagaceae (e.g. *Lithocarpus havilandii* (Stapf) Barnett), Paracryphiaceae (e.g. *Quintinia apoensis* (Elmer) Schltr.), and other Elaeocarpaceae (e.g. *Elaeocarpus steupii* Coode, *E. teysmannii* Koord. & Valeton subsp. *domatiferus* Coode).

2.4.8 Etymology

The specific epithet honours our colleague Firdaus Dg. Matta (born 1984), formerly with Herbarium Celebense in Palu, Sulawesi, who collected the type specimen and contributed greatly to the success of our fieldwork with his skills in plant collection and identification.

2.4.9 Conservation status

Based on the locations of the estimated potential habitat for *E. firdausii* we calculated an EOO of 58 534 km^2 and an AOO of 5 760 km^2. The latter is presumably an overestimate as not all potentially suitable sites will necessarily be occupied by the species. Nevertheless, occurrence over a relatively wide range is plausible, given the large distance (c. 55 km) between two of the collection sites. It is thus unlikely that either EOO or AOO will fall below the thresholds of criteria B1 or B2 for IUCN category VU (IUCN 2012). While deforestation is an ongoing threat to Sulawesi's forests, upper montane forests are usually less affected because of their remote locations and difficult access (Cannon et al. 2007). Hence, we do not consider habitat destruction or exploitation by humans as an imminent threat to population levels. Given (1) the uncertainties in the estimated EOO and AOO and (2) the recommendation to use a precautionary attitude in conservation assessments (IUCN Standards and Petitions Subcommittee 2017), we propose a preliminary extinction risk assessment of "Near Threatened" (NT) following the IUCN Red List Categories and Criteria (IUCN 2012).

2.4.10 Notes

Based on the morphological information available, *E. firdausii* is probably related to *E. luteolignum*, *E. gambutanus* Coode and *E. linnaei* Coode; this assemblage may be sister to the *Polystachyus* group from Western Malesia.

In addition to the morphological differences between *E. firdausii* and *E. luteolignum* mentioned in the diagnosis above, according to our present knowledge there are differences in habitat preference: *E. firdausii* occurs in mossy forest at higher elevations while *E. luteolignum* is known from lower to mid-montane forest dominated by Fagaceae at 1200–1800 m (Coode 1995).

Both observations in the field and examination of dried specimens show that there are morphological differences between smaller understorey plants and mature canopy-forming individuals. The former have less-clustered, longer, thicker and relatively narrower leaves with more clearly bipulvinate petioles, less-rounded tips and more clearly serrate margins. We do not know whether these differences are related to age or rather to environmental factors, e.g. stronger radiation and transpiration in the canopy. Seedlings have even narrower leaves but the very short petioles are only swollen at the base. Conspicuous cup-shaped leaf galls or their presumed scars (Figure 2.2) were present in all collected specimens. All sepals and petals have a glabrous patch at the base of the otherwise hairy inner surface. These glabrous portions are apparently pressed against the 10-lobed disc before anthesis. Wood density, based on three specimens, varied from 0.45–0.56 g/cm³.

2.4.11 Specimens examined

Accession numbers are given in parentheses, barcode numbers in square brackets. Barcodes of specimens in K and L link to specimen records in the respective databases (RBG Kew 2015, Wieringa 2015).

INDONESIA. Central Sulawesi (Sulawesi Tengah), Lore Lindu National Park:

Kabupaten Poso, Kecamatan Lore Utara, 8.7 km NNE of village Sedoa, Mt Rorekautimbu, tree-inventory plot “Rorekautimbu”, 1°16.7'S, 120°18.6'E, 2400 m:

> Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0721 (18–30 Jul 2011, sterile, BO (BO 1926844)!, CEB, GOET [GOET014481]!, K [K000720899]!, L [L.2055437]!);
>
> Culmsee H 2152 (Aug–Sep 2007, sterile, GOET [GOET014482]!).

Kab. Poso, Kec. Lore Utara, 7.7 km NNE of village Sedoa, Mt Rorekautimbu, tree-inventory plot “Bulu Torenali”, 1°17.2'S, 120°18.7'E, 2350 m, 21–24 Apr 2012:

> Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 2041 (flowers, BO (BO 1926843)!, CEB, GOET [GOET014478]!, K [K000720902]!, L [L.2055436]!);
>
> Mangopo H, Firdaus, Brambach F 11 (seedling, L [L.2055440]!).

Kab. Sigi, Kec. Kulawi Selatan, 7.7 km ENE of village Moa, Mt Malemo, tree-inventory plot “Tutu Malemo”, 1°45.9'S, 120°09.6'E, 2150 m, 18–23 Oct 2011:

> Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0937 (sterile, CEB, GOET [GOET014480]!);
>
> Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0998 (sterile, CEB, K [K000720900]!, L [L.2055438]!),
>
> Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1026 (sterile, CEB, L [L.2055439]!),
>
> Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1028 (sterile, CEB, GOET [GOET014479]!, K [K000720901]!).

3 Five new species of *Syzygium* (Myrtaceae) from Sulawesi, Indonesia

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3.1 Abstract

Following ongoing ecological research on the tree diversity of the Indonesian island of Sulawesi, we describe five new species of *Syzygium*. These are the first descriptions of *Syzygium* species from the island since Blume (1850, *Jambosa celebica* and *J. cornifolia*), highlighting the significant lack of taxonomic research on the genus for the region. The five species proposed as new are *Syzygium balgooyi* sp. nov., *Syzygium contiguum* sp. nov., *Syzygium devogelii* sp. nov., *Syzygium eymae* sp. nov., and *Syzygium galanthum* sp. nov. All species are illustrated and information on their distribution, ecology, and conservation status is given.

3.2 Introduction

The botanical diversity of the Indonesian island of Sulawesi is poorly known and remains one of the least studied in Southeast Asia (Vogel 1989, Cannon et al. 2007). The *Checklist of woody plants of Sulawesi* by Keßler et al. (2002), the most comprehensive taxonomic work for the island, highlighted how numerous taxonomic groups were in need of specialist systematic work. Myrtaceae and the largest genus in the family, *Syzygium* P.Browne ex Gaertner (1788, 166), were in particular emphasised because only four species of *Syzygium* were recorded in the checklist while approximately 350 un-named collections were listed. Several species now accepted as belonging to *Syzygium* were listed under other generic names in the checklist, such as *Acmena* de Candolle (1828, 262) and *Eugenia* Linnaeus (1753, 470), which further underscores the complex history of the genus.

Syzygium is the most species rich genus of woody plants in Southeast Asia with around 1000 species but little is known of the genus in Wallacea, the biogeographically important transition zone between the Asian and Australian continental areas. As in the other Wallacean regions, the Maluku Islands and Lesser Sunda Islands, the *Syzygium* species of Sulawesi have never been revised or monographed so there is no robust baseline data of which species occur in the region. The last *Syzygium* species to be described from Sulawesi were by Blume (1850) under the generic name *Jambosa*: *J. celebica* Blume and *J. cornifolia* Blume. The occurrence of other, mostly widespread species of *Syzygium*, have been noted over time and resulted in 14 species recorded from Sulawesi at present (WCSP 2019). This number is unrealistically low when considering *Syzygium* diversity in neighbouring regions: Java holds c. 60 species; Borneo, the Philippines, and New Guinea c. 200 species each (WCSP 2019). In fact, recent extensive examination of herbarium material suggests that Sulawesi harbours > 100 species, the great majority of them yet unnamed (Syzygium Working Group et al. 2016).

Species of *Syzygium* are present in virtually all ecosystems of Sulawesi, and are often important components of the biological communities (Balgooy and Tantra 1986, Whitten et al. 1987, Milliken and Proctor 1999, Culmsee et al. 2010a), so the lack of taxonomic resolution presents a serious impediment for a better understanding of ecological processes as well as for conservation efforts on the island.

In 2006–2007 and 2011–2012, the University of Göttingen, Germany, and Tadulako University, Palu, Indonesia conducted ecological fieldwork campaigns in Lore Lindu National Park (LLNP), Central Sulawesi. Difficulties in the identification of *Syzygium* specimens collected during these surveys motivated us to take a closer look at the taxonomy of the genus. Fortunately, the area of LLNP had been visited before by other botanists (Bloembergen 1940, Meijer 1983, Balgooy and Tantra 1986), so good fertile collections for comparison were available in herbaria. Five species could not be matched with previously published taxa and are here proposed as new. This is the first time in > 165 years that species of *Syzygium* are described from Sulawesi.

3.3 Methods

3.3.1 Morphological Observations

The specimens collected during our ecological fieldwork in LLNP (HC, 2006–2007; HC and FB, 2011–2012) were the starting point for this study. Duplicates of relevant specimens, including types, were deposited in L and the Indonesian herbaria BO and CEB (herbarium acronyms follow Thiers, continuously updated: http://sweetgum.nybg.org/science/ih/). To identify our specimens, all *Syzygium* specimens from Sulawesi at A, B, BM, BO, E, GH, K, L, M and U were examined and all matching specimens sorted into morphospecies. We then attempted to identify our morphospecies using keys and floristic treatments from regions around Sulawesi: The Malay Peninsula (Henderson 1949), Borneo (Merrill and Perry 1939, Ashton 2011), Java (Amshoff 1963), the Philippines (Robinson 1909, Elmer 1914, Merrill 1915, 1921, 1951, Pelser et al. 2011), New Guinea (Diels 1922, 1924, Merrill and Perry 1942, Hartley and Perry 1973), and Australia (Hyland 1983). Because *Syzygium* is such a species-rich genus, we had to repeat this process several times to make sure we did not miss any species our specimens could be matched with. All specimens examined by us are marked with an exclamation mark. We recorded morphological characters of all cited specimens to produce the species descriptions using the package *monographaR* (Reginato 2016) in R (R Core Team 2016).

Photographs in the field were taken using a Canon EOS 500D camera with a Tamron AF 18-200mm f/6.2-38 lens, for later photographs of dried material we used the same camera with a Tamron SP 90mm F/2.8 MACRO lens. Colours of dried specimens were compared to Munsell Soil-Color Charts (Munsell Color 2010) and colour names used accordingly.

Wood density (oven-dry mass per fresh volume) was determined from wood cores extracted with increment borers. The samples' fresh volume was measured by Archimedes' principle and weight was noted from the same samples after oven-drying for 48h at 105°C.

For the descriptions, flowers and fruits were boiled in dilute detergent for 5 minutes and dissected thereafter. Dimensions were measured using a ruler with 0.5 mm accuracy. All colours and measures given refer to dried and pressed material unless otherwise stated. We measured the distance of intramarginal veins from leaf margin in the proximal 2/3 of the blade; it usually decreases towards the apex. Likewise, we measured the distance of secondary veins in the central ½ of the leaf; it decreases near the base. Dimensions of flower buds are given including the anthopodium, those of the hypanthium excluding the anthopodium (if present).

3.3.2 Terminology

Terminology for organs in *Syzygium* has been varied and often confusing, with authors using different terms for the same structures or similar terms for different structures.

We here adopt the detailed concepts of Briggs and Johnson (1979) on inflorescence structure but use more common terms instead of their rather technical vocabulary: bract instead of *pherophyll* and bracteole instead of *prophyll/ metaxyphyll*. We follow Briggs and Johnson (1979) in using the term *anthopodium* for the internode between the flower and its subtending bracteoles. This structure has been referred to as pseudopedicel (Schmid 1972) or pseudostalk(Henderson 1949), but Briggs and Johnson (1979) convincingly argued that it is indeed the last internode below the flower and coined the term anthopodium to avoid further confusion. The concept has been adopted by Hyland (1983) who, however, used the more common term pedicel. The anthopodium may be elongated or not; in the latter case the flowers are sessile, although they may appear stalked when arising from elongated higher-order axes of the inflorescence. Otherwise we follow the terminology of Beentje (2012) and Hyland (1983) except for using *hypanthium* instead of *calyx tube*.

3.3.3 Presentation of data

Since several specimens found in herbaria contained very limited information about the respective collecting localities, we interpreted the locality data of all specimens cited in this paper and translated it into a common format. The format contains approximate coordinates in WGS 84 (if not given on the label), the nearest village, and the administrative divisions in descending order: Province, Kabupaten (Kab., Regency), and Kecamatan (Kec., District).

Specimens collected in Sulawesi by the Forest Research Institute Buitenzorg (Bogor), also called Boschproefstation or Boschbouwproefstation (van Steenis-Kruseman and van Welzen 2014), often bear confusing information about the respective collectors. The original herbarium labels for these collections (usually deposited in BO) give the actual collector with a personal collection number and in addition the institutional *bb*- or *Cel.*-number. Duplicate labels usually only contain the institutional number and either read Neth. Ind. For. Service or Boschproef station as collector. We cite these specimens as NIFS (Netherlands' Indies Forest Service) with the respective institutional number.

In the diagnoses, we give floral formulas for each species, following the format and recommendations of Prenner et al. (2010). Furthermore, we apply Appropriate Citation of Taxonomy (Seifert et al. 2008) throughout the manuscript.

Under Distribution and Habitat, we characterised the forest stands of the species which were found primarily in our (FB and HC) inventory plots by mentioning the families with the five highest family importance values (FIV). The FIV is an objective measure of importance of a family in a stand taking into account the number of individuals, number of species, and basal area of that family and comparing them to the stand total (see Mori et al. 1983 for a detailed description of the method).

3.3.4 Conservation Assessment

We used GeoCAT (Bachman et al. 2011) to calculate the extent of occurrence (EOO) and area of occupancy (AOO) of each species as basis for the conservation assessments following the recommendations of IUCN Standards and Petitions Subcommittee (2017).

3.4 Results

All species here described are glabrous in all parts and possess flower characters placing them in the broadly defined *Syzygium* subg. *Syzygium* (Craven and Biffin 2010): anther sacs parallel and opening by longitudinal slits, placentation axile-median. The species of which we have seen fruiting material furthermore have seeds without intrusive tissue interlocking the cotyledons and free cotyledons, conforming with subgenus *Syzygium* as well. These characters are not mentioned again in the species descriptions.

3.4.1 *Syzygium balgooyi* Brambach, Byng & Culmsee, sp. nov.

urn:lsid:ipni.org:names:60474721-2 Figures 3.1, 3.2, 3.8.

"Eugenia spec. BB" (Koorders 1898, 173, 459, Koorders-Schumacher 1914, 95).

„Myrtaceae sp. 10" p.p. (Culmsee and Pitopang 2009, see also 2017 (Erratum), Culmsee et al. 2011).

3.4.1.1 Diagnosis

Syzygium balgooyi is characterised by long, elongate-clavate flowers, a character otherwise only known from the morphologically similar *Syzygium schumannianum* (Nied.) Diels (1922, 402) from New Guinea and the Maluku Islands. *Syzygium balgooyi* differs from that species by its smooth (vs prominently longitudinally ridged) hypanthium and fruit and by the hypanthium rim which remains entire after anthesis (vs apically splitting into 4 recurving lobes). Floral formula B1 Bt2 K4* C4* A∞* Ĝ(2)┼ Vx∞.

3.4.1.2 Type

INDONESIA. South Sulawesi (Sulawesi Selatan), Kab. Luwu Timur, Kec. Nuha, Between Soroako and Nickel plant site, c. 2°33'S, 121°22'E, 500 m, 10 Jul 1979: *van Balgooy 3956* (flowers; holotype L [L.2517558]! [spirit collection L 0771145] [wood sample L 0708624], isotype A [A01143212]!).

3.4.1.3 Description

Trees, up to 37 m tall, diameter at breast height ≤ 65 cm, trunk straight, ≤ 20 m tall, often fluted and with buttresses ≤ 3 m tall and 1 m out. Outer **bark** pale brown to bright red, peeling off in small or large sheets, inner bark dark red, usually paler towards inside, sometimes with little watery red sap, wood very hard and heavy, sapwood cream, clearly separated from the dark reddish brown heartwood. Young **branchlets** 1–2 × 1.5–4 mm, strongly flattened, the flat sides usually with two lateral, rounded ridges leading to the petioles and one central ridge continuing into the next internode, often resinous when dry, epidermis green, drying dusky red to reddish black and usually smooth; becoming terete, bark drying red to dark reddish brown, finely flaking and with conspicuous flaking remnants of epidermis.

Leaves (sub-)opposite. Petioles 2–12 × 1–3.5 mm, flat and sometimes narrowly winged above, rounded or keeled beneath, drying reddish black and smooth. Blades (4–) 7–11.5 (–16) × (1.5–) 3–5 (–9) cm, ratio (1.2–) 1.8–2.7 (–5), (narrowly) elliptic, obovate, or oblanceolate, base cuneate and attenuate at the very base or obtuse to rounded, apex usually rounded or obtuse, sometimes emarginate or acute, margin slightly to strongly revolute; (thick-)coriaceous, purple, pink, or reddish when young, fresh to dark glossy green above, paler glossy green beneath, drying dull to shiny, often resinous after drying, reddish brown to reddish black above, reddish brown to very dusky red beneath. Midrib channelled above, prominent and rounded or keeled, drying reddish black and smooth beneath. Secondary vein pairs (9–) 11–14 (–16), 4–12 (–15) mm apart, ± faint and lighter red than the lamina above, ± prominent and darker than the lamina beneath; intersecondary veins present. Tertiary veins sup-parallel near the midrib, reticulate towards the margins, ± faint above, faint or prominulous and darker than the lamina beneath. Inner intramarginal vein 1–5 mm from the leaf margin, ± looping; outer intramarginal vein < 1 mm from the leaf margin, often seemingly absent from leaf margin.

Inflorescences terminal and often in axils of distal leaf pair, rather dense panicles, 5–10 cm long, peduncles 1–6 cm long, axes subangular or rounded, flattened, resinous after drying. Bracts c. 3 mm long, linear, pellucid-dotted, caducous; bracteoles 2 per flower, sometimes seemingly 4 (by contraction of the ultimate inflorescence axes?), 1 mm long.

Flowers 5–15 per inflorescence, within the panicles in monads or clusters of 2–4, 4-merous, anthopodium absent, c. 20–30 mm in diameter at anthesis, mature buds 20–30 × 3–6 mm. Hypanthium 20–30 × 5–7 mm, elongate-clavate, yellowish green, drying smooth black, hypanthium rim 15 mm long, glandular inside. Calyx lobes c. 2 × 2 mm, claw- or hood-shaped. Petals c. 4 × 3 mm, ± obovate, pale green. Stamens c. 100, filaments 10–20 mm long, pale green, anthers c. 0.5–0.8 mm long, ellipsoid, yellow. Ovary bilocular, locules surrounded by spongy tissue, ovules c. 15–20 per locule, ascending, ± arranged in 2 longitudinal rows. Style 25–35 mm long, pointed.

Fruits 1–2-seeded, 27–33 × 12–16 mm, ampulliform, yellowish green (immature?), drying black, smooth or slightly warty, pericarp c. 1 mm thick, leathery when fresh, ± woody when dried, hypanthium rim 8–12 mm long, 4–5 mm in diameter.

Seeds 13–15 × 9–10 mm, ellipsoid, testa cartilaginous, attached to the pericarp, cotyledons free from the testa, ± half-globose, minutely verrucose, facing surfaces undulate.

3.4.1.4 Etymology

The species is named after Max Michael Josephus van Balgooy (*1932), botanist and authority on Southeast Asian plant taxonomy, identification, and biogeography. He collected over 900 specimens during a Dutch-Indonesian expedition to Sulawesi in 1979, among them the type specimen of this species. We enjoyed the privilege of learning from Max during several stays at the herbarium in Leiden and receiving his help with the identification of our specimens collected in Central Sulawesi.

3.4.1.5 Phenology

Flowering specimens have been encountered throughout the year without any apparent association with geography or climate. Fruiting specimens have been recorded in May (*de Vogel 5413*) and September (sight record by FB).

3.4.1.6 Distribution and Habitat

Syzygium balgooyi is restricted to Sulawesi and widespread across the island (Figure 3.2). The species occurs on a variety of geological substrates, namely volcanic rocks on the Northern Peninsula, acid plutonic rocks and schists in the Central Sulawesi Mountains (see Brambach et al. 2016 for definition), alluvial deposits at the base of the Southern Peninsula, and ultramafic rocks on the Eastern and Southeastern Peninsulas. According to the information on specimen labels it grows in primary forests, both virgin and disturbed, over a wide elevational range (c. 100–2000 m). There, it forms part of the canopy layer, sometimes co-dominant (Balgooy and Tantra 1986), but usually with scattered individuals (Culmsee et al. 2011, Brambach and Culmsee, unpublished).

3.4.1.7 Conservation Status

The AOO of 64 km² would place *Syzygium balgooyi* in the category “Endangered” (EN), despite its wide distribution in Sulawesi (Figure 3.2) as reflected by the estimated EOO of 94 451 km². The species has been found in a wide variety of habitats, including montane forests at different elevations, with scattered individuals or even co-dominant at times (see Distribution and Habitat above). We have no reason to believe that it is scarce throughout its range. Rather, we argue that the small estimated AOO is an artefact due to the generally low collection rate in Sulawesi and the real geographic distribution does not meet criterion B for any of the “threatened” categories of IUCN (2012). However, although we lack real evidence about possible changes in population size over time, using the Global forest change website (Hansen et al. 2013), we detected deforestation activities at or near five of the 18 collection localities (28%) of *S. balgooyi*. Given that the species is only recorded from old-growth forest habitats, we consider this a loss of suitable habitat, slightly below the 30% threshold for the "Vulnerable" category. Notably, all deforestation took place in places with relatively easy access and at low elevations. Thus, given (1) the relatively large EOO of *S. balgooyi*, (2) its apparent wide ecological niche, (3) its frequency of occurrence, (3) the low collection rates in Sulawesi, and (4) the loss of suitable habitat, we propose a preliminary extinction risk assessment of "Near Threatened" (NT) following the IUCN Red List Categories and Criteria (IUCN 2012).

3.4.1.8 Vernacular names

Cenke hutan (= forest clove, Indonesian, *de Vogel 2651*), Jambu (general name for *Syzygium*, Indonesian, *NIFS bb 33081*), Rokobako (*NIFS Cel./II-385*), Tambeanitu (Bahasa Behoa, *Brambach et al. 1047, 1083, 1290, 1316*), Wawahuling (Bahasa Tondano, Koorders 18251, see Koorders 1898, 173, 459).

3.4.1.9 Notes

Among *Syzygium* species of Sulawesi, *S. balgooyi* can be recognised in the field by its tall stature (Figure 3.1a), the bright red bark that peels off in thin sheets (Figure 3.1d, g) and the rather thick, usually obovate or oblanceolate leaves with ± rounded tips (Figure 3.1b–c, Figure 3.8a–e). Dry specimens are recognisable by the dark reddish-brown twigs bearing thick black flakes of the peeling epidermis and the very dark upper leaf surface with contrasting paler veins.

Leaf size and thickness are quite variable (Figure 3.8a–e), as can be expected for a species with such a wide ecological distribution. Small leaves are usually found at higher elevations, whereas thick leaves seem to be associated with ultramafic soils. While the extreme forms suggest that several distinct species are involved, when taking into account all the available material, intermediate states connecting the extremes appear. We therefore prefer to treat this as one species with the vegetative parts morphologically variable.

Team 2016) using the digital elevation model of Jarvis et al. (2008).

Syzygium balgooyi and *S. schumannianum* are difficult to separate in vegetative state. *S. balgooyi* usually has leaves with rounded, obtuse, emarginate, or acute tips, whereas they are shortly acuminate in *S. schumannianum*, but there are exceptions in both species. Flowers and fruits of the two species also share the same structure but there are two important differences which we consider sufficient to warrant specific separation: Firstly, as indicated by the original name *Eugenia neurocalyx* Schumann nom. illeg. (in Schumann and Hollrung 1889, 90), the outer surface of the hypanthium in *S. schumannianum* bears prominent "nerves", i.e. longitudinal ridges (Figure 3.1l–m). These ridges are already visible in young flower buds and remain present until the fruiting stage. Single, very faint ridges may appear in flowering specimens of *S. balgooyi* (seen in *de Vogel 2651*) but in the bulk of the material at our disposition, flower buds, flowers, and fruits are completely smooth (Figure 3.1j–k).

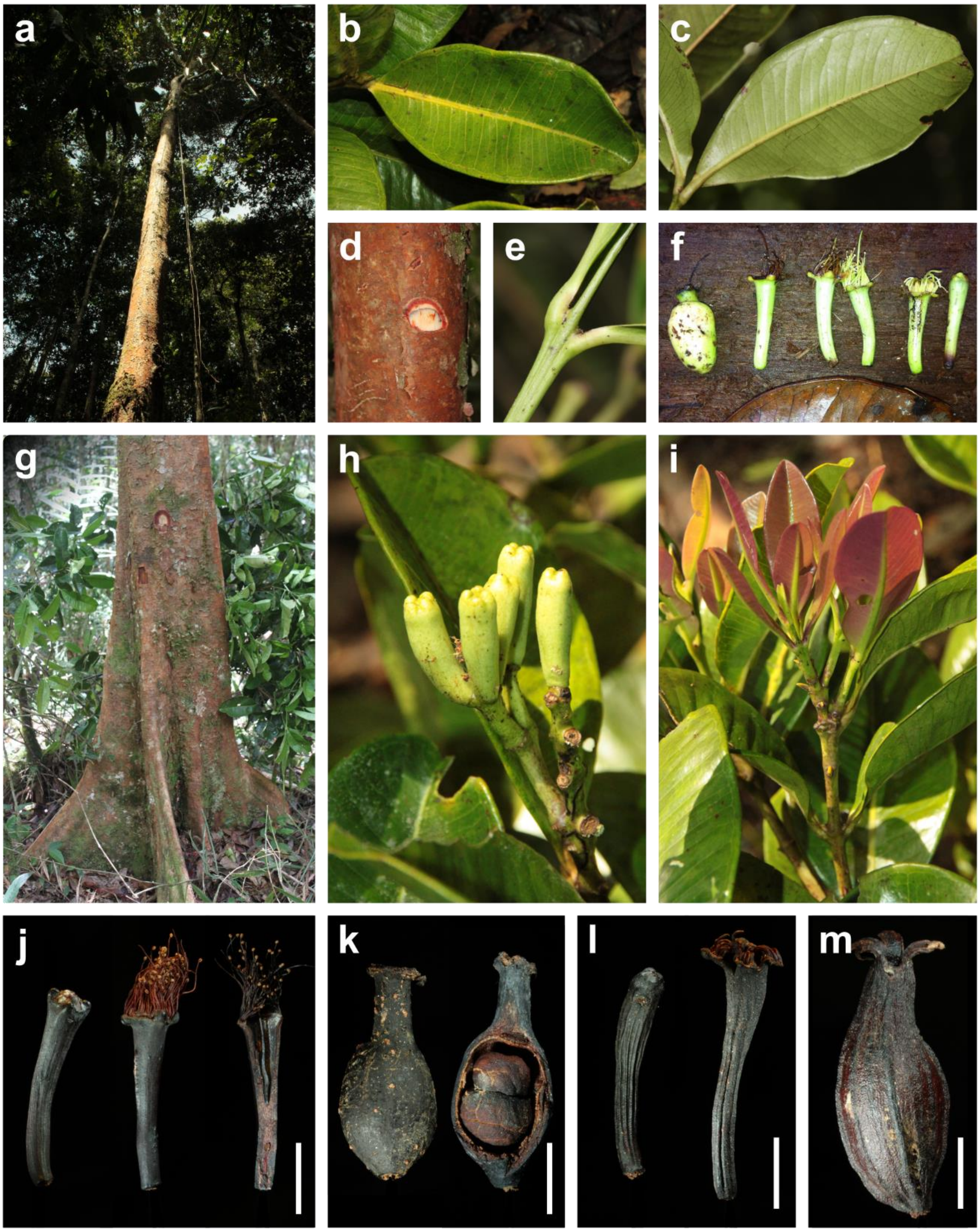

Figure 3.1 Morphological characters of *Syzygium balgooyi* and *S. schumannianum*. ***Syzygium balgooyi*** (a–k): **a** c. 20 m tall trunk; **b** upper leaf surface; **c** lower leaf surface; **d** bark with slash; **e** ridged shoot apex with subopposite leaves; **f** flowers at different stages during anthesis and fruit; **g** trunk base with steep narrow buttresses; **h** inflorescence with flower buds; **i** shoot with young leaves; **j** dried flowers before and during anthesis and longitudinal section of flower; **k** dried fruit and longitudinal section of fruit showing two cotyledons. ***Syzygium schumannianum*** (l-m): **l** dried flowers before and during anthesis; **m** dried fruit. **a**–**b** and **h**–**i** *Brambach et al. 1564*; **c** *Brambach et al. 0861*, **d**–**e** *Brambach et al. 0628*; **f** sighting on Mt Katopas by FB, **g** *Brambach et al. 0889*; **j** holotype *van Balgooy 3956* [L.2517558]; **k** *de Vogel 5413* [L.2517563]; **l** *Wiakabu et al. LAE 50571* [L.2535534]; **m** *Brass 13610* [L.2524420]. All scale bars = 1 cm.

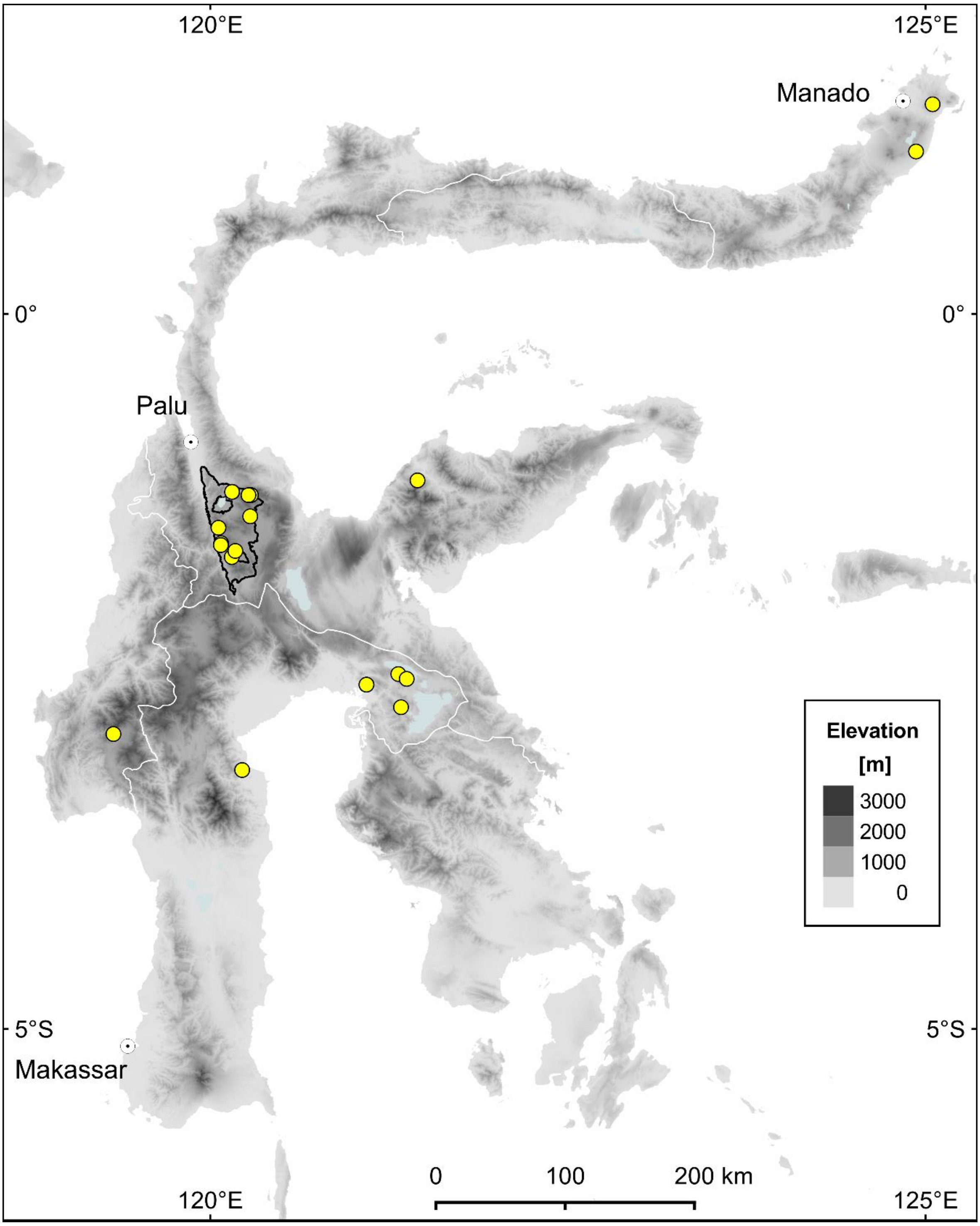

Figure 3.2 Distribution map of *Syzygium balgooyi* in Sulawesi. Collecting localities are shown as yellow dots; Lore Lindu National Park is indicated by a black line. Map created with QGIS (QGIS Development

Furthermore, in *S. balgooyi* the stamens are arranged in a ring along the upper margin of the hypanthium rim, which remains entire through the fruiting stage (Figure 3.1j–k). In *S. schumannianum*, the apical portion of the woody hypanthium rim splits into 4 outward-curving lobes and the stamens are arranged in a small area at the inside of each lobe near its tip (Figure 3.1l–m, Schumann and Hollrung 1889, Merrill and Perry 1942).

The wood of *S. balgooyi* is used for construction in North Sulawesi, but is not water-resistant (Koorders 1898, 173). Several collectors describe it as very hard and heavy. Mean wood density, as measured from 13 wood cores in LLNP was 0.74 g cm^{-1} (± 0.05 SD).

3.4.1.10 Additional Specimens Examined (Paratypes)

INDONESIA. North Sulawesi (Sulawesi Utara):

> Kab. Minahasa, Kec. Kakas, Old-growth forest Pinamorongan, c. 1°08'N, 124°56'E ("Noord-Celebes, Residentie Menado, Pinamorongangebergte bij Kakas"), 500 m, 30 Jan 1895: *Koorders 18251* (sterile; L [L.2517502]! [L.2535743]!).
>
> Kota Bitung, Kec. Ranuwulu, southern part of Wiau Forest Reserve (Hutan Lindung G. Wiau), base of Mt Klabat, c. 1°28'N, 125°03'E, 400 m, 1 Nov 1973: *de Vogel EF 2651* (flowers; L [L.2535729]! [L.2535730]! [wood sample L 0204047]).

Central Sulawesi (Sulawesi Tengah), LLNP:

> Kab. Poso, Kec. Lore Utara, west slope of Mt Rorekautimbu, c. 1°16'S, 120°16'E, 1700 m, 15 May 1979: *van Balgooy MMJ 3371* (sterile; L [L.2535697]!).
>
> Kab. Poso, Kec. Lore Utara, west slope of Mt Rorekautimbu, c. 1°16'S, 120°17'E, 2000 m: 5 May 1979: *Tantra IJM 1589* (sterile; L [L.2517457]!), & *1592* (sterile; L [L.2535672]!); ibid. loco, 17 May 1979: *de Vogel EF 5413* (fruits; BO [BO-1686561], K [K001024419]!, L [L.2517562]! [L.2517563]!, [wood sample L 0708565]).
>
> Kab. Poso, Kec. Lore Utara, 4 km E of Wuasa, c. 200 m N of Rumuku waterfall, tree-inventory plot Torongkilo, 1°24.9'S, 120°16.7'E, 1450 m, 6 Mar 2012: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1478* (sterile; BO [BO-1938440]!, CEB, L!) & *1564* (flower buds; BO [BO-1938441]!, CEB, K [K000993483]!) & *1583* (sterile; GOET [GOET020022]!).
>
> Kab. Poso, Kec. Lore Tengah, 9 km NW of Bariri, 100 m E of climate tower, tree-inventory plot Bariri NE, 1°39.4'S, 120°10.5'E, 1400 m: Jul 2007: *Culmsee H y896* (sterile; CEB, L!); ibid. loco, 21 Aug 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0861* (sterile; BO [BO-1938438]!, CEB, GOET [GOET020025]!) & *0889* (sterile; BO [BO-1938439]!, CEB, L!) & *0907* (sterile; CEB, GOET [GOET020024]!, L!).
>
> Kab. Poso, Kec. Lore Tengah, 9 km NW of Bariri, 80 m south of climate tower, tree-inventory plot Bariri S, 1°39.5'S, 120°10.4'E, 1400 m, Jul 2007: *Culmsee H 1459* (sterile; CEB, GOET [GOET020006]!) & *1495* (sterile; BO [BO-1938457]!, CEB); ibid loco, Jul 2007: *Culmsee H r808* (sterile; CEB, GOET [GOET020008]!).
>
> Kab. Poso, Kec. Lore Tengah, 7 km WNW of Hanggira, E flank of Mt Dali, tree-inventory plot Pantakleabae, 1°42.0'S, 120°09.0'E, 1950 m: 3 Mar 2011: *Culmsee H, Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R r2162* (sterile; CEB, GOET [GOET020021]!) & *r2254* (sterile; BO [BO-1927087], CEB, GOET [GOET020023]!); ibid. loco, 30 Mar 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0038* (sterile; BO [BO-1926965], CEB, GOET [GOET020027]!, K [K000993482]!, L!) & *0058* (sterile; BO [BO-1926969]!, [BO-1926970]!, CEB, GOET [GOET020033]!) & *0082* (sterile; BO [BO-1938382]!, CEB, GOET [GOET020030]!, L!) & *0097* (sterile; CEB, GOET [GOET020029]!, L!); ibid. loco., 23 Jan 2012: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1333* (sterile; CEB, GOET [GOET020020]!, L!).
>
> Kab. Sigi, Kec. Kulawi, 2.4 km ENE of Toro, NE edge of Pono Valley, tree-inventory plot Pono, 1°29.7'S, 120°03.4'E, 1050 m: 4 Aug 2006: *Culmsee 125* (sterile; BO [BO-1938456]!, CEB, L!) &

209 (sterile; CEB, K [K000993486]!); ibid. loco, Jul 2007: *Culmsee r211* (sterile; CEB, GOET [GOET020009]!).

Kab. Sigi, Kec. Kulawi Selatan, 4 km E of Watukilo, following footpath to Mt Tokepangana, tree-inventory plot Tokepangana, 1°36.9'S, 120°04.4'E, 850 m, 16 Apr 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0176* (sterile; BO [BO-1926967]!, CEB, GOET [GOET020028]!, L!) & *0206* (sterile; BO [BO-1926968]!, CEB) & *0283* (sterile; BO [BO-1926973]! [BO-1926974]!, CEB, GOET [GOET020032]!, K [K000993481]!, L!) & *0319* (BO [BO-1926934]!, CEB) & *0332* (BO [BO-1926966]!, CEB) & *0363* (BO [BO-1926919]!, CEB).

Kab. Sigi, Kec. Kulawi Selatan, 4 km ENE of Watukilo, 400 m N of Mboe River, tree-inventory plot Rantena, 1°36.2'S, 120°04.5'E, 700 m: 17 Jun 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0466* (sterile; BO [BO-1938383]!, CEB, GOET [GOET020031]!); ibid. loco, 21 Jun 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0628* (sterile; CEB, GOET [GOET020026]!, L!).

Kab. Sigi, Kec. Nokilalaki, 4.3 km SSW of Tongoa, NW flank of Mt Nokilalaki, ca. 400 m S of Shelter 2, tree-inventory plot Nokilalaki 2, 1°14.6'S, 120°09.1'E, 1850 m, Sep 2007: *Culmsee 2923* (sterile; CEB, L) & *3075* (sterile; BO [BO-1938463]!, CEB).

Kab. Sigi, Kec. Nokilalaki, 4.3 km SSW of Tongoa, NW flank of Mt Nokilalaki, ca. 500 m SSE of Shelter 2, tree-inventory plot Nokilalaki 1, 1°14.7'S, 120°09.2'E, 1900 m, Aug 2007: *Culmsee 2636* (sterile; CEB, L!) & *2641* (sterile; BO [BO-1938462]!, CEB, GOET [GOET020007]!) & *2721* (sterile; CEB, K [K000993487]!).

Kab. Tojo Una-una, Kec. Ulubongka. N slope of Mt Katopas, 1°9.8'S, 121°26.9'E, 1100 m, 4 Sep 2014: Sight record by F Brambach (photograph Figure 3.1f).

West Sulawesi (Sulawesi Barat):

Kab. Mamasa. Kec. Mamasa, near Osango c. 2°56'S, 119°19'E ("Celebes en Ond. Boven Binoeang, ca. Osango"), c. 1500 m, 1 Jul 1939: *Netherland's Indies Forest Service (NIFS) bb 28293* (sterile; L [L.2529832]!).

South Sulawesi (Sulawesi Selatan):

Kab. Luwu, Kec. Ponrang, near Kampung Tampa, c. 3°11'S, 120°13'E ("Celebes en Ond. Palopo, Bakka, Kampoeng Tampa"), c. 100 m, 15 Sep 1941: *NIFS bb 33081* (flowers; L [L.2535805]!).

Kab. Luwu Timur: Kec. Malili, Ussu, c. 2°36'S, 121°06'E ("Selebes, Malili, Oesoe): c. 300 m, 13 Jul 1931: *NIFS Cel./II-385* (flower buds; L [L.2535679]!); ibid. loco, c. 400 m, 19 Jun 1934: *NIFS Cel./II-293* (sterile; L [L.2517541]!); ibid. loco, 100 m, 28 Mar 1941: *NIFS bb 32595* (sterile; BO [BO-1304600], L [L.2517463]!).

Kab. Luwu Timur, Kec. Wasuponda, Larona, c. 2°45'S, 121°20'E, 500–1000 m ("Celebes. Goud. Celebes, Ond. afd. Malili, nabij La Rona"), n.d.: *NIFS bb 1843* (sterile; L [L.2535842]!) & *bb 1895* (sterile; L [L.2535843]!).

Kab. Luwu Timur, Kec. Nuha, Hills W of Soroako, c. 2°31'S, 121°19'E, 550 m, 17 Jun 1979: *van Balgooy MMJ 3767* (old inflorescences; L [L.2535910]! [wood sample L 0708626]).

3.4.2 *Syzygium contiguum* Brambach, Byng & Culmsee, sp. nov.

urn:lsid:ipni.org:names:60474722-2 Figures 3.3, 3.4, 3.8.

"Myrtaceae sp. 9" (Culmsee and Pitopang 2009).

3.4.2.1 Diagnosis

Syzygium contiguum is a species of treelets with slender, angular young branchlets and (sub-)sessile, chartaceous leaves with few (8–13), distinct secondary veins, two marginal veins, and conspicuous cordate bases; the basal lobes of opposed leaves often reach each other. The dense or lax paniculate inflorescences are terminal or arise from the upper leaf axils and bear small (5–6 × 3–4 mm in mature buds) pyriform flowers with numerous white stamens. The species is similar to *Syzygium urdanetense* (Elmer) Merrill (1951, 420) from the Philippines but differs from that species by angular (vs usually terete) young branchlets and inflorescence axes, by smaller (usually 9–14 × 3.5–5 vs 18–35 × 6–11cm), chartaceous (vs coriaceous) leaves with shorter (0–1.5 vs 3–5 mm) petioles and fewer secondary vein pairs (8–13 vs 17–35), and by gland-dotted (vs smooth) petals. It differs from *Syzygium paucipunctatum* (Koord. and Valeton) Merrill and Perry (Merrill and Perry 1939, 169) (1939, 169) from Sumatra, Java, and Borneo, in chartaceous (vs coriaceous), leaves with no or few gland dots (vs gland-dotted beneath) which dry dark reddish brown to very dusky red above and (dark) reddish brown beneath (vs. olive-green above and brownish beneath) and shorter (5–6 vs c. 9 mm long) mature flower buds. Floral formula B1 Bt2 K4* C4* A∞* Ĝ(2)┼ Vx~8.

3.4.2.2 Type

INDONESIA. Central Sulawesi (Sulawesi Tengah), LLNP, Kab. Sigi, Kec. Kulawi, 2.4 km ENE of Toro, NW of Pono Valley, tree-inventory plot Pono, 1°29.7'S, 120°03.4'E, 1050 m, Jul 2006: *Culmsee H 535* (flowers; holotype L[L.3962133]!, isotype CEB).

3.4.2.3 Description

Treelets, up to 10 m tall, diameter at breast height ≤ 11 cm. **Bark** and wood not known. Young **branchlets** 0.5–1 × 1–2 mm, slender, rectangular in cross section, sometimes narrowly winged, epidermis drying dark reddish brown, smooth; soon becoming terete with 4 ridges and eventually terete, bark pale or yellowish brown with flaking remnants of epidermis; with (1–) 2 (–4) pairs of ≤ 2 mm long, caducous cataphylls near the base of the current flush.

Leaves opposite, (sub-)sessile. Petioles 0–1.5 × 1–2 mm, absent or very short and stout, drying very dusky red. Blades (6.5–) 9–14 (–19) × (2.3–) 3.5–5 (–6.1) cm, ratio (1.9–) 2.5–3.2 (–3.6), narrowly elliptic or lanceolate, rarely oblanceolate, base distinctly cordate (or auriculate), basal lobes of opposed leaves often touching each other, apex (long-)acuminate or caudate, margin flat or sometimes minutely revolute; chartaceous, drying dull to satin, dark reddish brown to very dusky red above, (dark) reddish brown beneath; sometimes with scattered black gland dots. Midrib channelled above, prominent, rounded, and darker than the lamina beneath. Secondary vein pairs 8–12, (3–) 5–11 (–18) mm apart, slightly sunken or sometimes slightly prominent, rather inconspicuous above, very prominent and darker than the lamina beneath; some intersecondary veins usually present. Tertiary veins sub-parallel near the midrib to reticulate towards the margin, faint above, prominulous beneath. Inner intramarginal vein 3–7 mm from leaf margin, hardly looping; outer intramarginal vein 0.5–2 mm from leaf margin.

Inflorescences terminal and in the axils of 1–2 distal leaf-pairs, ± lax panicles, (2.5–) 3.5–7.5 (–11) cm long, peduncles 1–3.5 cm long, axes (sub-)angular, flattened. Bracts c. 0.5–2 (–7) mm long, lowermost foliaceous, caducous, others deltate, keeled, ± persistent; bracteoles 2 per flower, 0.5–1 mm long, similar to bracts.

Flowers ≤ 40 per inflorescence, within the panicles in monads or triads, 4-merous, anthopodium absent, c. 15 mm in diameter at anthesis, mature buds 5–6 × 3–4 mm. Hypanthium 4–5 × 3–5.5 mm, obconical to infundibuliform, gland-dotted or ± smooth, hypanthium rim 2 mm long. Calyx lobes 0.5–1 × 1–2.5 mm, deltate first, becoming broadly rounded and eventually splitting irregularly at anthesis. Petals 3–6 × 3–6 mm, pseudocalyptrate, orbicular, gland-dotted. Stamens c. 80–100, filaments 6–10 mm long, white, anthers c. 0.5 mm long, ellipsoid. Ovary bilocular, locules subtended by spongy tissue, ovules c. 8 per locule, spreading. Style 6–8 mm long, pointed.

Fruits 2-seeded, 1.1–1.3 x 1.8–1.9 cm, globose to oblate, drying smooth, pericarp c. 2 mm thick, hypanthium rim c. 5 mm in diameter.

Seeds 9–10 x 12–13 mm, half-moon shaped.

3.4.2.4 Etymology

The specific epithet refers to the leaf bases of opposing leaves which, due to their cordate shape and the short petioles, often approach or touch each other.

3.4.2.5 Phenology

In Central Sulawesi a slight dry season usually lasts from May to September or October. Flowering was observed during the wet and dry seasons: in July 2016, January/February 2007, July 2007 in Pono and in April 1975 on Mt Nokilalaki.

Distribution and Habitat

According to our present knowledge, the species is endemic to the province of Central Sulawesi. It has been recorded from only three localities in and around LLNP at 1000–1150 m elevation (Figure 3.4). Most of the specimens were collected in our (FB and HC) inventory plot in Pono Valley near the western border of LLNP.

In the Pono inventory plot, the species was found in undisturbed submontane rainforest on flat terraces with Sideralic Cambisols (IUSS Working Group WRB 2014) developed from metamorphic rocks. The forest at Pono was dominated by Fagaceae, Lauraceae, Sapotaceae, Moraceae, and Rubiaceae species (families with top five FIV) and contained seven other species of *Syzygium*: *S. acuminatissimum* (Blume) de Candolle (1828, 261), *S. balgooyi*, *S. galanthum*, *S. lineatum* (DC.) Merrill and Perry (1938a, 109), *S. phaeostictum* Merrill and Perry (1942, 270), and two undetermined species (Brambach and Culmsee, unpublished). See Culmsee and Pitopang

(2009) for more information on the floristics of the Pono valley plot. The collection locality of *Widjaja EAW 3502* in the almost entirely deforested Napu valley suggests remnant riparian forest as habitat.

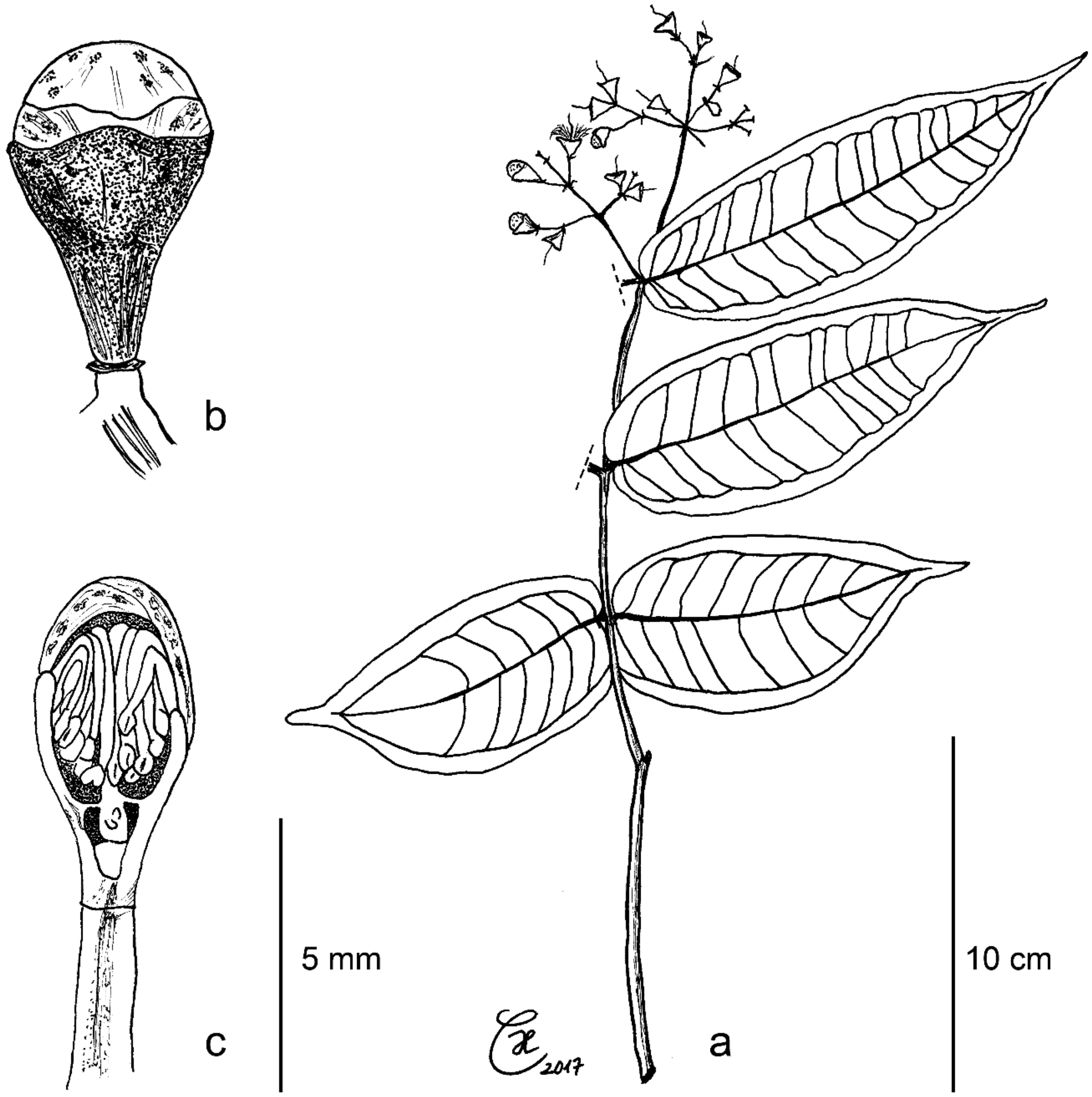

Figure 3.3 *Syzygium contiguum:* **a** leafy twig with flowers in different developmental stages; **b** flower bud with gland-dotted petals and shallow calyx lobes; **c** flower bud, longitudinal section. All from holotype *Culmsee 535.*

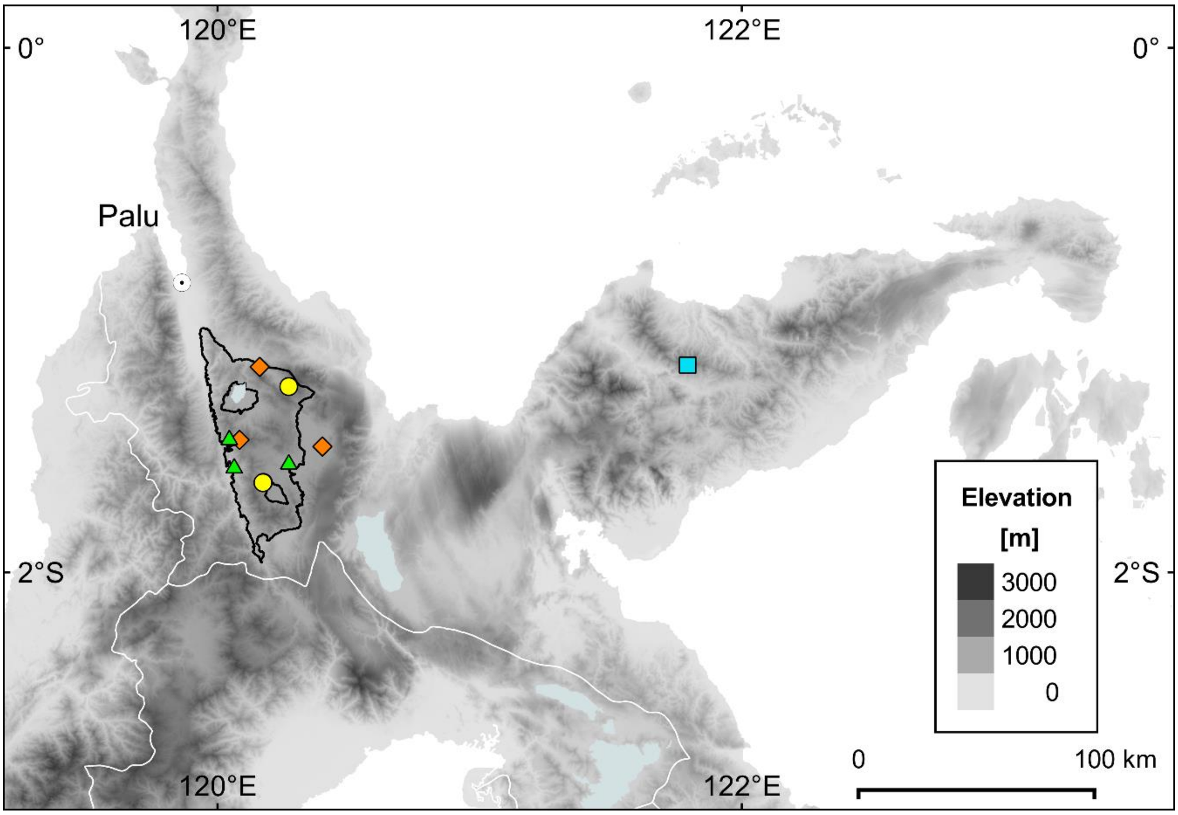

Figure 3.4 Distribution map of four species of *Syzygium* in Central Sulawesi: *Syzygium contiguum* (orange diamonds), *S. devogelii* (yellow dots), *S. eymae* (light blue square), and *S. galanthum* (green triangles). Lore Lindu National Park is indicated by a black line. Map created with QGIS (QGIS Development Team 2016) using the digital elevation model of Jarvis et al. (2008).

3.4.2.6 Conservation Status

Syzygium contiguum has a limited geographical distribution (estimated EOO 557 km²) and seems to be restricted to sub-montane forest within a narrow elevational belt. We assume that the estimated AOO of 12 km² is unrealistically low, due to limited collection activities in Central Sulawesi. However, only the collection locality of *Meijer 9572* seems to be covered by intact forest habitat. The other two localities are small forest fragments (*Widjaja EAW 3502*) and forest with recent deforestation activities in close proximity (Pono inventory plots, detected using the Global Forest Change website, Hansen et al. 2013), possibly related to the establishment of cocoa plantations (Aiyen Tjoa, Tadulako University, personal communication, June 2015). Given the apparent narrow geographical and elevational distribution and the recommendation to use a precautionary attitude in conservation assessments (IUCN Standards and Petitions Subcommittee 2017) we propose a preliminary extinction risk assessment of "Endangered" (EN B1ab(i,ii,iii)).

3.4.2.7 Notes

Syzygium urdanetense (as *Eugenia urdanetensis*, Elmer 1914, 2356), the species most similar to *S. contiguum*, was originally described from Mt Masay (previously Mt Urdaneta) on the southern Philippine island of Mindanao and is widespread throughout the Philippines (Merrill 1951, Pelser et al. 2011). The species is variable in vegetative characters such as leaf size, leaf base (usually rounded and only the very base cordate, but sometimes distinctly cordate) and branchlet shape (usually terete, but rarely subangular). In addition to the characters mentioned in the diagnosis, there are differences in the tertiary venation, the veins being ± ladder-like and perpendicular to the midrib in *S. urdanetense* whereas in *S. contiguum* they are ± parallel to the secondary veins near the midrib and become reticulate towards the leaf margin (Figure 3.8f). While with the available material, *S. contiguum* can be clearly distinguished from *S. urdanetense* on morphological grounds, we do not discard the possibility that future collections, especially from the northern peninsula of Sulawesi, will uncover populations with intermediate characters. If so, *S. contiguum* may eventually have to be sunk into an expanded *S. urdanetense*. In light of the almost complete lack of taxonomic resolution for *Syzygium* in Sulawesi, we nevertheless consider it advisable to propose *S. contiguum* as a distinct species.

Two fruiting specimens collected at low elevations (200–300 m) on Sulawesi's Southeast Peninsula, *Prawiroatmodjo & Maskuri 1231* [L.2517450] and *1957* [L.2517547], are morphologically similar to *S. contiguum* as defined above except for the leaf tips which are not long-acuminate. In the absence of flowering material, and because of the different habitat and distribution, we prefer not to include them here at present, but future additional collections may prove otherwise.

We choose *Culmsee 535* as type specimen because it contains flowers in all stages of maturity although unfortunately, it was collected with only two duplicates (in CEB and L). Nevertheless, the more widely distributed paratypes collected by HC at the type locality all belong to the same population as the type.

3.4.2.8 Additional Specimens Examined (Paratypes)

INDONESIA. Central Sulawesi (Sulawesi Tengah), LLNP:

> Kab. Poso, Kec. Nokilalaki, N slopes of Mt Nokilalaki. ("Celebes, central part, area of Mt. Nokilalaki, Loro Kalimata Reserve"), 1°13'S, 120°08'E, ± 1000 m, 24 Apr 1975: *Meijer 9572* (flowers; L [L.2535817]!, US [US-2995269] photo!).
>
> Kab. Poso, Kec. Lore Peore, Road to Napu from camp Dongi-dongi, 1°31.2'S, 120°22.4'E, 1127 m, 26 Dec 1988: *Widjaja EA EAW 3502* (fruits; BO [BO-1917489]! [BO-1917490]!, K! , L).
>
> Kab. Sigi, Kec. Kulawi, 2.4 km ENE of Toro, NW of Pono Valley, tree-inventory plot Pono, 1°29.7'S, 120°03.4'E, 1050 m, Jul 2006: *Culmsee H 284* (flowers; GOET [GOET020010]!).
>
> Kab. Sigi, Kec. Kulawi, 2.4 km ENE of Toro, NW of Pono Valley, tree-inventory plot "Pono", 1°29.7'S, 120°03.4'E, 1050 m, Jan 2007: *Culmsee H y410* (flower buds; BO [BO-1938450]! [BO-1938451]!, CEB, GOET [GOET020012]!, K [K000993488]!, L!); ibid. loco, Jul 2007: *Culmsee H r463* (flower buds; BO [BO-1938464]!, CEB, GOET [GOET020011]!, K [K000993489]!, L!!) & *y503* (flower buds; CEB, GOET [GOET020013]!) & *y514* (flower buds; BO [BO-1938452]!, CEB) & *y581* (flower buds; CEB, L!) & *y582* (flower buds; CEB, K [K000993490]!) & *y592* (flower buds; BO [BO-1938453]! [BO-1938454]!, CEB) & *y595* (flower buds; CEB, GOET [GOET020014]!, L!).

3.4.3 *Syzygium devogelii* Brambach, Byng & Culmsee, sp. nov.

urn:lsid:ipni.org:names:60474723-2 Figures 3.4, 3.5, 3.8.

„Myrtaceae sp. 10“ p.p. (Culmsee and Pitopang 2009, see also 2017 (Erratum)).

3.4.3.1 Diagnosis

Syzygium devogelii is a species of treelets characterised by slender, narrowly winged young branchlets, medium-sized narrowly elliptic leaves, straight and distinct secondary veins connected by an intramarginal vein impressed above and prominent beneath, small flowers (5 × 3 mm in bud) in terminal inflorescences that develop into rather large fruits (c. 20 × 25 mm), mature seeds lacking a testa, and cotyledons with echinate outer surfaces. The species is morphologically similar to *Syzygium perspicuinervium* (Merr.) Masamune (1942, 537) but differs from that species in smaller leaves with fewer secondary veins and in flowers with distinct calyx lobes (vs calyx calyptrate). It is furthermore similar to *Syzygium valdevenosum* (Duthie) Merrill and Perry (1939, 182) but differs in lateral veins which are impressed above (vs prominent), much smaller inflorescences, and smaller, obconical (vs infundibuliform) flowers. Floral formula B1 Bt2 K4* C4* A∞* Ĝ(2)┼ Vx∞.

3.4.3.2 Type

INDONESIA. Central Sulawesi (Sulawesi Tengah), LLNP, Kab. Poso, Kec. Lore Utara, west slope of Mt Rorekautimbu, c. 1°17.5'S 120°16.3'E, 1350 m, 11 May 1979: *de Vogel EF 5293* (fruits; holotype L [L.2535665]! [L.2535666]!; isotype K!).

3.4.3.3 Description

Trees, up to 13 m tall, diameter at breast height ≤ 13 cm, trunk ≤ 7 m tall. Outer **bark** whitish to brown, mealy or peeling off in thin sheets, inner bark pale or dark red, wood cream-coloured. Young **branchlets** 1–2.5 × 2–3 mm, ± flattened, angular or oblong in cross section with 4 narrow wings, epidermis dark red when young, drying reddish or yellowish brown, smooth; becoming rounded with 4 ridges, bark (yellowish) brown, peeling off in thin sheets.

Leaves (sub-)opposite. Petioles 7–16 × 1–3 mm, channelled above, rounded beneath, epidermis drying smooth or with transverse cracks. Blades (12.5–) 14–19 (–22.5) × (4–) 4.5–7 (–8.5) cm, ratio (2.1–) 2.6–3.3 (–4), narrowly elliptic (or lanceolate), base cuneate or obtuse, apex acuminate, margin revolute; chartaceous or coriaceous, red or pink when young, above, beneath, drying dull to satin, variable in colour from greyish brown and olive grey to very dusky red above, dull to satin and, dark reddish brown beneath; pellucid dots rather few, visible or not on both sides. Midrib channelled above, very prominent, rounded, smooth and drying darker than the lamina beneath. Secondary vein pairs (9–) 11–14 (–17), 5–22 mm apart, channelled or impressed above, prominent and drying darker than the lamina beneath, straight or slightly arching from the midrib; intersecondary veins sometimes present. Tertiary veins dense, ± ladder-like and perpendicular to the midrib, faint above, prominulous beneath. Inner intramarginal vein 2–9 mm from leaf margin, looping or not and prominent; outer intramarginal vein 0.5–1.5 mm from leaf margin, as prominent as tertiary venation.

Inflorescences terminal, dense metabotryoids, 2.5 cm long, peduncles 1 cm long, axes flattened, with 2 or 4 narrow wings, drying brown. Bracts c. 1.5 mm long, ovate, keeled, caducous; bracteoles 2 per flower, 1 mm long, similar to bracts.

Flowers c. 15 per inflorescence, within the inflorescence in triads, 4-merous, anthopodium absent, only known before anthesis, mature buds 5 × 3 mm. Hypanthium c. 4 × 3 mm, obconical, drying dark reddish brown, densely glandular-warty, hypanthium rim 2 mm long, glandular inside. Calyx lobes c. 1 × 2 mm, broadly rounded. Petals c. 3 × 3 mm, cucullate in bud. Stamens c. 100, filaments 2–3 mm long, anthers c. 0.4 mm long, ellipsoid. Ovary bilocular, surrounded by spongy tissue, ovules numerous per locule, ascending. Style 3–4 mm long, pointed.

Fruits 1-seeded, c. 20 × 25 mm, irregularly depressed globose, laterally compressed, green, drying black and, smooth, pericarp ± woody, 1 mm thick, hypanthium rim 1–2 mm long, 5–9 mm in diameter.

Seeds c. 15 × 20 mm, transverse ellipsoid, testa adhering to the pericarp, spongy inside and adhering to the outer surface of the cotyledons, cotyledons ± half-globose, facing surfaces undulate, outer surfaces densely echinate, protuberances obscured by spongy testa tissue.

3.4.3.4 Etymology

The species is named after Eduard Ferdinand de Vogel (*1942). Ed de Vogel is a renowned authority on Malesian orchids, especially those from New Guinea. His contributions to the flora of Sulawesi are perhaps less well known: with almost 2000 specimens of excellent quality collected there in 1973–74 and 1979 – among them the type specimen of this species – he was one of the most prolific plant collectors on the island during the 20th century.

3.4.3.5 Phenology

Flowering was recorded in August, fruiting in May.

3.4.3.6 Distribution and Habitat

Syzygium devogelii is endemic to the province of Central Sulawesi, currently known to occur in lower montane forest at two localities in LLNP from 1350–1400 m elevation (Figure 3.4). In the Bariri NE inventory plot, it was fairly common, growing on mid-slope terraces with Rhodic Ferralsols (IUSS Working Group WRB 2014) derived from acid plutonic rocks. The forest there was dominated by Fagaceae, Myrtaceae, Burseraceae, Lauraceae, and Elaeocarpaceae (families with top five FIV) and contained six other species of *Syzygium*: *S. acuminatissimum*, *S.* aff. *baeuerlenii* (F.Muell.) Craven and Biffin (in Craven et al. 2006, 135), *S. lineatum*, *S. zeylanicum* (L.) de Candolle (1828, 260), and two undetermined species (Brambach and Culmsee, unpublished). See Culmsee and Pitopang (2009) for more information on the floristics of the Bariri forest.

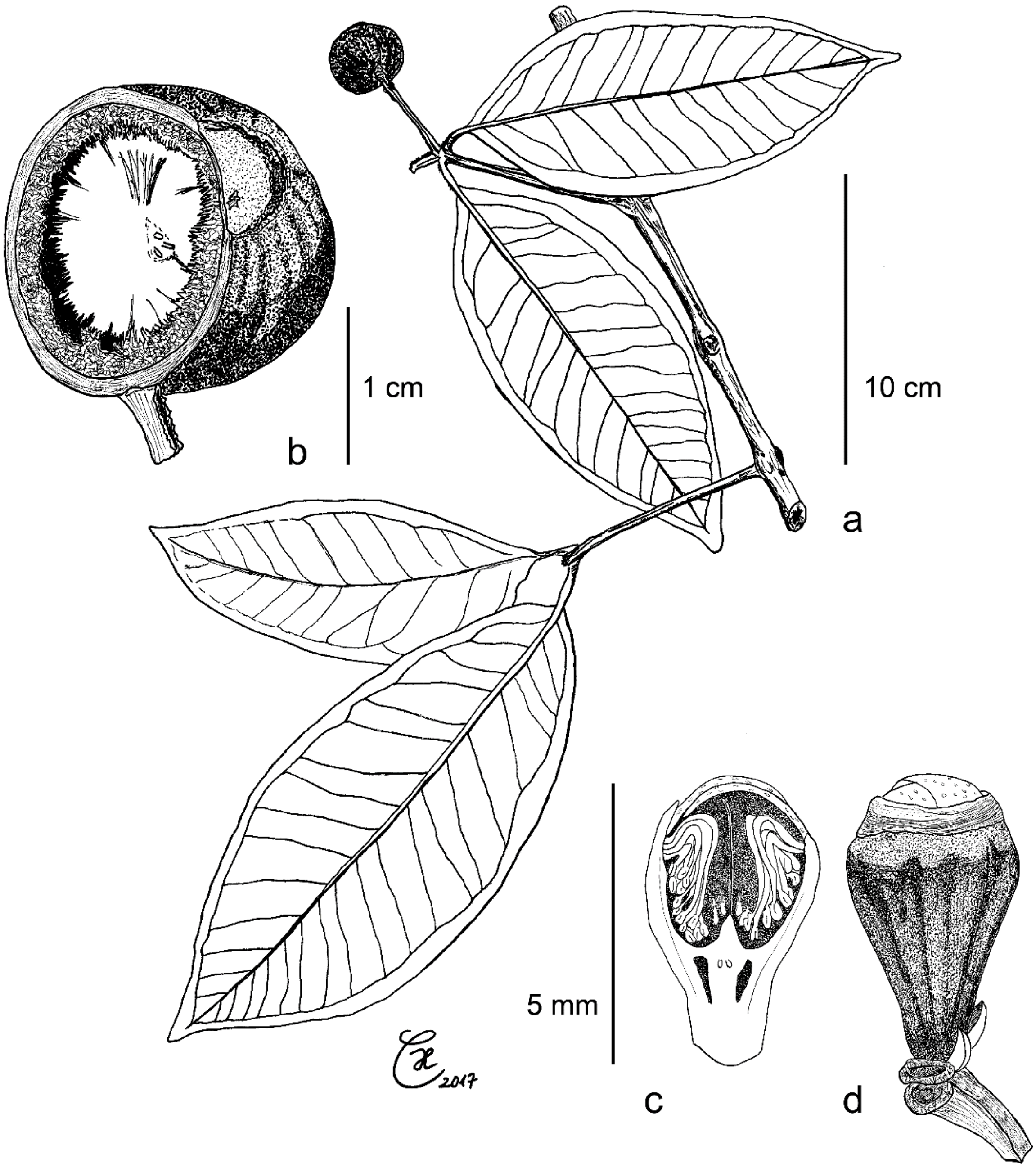

Figure 3.5 *Syzygium devogelii*: a leafy twig with fruit; b longitudinal section of ripe fruit with inner, flat side of cotyledon and echinate outer surface; c flower bud, longitudinal section; d flower bud, exterior view. a–b holotype *de Vogel 5293*, c–d *Culmsee 1564*.

3.4.3.7 Conservation status

Syzygium devogelii has a limited geographical distribution and seems to be restricted to lower montane forest within a narrow elevational belt. Known from only two localities, the EOO and AOO cannot be estimated reliably for the species. Because of the low collection density in Central Sulawesi, we believe that the species is more widespread and common than it currently appears. Deforestation has been recorded close to the type locality (using the Global Forest Change website, Hansen et al. 2013). Given the apparent narrow geographical and elevational distribution, ongoing deforestation and the recommendation to use a precautionary attitude in conservation assessments (IUCN Standards and Petitions Subcommittee 2017), we propose a preliminary extinction risk assessment of “Endangered” (EN B1ab(i,ii,iii)).

3.4.3.8 Notes

Most species of *Syzygium* are reported to have cotyledons with rather smooth outer surfaces, unlike the peculiar echinate cotyledons of *S. devogelii*. We here interpret the tissue covering the outer surface of the cotyledons (Figure 3.5) and obscuring its protuberances as derived from the testa, as reported for the Australian species *Syzygium bungadinnia* (F.M.Bailey) Hyland (1983, 64) (1983, 64), but closer examinations of fruit and seed structures are necessary to corroborate this interpretation.

Juvenile specimens of *Syzygium balgooyi* are similar to *S. devogelii* in their leaf shape, colour, and venation. In fact, both species were treated as one morphotype in Culmsee and Pitopang (2009, 2017). Besides the very different flowers, they can, however, be distinguished by the shape of the young branchlets: strongly flattened and with rounded ridges in *S. balgooyi* (Figure 3.1e) vs ± flattened with 4 narrow wings in *S. devogelii* (Figure 3.5).

3.4.3.9 Additional Specimens Examined (Paratypes)

INDONESIA. Central Sulawesi (Sulawesi Tengah), LLNP, Kab. Poso, Kec. Lore Tengah:

> 9 km NW of Bariri, 100 m east of climate tower, tree-inventory plot Bariri NE, 1°39.4'S, 120°10.5'E, 1400 m, 9 Sep 2006: *Culmsee H 1333* (sterile; BO [BO-1938455]!, CEB) & *1378* (sterile; CEB, K [K000993491]!); ibid. loco, 18 Aug 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0818* (sterile; BO [BO-1938442]!, CEB, GOET [GOET020015]!) & *0845* (sterile; BO [BO-1938443]!, CEB, L!).
>
> 9 km NW of Bariri, 80 m south of climate tower, tree-inventory plot Bariri S, 1°39.5'S, 120°10.4'E, 1400 m, Jul 2006: *Culmsee H 1252* (sterile; CEB, GOET [GOET020016]!) & *1564* (flower buds; CEB, L!).

3.4.4 *Syzygium eymae* Brambach, Byng & Culmsee, sp. nov.

urn:lsid:ipni.org:names:60474724-2 Figures 3.4, 3.6, 3.8

3.4.4.1 Diagnosis

Syzygium eymae is characterised by small (usually 2.3–4 × 1.5–2.5 cm), (sub-)sessile, leaves with thickly coriaceous, (broadly) elliptic or obovate blades, dense terminal inflorescences, and small, pyriform flowers with a calyptrate calyx that bears a minute apical opening and splits irregularly at anthesis. It differs from the morphologically similar *Syzygium paradoxum* (Merr.) Masamune (1942, 536) in angular young branchlets (vs terete), leaves without conspicuous gland dots (vs leaves conspicuously gland-dotted beneath), fewer pairs of secondary veins (5–7 vs 10–14), and smaller (5–6 × 3 vs c. 12 × 5 mm in mature buds), pyriform flowers without anthopodia (vs infundibuliform with anthopodia 5–7 mm long). Floral formula B1 Bt2 (K4?* C4?*) A∞* Ĝ(2)┼ Vx?.

3.4.4.2 Type

INDONESIA. Central Sulawesi (Sulawesi Tengah), Kab. Tojo Una-Una, Border of Kec. Ulubongka and Kec. Ampana Tete, Mt Lumut, between summit and western secondary peak, c. 1°12.3'S, 121°47.6'E, ± 2200 m ("Selebes, Res. Menado. O.afd. Poso. G. Lóemoet, Pilaartop en W. bijtop. (summit)"), 5 Sep 1938: *Eyma 3624* (flowers; holotype U [U.1439024]!; isotypes: BO [BO-1679767]!, L [L.2535689]!).

3.4.4.3 Description

Trees, height, **bark** and wood unknown. Young **branchlets** slender, 0.5–1 × 1–2 mm, rectangular in cross section, ridges arising at the petioles and running downwards to next node, epidermis drying reddish black; remaining angular or becoming ± terete, bark reddish brown and scaly; with 1–2 pairs of minute cataphylls near the base of the current flush.

Leaves opposite, (sub-)sessile. Petioles 0.5–2 × 1–1.5 mm, absent or very short and stout, drying black. Blades (1.8–) 2.3–4 (–5.2) × (1.2–) 1.5–2.5 (–3.1) cm, ratio 1.3–2, (broadly) elliptic or (broadly) obovate, base obtuse or rounded, apex rounded, acute, or shortly acuminate, margin revolute; thickly coriaceous (c. 0.3 mm thick), dull, drying dark reddish grey to reddish black above, (very) dusky red beneath; without black gland dots. Midrib impressed above, prominent, rounded, and darker than the lamina beneath. Secondary vein pairs (4–) 5–7, 3–10 mm apart, channelled and inconspicuous above, (slightly) prominent and more reddish than the lamina beneath; intersecondary veins sometimes present. Tertiary veins reticulate, channelled above, indistinct beneath. Inner intramarginal vein 1–2 mm from leaf margin, looping; outer intramarginal vein not present.

Inflorescences terminal, 2-nodate metabotryoids, ≤ 3 cm long, peduncles ≤ 1 cm long, axes angular. Bracts c. 1–1.5 mm long, deltate, keeled, caducous; bracteoles 2 per flower, c. 1 mm long, similar to bracts.

Flowers ≤ 10 per inflorescence, within the inflorescence in triads, anthopodium absent, mature buds 5–6 × 3 mm. Hypanthium 4–5 × 4–5 mm, pyriform, smooth, hypanthium rim 1.5 mm long. Calyx lobes calyptrate with small apical opening, slightly lighter-coloured than hypanthium when dry, splitting irregularly at anthesis, caducous. Petals calyptrate, adhering to the calyx. Stamens c. 50, filaments 6–7 mm long, white, anthers c. 0.4 mm long, ellipsoid. Ovary bilocular, ovules several per locule, ascending. Style 6–7 mm long, pointed.

Fruits and **seeds** unknown.

3.4.4.4 Etymology

The species is named after Pierre Joseph Eyma (1903-1945), one of the early botanists to explore the mountainous regions of Central Sulawesi (Eyma 1940, 194, van Steenis-Kruseman and van Welzen 2014). Eyma collected many valuable specimens from high-elevation areas, including the type specimen of this species.

3.4.4.5 Phenology

The species was collected in flowering state in September 1938.

3.4.4.6 Distribution and Habitat

S. eymae is endemic to the province of Central Sulawesi and currently only known from the type locality: Mt Lumut on Sulawesi`s eastern peninsula (Figure 3.4). No information on habitat is given on the label of the type specimen. Mt Lumut is made up of ultramafic rocks (Geological Research and Development Centre 1993) and upper montane (cloud) forest would be the expected vegetation type there at 2200 m.

3.4.4.7 Conservation Status

With only the type specimen known, we consider *S. eymae* “Data Deficient” (DD) at present, following the IUCN Red List Categories and Criteria (IUCN 2012).

3.4.4.8 Notes

The species of tribe *Syzygieae* Wilson (in Wilson et al. 2005, 15) bearing a calyptrate calyx have mostly been treated under the genus *Cleistocalyx* Blume (1850, 84, see Merrill and Perry 1937). The calyptrate calyx is a relatively rare character, currently known to occur in only about 30 of the > 1200 species of *Syzygieae* (Merrill and Perry 1937, Chantaranothai and Parnell 1993, Takeuchi 2002, Biffin et al. 2005, Craven and Biffin 2010). Its occurrence, however, is widely spread over the phylogenetic tree of the tribe; so *Cleistocalyx* is not monophyletic and has therefore been synonymised under an expanded *Syzygium* (Craven et al. 2006, Craven and Biffin 2010).

The flowers of *Cleistocalyx* are described as having “calyptrate calyces, the undivided, often more or less indurated upper parts of which fall as a lid”, the lid often remaining attached at one side of the flower at early anthesis (Merrill and Perry 1937). In *S. eymae*, the calyx clearly has the form of a calyptra, but at anthesis it splits irregularly into four or five parts, starting with a minute (< 0.5 mm diam.) apical opening (Figure 3.6). One or several of the irregular segments may remain attached to the hypanthium rim shortly after anthesis before eventually being shed. The mode of dehiscence of the calyx thus seems to represent an intermediate condition between *Cleistocalyx* and classical *Syzygium*, similar to the situation in *Syzygium apodophyllum* (F.Muell.) Hyland (1983, 49) from Queensland, Australia.

Most species of *Syzygium* with calyptrate calyces are clearly different from *S. eymae* in their much larger leaves with more pairs of secondary veins. The few small-leaved species can all be easily distinguished: *S. paradoxum* from Borneo differs by the characters given in the diagnosis. *S. pseudocalcicola* Craven and Biffin (in Craven et al. 2006, 139) from the Philippines and *S. canicortex* Hyland (1983, 66) from Queensland have many, closely parallel secondary veins and caudate leaf apices, *S. apodophyllum* has ovate leaves with a long-acuminate apex and clavate flowers. Several specimens collected on Mt Rorekautimbu in LLNP at 2400 m (e.g. *Brambach et al. 0768*) may belong here. They are morphologically similar to the type specimen, but have longer petioles. Since we currently lack flowering material of these specimens and because of the large distance between the respective collection localities, we prefer to await more specimens before incorporating these collections in *S. eymae*.

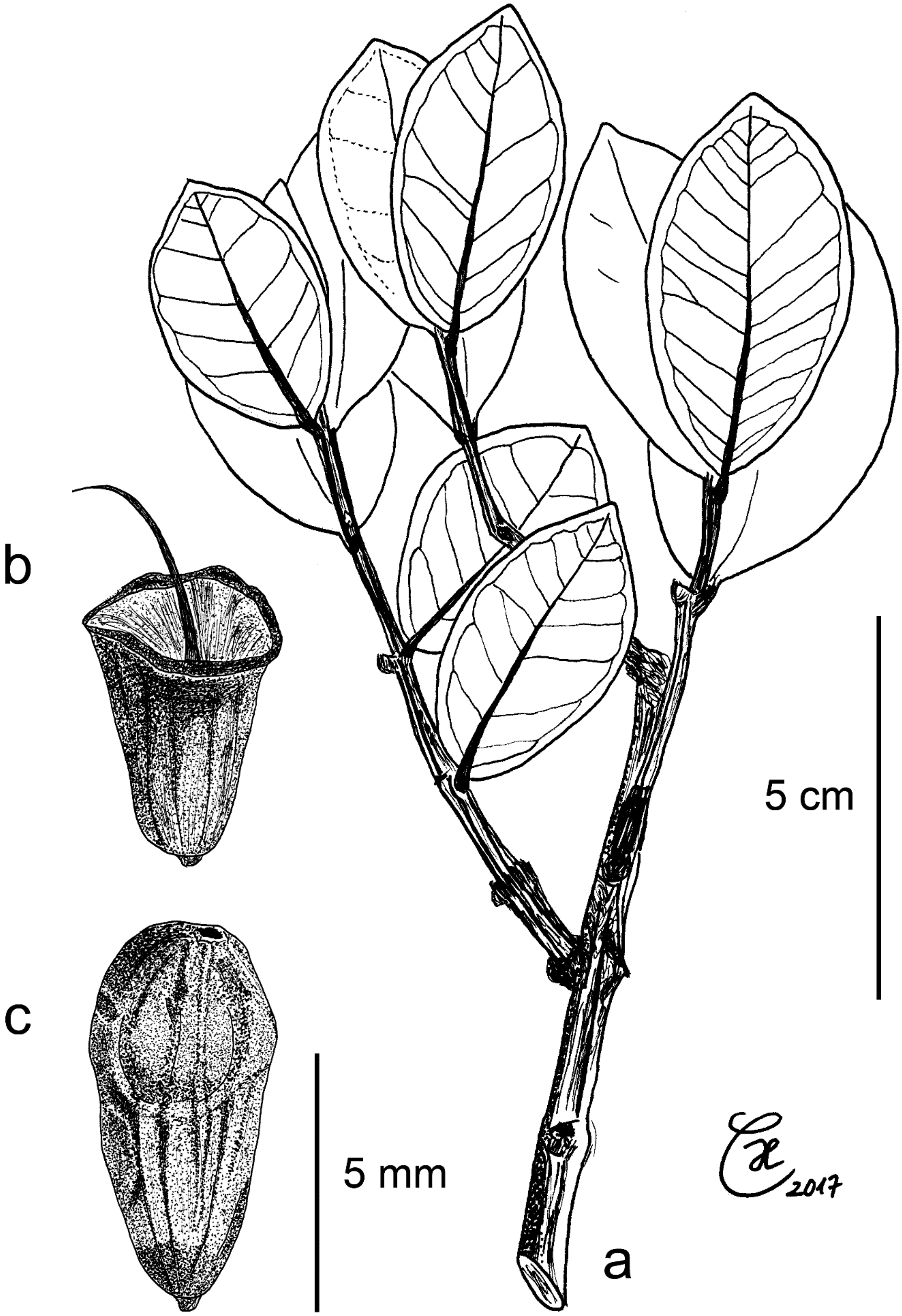

Figure 3.6 *Syzygium eymae*: **a**. leafy twig; b. flower after shedding of calyx and stamens; c. closed pyriform flower, calyptrate calyx with minute apical opening. All drawings from isotype (L) *Eyma 3624.*

3.4.5 *Syzygium galanthum* Brambach, Byng & Culmsee, sp. nov.

urn:lsid:ipni.org:names:60474725-2 Figures 3.4, 3.7, 3.8.

“Myrtaceae sp. 7” (Culmsee and Pitopang 2009)

3.4.5.1 Diagnosis

Syzygium galanthum is similar to *Syzygium hylochare* (Diels) Merrill and Perry (1942, 249) from New Guinea but differs from that species in larger leaves (usually 15–22 vs 8–14 cm long), more slender flowers with longer anthopodia (5–10 vs 3–5 mm) and milky white petals (vs pink or red). It is also similar to the widely cultivated *Syzygium malaccense* (L.) Merrill and Perry (1938b, 215) but has subangular (vs clearly angular) and more slender branchlets (2–3 vs 6–8 mm in diameter), smaller, chartaceous leaves (vs coriaceous), more slender inflorescences, more slender flowers with longer anthopodia (5–10 mm vs 0–5 mm), hypanthia which dry reddish brown with many black glands (vs drying dark brown without conspicuous glands), and creamy-white petals (vs pink or red). Floral formula B1Bt2 K2:2┼ C4* A∞* Ĝ(2)┼ Vx∞.

3.4.5.2 Type

INDONESIA. Central Sulawesi (Sulawesi Tengah): LLNP, Kab. Poso, Kec. Lore Tengah, 3.5 km NE of Rompo, following road to Katu for 3 km, then following footpath N for 2 km, tree-inventory plot Tarara, 1°35.3'S 120°17.0'E, 1200 m, 29 Nov 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1316* (flowers; holotype L[L.3962132]!; isotypes BO [BO-1938381]!, CEB, GOET [GOET020017]!, K [K000993484]!).

3.4.5.3 Description

Trees, up to 25 m tall, diameter at breast height ≤ 30 cm, trunk straight, ≤ 15 m tall, with buttresses 0.4 m tall, sometimes with stilt roots. Outer **bark** bright- or rusty red, peeling off in thin sheets, inner bark pale or dark red, wood straw or cream-coloured. Young **branchlets** 1–2 × 2–3 mm, subangular, flattened, epidermis olive, drying reddish brown, striate; becoming ± terete, bark (reddish) brown, striate or fissured, later peeling off in small thin sheets.

Leaves (sub-)opposite. Petioles 6–18 × 1–3 mm, channelled above, rounded beneath, turning corky, pale brown, drying (reddish) brown. Blades (10–) 12–23 (–26) × (4–) 5.5–7.5 (–9) cm, ratio (1.7–) 2.5–3.2 (–3.5), (narrowly) elliptic or rarely oblanceolate, base acute, obtuse, or rounded, apex acuminate, acumen often recurved, margin flat or revolute; chartaceous, glossy green and often ± bullate above, paler green beneath, drying dull and (greyish or olive) brown above, dull and (yellowish or greyish) brown beneath; pellucid dots scattered or numerous, usually visible on lower surface and sometimes also on upper surface. Midrib channelled above, prominent, rounded, drying pale or reddish brown, striate and with dark gland dots beneath. Secondary vein pairs (6–) 8–10 (–12), 7–25 mm apart, prominulous or not, concolorous with the lamina and usually inconspicuous above, prominent and concolorous with or more reddish than the lamina beneath; intersecondary veins present. Tertiary veins reticulate, lax, prominulous or not, concolorous with the lamina and usually inconspicuous above, prominent and concolorous with or more reddish than the lamina beneath. Inner intramarginal vein 3–8 mm from leaf margin, (strongly) looping; outer intramarginal vein 1–3 mm from leaf margin.

Inflorescences axillary on leafless portion of the twigs, often fascicled, lax, (sub-)sessile botryoids or monads, 3–5 cm long, peduncles absent or ≤ 1 cm long, axes angular, drying (reddish) brown with many black gland dots, turning corky at the base, often with conspicuous whitish blisters. Bracts c. 0.5 mm long, early caducous; bracteoles 2 per flower, similar to bracts.

Flowers 1–8 per inflorescence, within the inflorescence in monads, 4-merous, only known before anthesis, mature buds 15–25 × 5–7 mm, anthopodium 5–10 (–14) mm long, slender. Hypanthium 7–11 × 5–7 mm, infundibuliform, pale green, drying dark reddish brown, wrinkled, densely black gland-dotted and with conspicuous whitish blisters, hypanthium rim 3 mm long. Calyx lobes 2 × 3–5 (outer) and 3–4 × 5–7 (inner) mm, broadly rounded with thin hyaline margins, greenish white, drying red, sparsely gland-dotted. Petals c. 8 × 6 mm, hood shaped before anthesis, milky white, drying yellowish red, faintly veined and densely pellucid-dotted. Stamens c. 100, filaments 4–10 mm long before anthesis, yellowish green, anthers c. 1 mm long, ovoid or ellipsoid, yellow. Ovary bilocular, locules surrounded by spongy tissue, ovules many per locule, ascending. Style 10 mm long before anthesis, pointed, green.

Fruits and **seeds** unknown.

3.4.5.4 Etymology

The species name derives from the Greek *γάλα* (milk) and *άνθος* (flower) and refers to the petals' milky white colour (Figure 3.7g, j). The colour pattern of the flowers is furthermore similar to the one found in the amaryllidaceous genus *Galanthus* Linnaeus (1753, 288).

3.4.5.5 Phenology

The type specimen was collected with mature flower buds in late November, suggesting flowering in December.

3.4.5.6 Distribution and Habitat

Syzygium galanthum is currently only recorded from LLNP in the province of Central Sulawesi (Figure 3.4). There it occurs scattered in undisturbed submontane forest at three localities from 700–1200 m over Sideralic Cambisols and mollic Umbrisols derived from varied parent material. The forests at these localities were dominated by species of Fagaceae, Lauraceae, Moraceae, and Sapotaceae, among others.

3.4.5.7 Conservation Status

Syzygium galanthum has a limited geographical distribution (estimated EOO 140 km²) and seems to be restricted to submontane forest between 700 and 1200 m. We assume that the estimated AOO of 12 km² is unrealistically low, due to limited collection activities in Central Sulawesi. However, despite being inside the protected LLNP, recent deforestation activities have been detected near one of the collection sites (Pono inventory plot, detected using the Global Forest Change website, Hansen et al. 2013), possibly related to the establishment of cocoa plantations (Aiyen Tjoa, Tadulako University, personal communication June 2015). Given the ongoing deforestation activities in the species' narrow geographical range and the recommendation to use a precautionary attitude in conservation assessments (IUCN Standards and Petitions Subcommittee 2017) we propose a preliminary extinction risk assessment of "Endangered" (EN B1ab(i,ii,iii)).

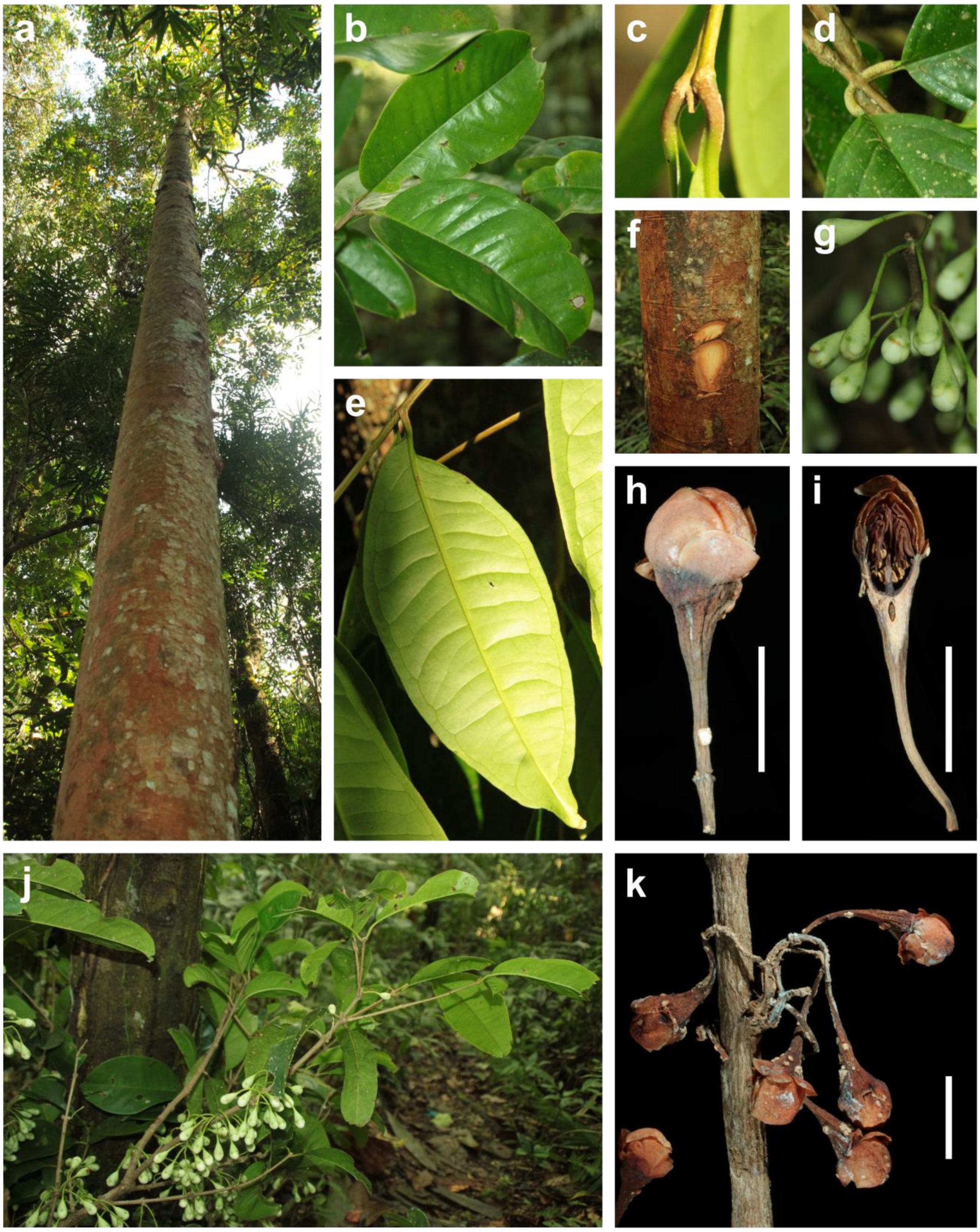

Figure 3.7 Morphological characters of *Syzygium galanthum*. **a** trunk, c. 15 m tall; **b** upper side of leaves; **c** branchlet tip with smooth younger petioles; **d** older corky petioles; **e** underside of leaf; **f** bark slash; **g** mature flower buds in fresh state; **h** dried mature flower bud with apical part of inflorescence axis and white blister on the anthopodium; **i** longitudinal section of mature flower bud in dried state; **j** branch with mature flower buds below the leaves; **k** detail of dried, fascicled inflorescences. **a**–**b** and **f**–**k** type collection *Brambach et al. 1316*; **c** and **e** *Brambach et al. 1083*; **d** *Brambach et al. 1047*. All scale bars = 1 cm.

3.4.5.8 Vernacular name

Tambeanitu (Bahasa Behoa, *Brambach et al. 1316*).

3.4.5.9 Notes

In the field, *S. galanthum* can be recognised by the leaves with corky petioles and rather few, ± arching secondary veins. Similar corky petioles occur in *S. peregrinum* (Blume) Merrill and Perry (1939, 154) from Borneo and the Southern Philippines. A peculiarity is the presence of white blisters on the inflorescence axes and flowers of dried material (Figure 3.7h, k). These blisters were not observed in fresh state and must have appeared during the drying process.

It appears that there is a group of morphologically similar species in Malesia, all characterised by pale-drying leaves with rather few secondary veins, inflorescences below the leaves, and medium-sized to large, showy, infundibuliform flowers with short or long anthopodia and either white or red/pink petals and stamens: e.g. *S. iliasii* Ashton (2011, 222) from Borneo, *S. galanthum* and several unnamed collections from Sulawesi, *S. hylochare*, *S. laqueatum* Merrill and Perry (1942, 257), and *S. phaeostictum* from New Guinea and possibly the Maluku Islands, and the widely cultivated *S. malaccense* with unknown geographical origin. As can be seen from material in L, the assignation of specimens to these species has not been consistent in the past and specific limits in the group need to be critically revised.

3.4.5.10 Additional Specimens Examined (Paratypes)

INDONESIA. Central Sulawesi (Sulawesi Tengah), LLNP:

> Kab. Poso, Kec. Lore Tengah, 3.5 km NE of Rompo, following road to Katu for 3 km, then following footpath N for 2 km, tree-inventory plot Tarara, 1°35.3'S 120°17.0'E, 1200 m, 22 Nov 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1047* (sterile; BO [BO-1938446]!, CEB, GOET [GOET020018]!) & *1083* (sterile; BO [BO-1938445]!,CEB, L!) & *1290* (sterile; BO [BO-1938444]!, CEB, K [K000993485]!).
>
> Kab. Sigi, Kec. Kulawi, 2.4 km ENE of Toro, NE edge of Pono Valley, tree-inventory plot Pono, 1°29.7'S, 120°03.4'E, 1050 m, 16 Aug 2006: *Culmsee 537* (sterile; CEB, K [K000993492]!) & *890* (sterile; BO [BO-1938448]!, CEB); ibid. loco, Jul 2007: *Culmsee r497* (sterile; BO [BO-1938449]!, CEB, GOET [GOET020019]! , L!).

Kab. Sigi, Kec. Kulawi Selatan, 4 km ENE of Watukilo, 400 m N of Mboe River, tree-inventory plot Rantena, 1°36.2'S, 120°04.5'E, 700 m, 17–26 Jun 2011: *Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0533* (sterile; BO [BO-1938447]!, CEB, L!).

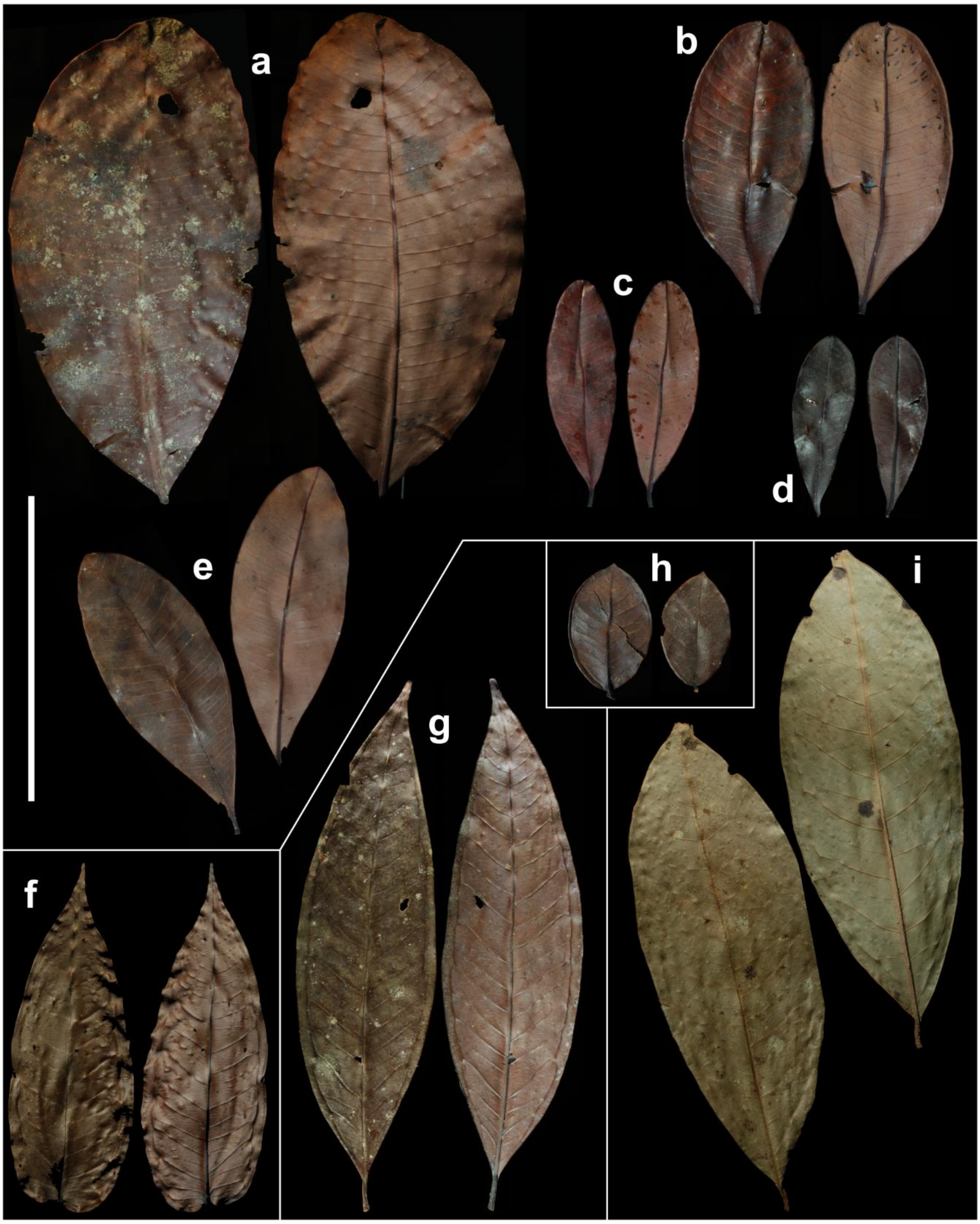

Figure 3.8 Leaves of all new species described. Variation of ***Syzygium balgooyi*** (a–e), ***S. contiguum*** (f), ***S. devogelii*** (g), ***S. eymae*** (h), and ***S. galanthum*** (i). a *Brambach et al. 0283*, b *Brambach et al. 0681*, c *Brambach et al. 1333*, d *de Vogel 5413* [L.2517563], e *Culmsee r2162*, f *Culmsee r463*, g *Brambach et al. 0818*, h *Eyma 3624* [L.2535689], i *Brambach et al. 0533*. Scale bar = 10 cm, valid for all leaves.

4 Diversity, endemism, and composition of tropical mountain forest communities in Sulawesi, Indonesia, in relation to elevation and soil properties

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4.1 Abstract

Explaining the diversity and distribution of tree taxa in the isolated tropical mountain forests (TMF) of the Malesian archipelago remains one of the great challenges of tropical biogeographical research. We investigated tree diversity, endemism and community composition in 13 plots of 0.24 ha between 700 and 2400 m in the TMF of Central Sulawesi's (Indonesia) highlands and related the patterns to gradients in elevation, climate and soil properties. Special attention was paid to understorey trees with stem diameters as low as 2 cm, not exceeding 2/3 of stand canopy height. Based on extensive taxonomic work on the plots, we found that Sulawesi's TMF flora is with 27–78 species per 0.24 ha not species-poorer than that of other Malesian islands, and vascular plant endemism is higher (22% of the species endemic to Sulawesi) than previously thought. Alpha diversity was mainly dependent on elevation and not soil factors (7 parameters tested). The alpha diversity of tree species, genera and families declined linearly with elevation, as did the number of species and genera per family, revealing higher phylogenetic clustering at lower elevations. Indicator Species Analysis and cluster analysis identified three main forest belts (sub-montane at c. 700–1400 m, lower montane at c. 1400–2000 m, upper montane at >c. 2000 m), deviating from earlier zonation concepts by separating sub-montane (rich in taxa related to the lowlands) and lower montane communities (rich in Fagaceae and Myrtaceae). With 27–51% of all tree species in a plot never found in the upper canopy, our data suggest that the guild of true understorey tree species is species-rich (estimated at c. 130 species in our region), contradicting the hypothesis that Southeast Asian tropical forests with mass-flowering trees (here: Fagaceae) are particularly poor in understorey tree species. We conclude that the mountains of Sulawesi harbour remarkably species-rich, but still understudied, TMF with a unique tree flora rich in understorey trees, which are of high conservation priority.

4.2 Introduction

Tree species richness is not uniformly distributed across the tropics. In addition to differences at the continental scale (Barthlott et al. 2007, Slik et al. 2015), driven in part by the available species pool as a result of geological history (Parmentier et al. 2007), environmental factors like climate and soil properties (ter Steege et al. 2003, Koponen et al. 2004) and biological interactions (Noguchi et al. 2007) are important determinants of tree diversity patterns. Both climate and soil conditions change markedly along mountain slopes, making them preferred objects of research on the drivers of tree species diversity (Ohsawa et al. 1985, Aiba and Kitayama 1999, Culmsee and Pitopang 2009, Homeier et al. 2010, Culmsee et al. 2011, Culmsee and Leuschner 2013, Merckx et al. 2015). Due to the close proximity of different habitats and communities and resulting high beta diversity along the slope, tropical mountain forests (TMF) constitute one of the biologically richest landscapes on earth (Aldrich et al. 1997) and often contain a large number of endemic species (Merckx et al. 2015).

Along tropical mountain slopes, two principal patterns of plant alpha diversity change with elevation have been observed, a hump-shaped pattern, often found in herbs and ferns (Kessler 2000, Bhattarai and Vetaas 2003, Bhattarai et al. 2004, Willinghöfer et al. 2011, Dossa et al. 2013) and a monotonic decline with elevation, apparently prevalent in trees (Ohsawa et al. 1985, Aiba et al. 2002, Homeier et al. 2010, Culmsee and Leuschner 2013, Dossa et al. 2013). It has been argued that the latter pattern might be an artefact caused by incomplete sampling along the elevation gradient (Rahbek 1995, 2005), but studies on the complete vascular plant flora on the slope of Mount Kinabalu (Borneo) have confirmed the existence of both elevation patterns for the groups of ferns/herbs and trees (Grytnes and Beaman 2006). In Malesian TMF, where patterns of tree alpha diversity have been studied at the genus level (van Steenis 1935b, 1962, Culmsee and Leuschner 2013), a monotonic decline in taxonomic diversity was found as well. Here, the number of genera per family also decreased with elevation, reflecting phylogenetic clustering at lower elevations and overdispersion further upslope. It has been suggested that the diversity pattern of genera closely reflects that of species in Amazonian lowland forests and that therefore genus-level analyses are sufficient in many cases (Higgins and Ruokolainen 2004). However, the relationship between elevational patterns of species, genera, and family diversity of trees is so far unknown for Southeast Asian forests. We also lack information as to whether elevational patterns of species diversity differ between different phytogeographic regions in Southeast Asia. The geologically relatively young region of Wallacea, which includes Sulawesi, is generally assumed to harbour lower levels of biodiversity than the better-explored continental shelf area known as Sundaland to the west (Barthlott et al. 2007, Kier et al. 2009), but this may merely be an artefact caused by differences in land area (Roos et al. 2004).

Elevational gradients represent experiments of nature with respect to the response of plant communities to gradual environmental change (Körner 2007). In humid tropical mountains, the most influential abiotic factor that changes more or less monotonically with elevation is temperature. Temperature not only influences the physiology of the trees but also key ecosystem functions such as decomposition and mineralisation rates and the accumulation of soil organic matter (Letts et al. 2010). However, small-scale variation in topography on mountain slopes and related gradients in bedrock and soil properties are often overlaying the effects of the temperature decrease with elevation and they considerably increase habitat diversity in tropical mountains. For example, the extraordinarily high tree species richness in the TMF of the eastern slopes of the Ecuadorian Andes is in part the consequence of a high diversity of habitats on upper, mid and lower slope positions and variable slope aspects (Homeier et al. 2010). On Mount Kinabalu, Borneo, bedrock and thus soil chemical properties show a marked change along an elevation transect spanning about 2400 m (Kitayama and Aiba 2002). Although elevation was the most influential environmental correlate for the diversity and composition of tree communities in that elevational transect study, a significant proportion of the variation in tree diversity on Borneo was explained by soil properties (Slik et al. 2009). It appears that large differences in edaphic conditions, such as the contrast between soils on silicate, calcareous or ultramafic rocks, may in certain cases lead to larger differences in tree diversity and community structure than the elevation gradient itself (Aiba et al. 2015).

Since the first studies of Alfred Russel Wallace (1869), the strong endemic element in Sulawesi's fauna has been well recognised (e.g. Musser 1987, Michaux 2010, Stelbrink et al. 2012), while endemism in Sulawesi's flora has been thought to be less pronounced with estimates ranging from 12.3 to 14.2% (van Balgooy 1987, Roos et al. 2004, van Welzen et al. 2011). If valid, this proportion would be much lower than for the neighbouring islands of Borneo, the Philippines and New Guinea (van Welzen and Slik 2009, Culmsee et al. 2011, van Welzen et al. 2011). However, reliable estimates of plant endemism are difficult to obtain for Sulawesi, mainly due to insufficient knowledge of the island's flora (Cannon 2001, Keßler et al. 2002, Culmsee et al. 2011). The presence of mountain ranges is an important factor which increases the number of endemic organisms. Unique biotas are also the main cause for the high conservation values of tropical mountains (Aldrich et al. 1997, Brummitt and Lughadha 2003, Brehm et al. 2005, Richter 2008). In the Malesian region, patterns of plant endemism in TMF have rarely been investigated (Raes et al. 2009, Merckx et al. 2015). On Sulawesi, which has 7% of its total land surface area at montane elevations (> 1500 m; Culmsee and Leuschner 2013), tree inventories at mid- and upper montane elevations (Culmsee et al. 2011) found higher values (20%) for endemic trees than those previously reported (see above) suggesting that endemism patterns in vascular plants at higher elevations of this island should be re-evaluated.

Many diversity analyses in tropical forests are incomplete because part of the understorey species is neglected due to the conventional stem diameter threshold of 10 or 7 cm. However, this neglected guild of shade-tolerant, low-stature trees may significantly contribute to overall tree diversity and play an important role in canopy light interception, as it reduces transmission to very low levels. According to LaFrankie et al. (2006), the guild of understorey trees is less species-rich in Asian lowland rainforests than in Neotropical forests; this assumption needs verification by carefully collected field data.

We investigated tree diversity, endemism and community composition of natural forests along an elevational gradient from 700 to 2400 m in the highlands of Central Sulawesi and related the patterns to gradients in climate and soil properties. Special attention was laid on the inclusion of the understorey trees with stem diameters as low as 2 cm. We expanded the data set of earlier work (Culmsee and Pitopang 2009, Culmsee et al. 2011, Culmsee and Leuschner 2013) to 13 intensive tree inventory plots, focused rigorously on correct species-level identification, and analysed endemism patterns in the woody flora in detail. The poor knowledge of the forest vegetation in this region required elaborating a basic forest community classification as a foundation for the analysis of diversity patterns. Specifically, we addressed the following questions:

1. How does tree alpha diversity at different taxonomic levels (species, genera, families) vary along environmental gradients (climate, soil)?
2. How does alpha diversity change along the elevation gradient in comparison with other mountain ridges in Malesia?
3. Does the diversity of endemic tree species change along the gradients?
4. How do beta diversity and community composition change along these environmental gradients?
5. Do true canopy and understorey species disperse differently along the climate and soil gradients?

4.3 Material and Methods

The study was carried out in Lore Lindu National Park (LLNP; Figure 4.1) in the central mountain range of Sulawesi, Indonesia, an area dominated by acid plutonic and metamorphic rocks and displaying a variety of soil types. The climate of the area is perhumid with most rainfall occurring during April–May and November–December and a slightly drier period from July to October. Drought stress can occur periodically in the intermontane valleys below 1500 m and at irregular intervals due to ENSO events (Wündsch et al. 2014). Seasonal temperature variation is minimal; mean annual temperature decreases by c. 5.2 K per 1000 m elevation from 23.0 °C at 700 m to 14.1 °C at 2400 m (Hijmans et al. 2005, WorldClim 2014). LLNP was created in 1999 and predominantly comprises rainforest from colline (c. 500 m a.s.l.) to upper-montane (2525 m a.s.l.) elevations (Cannon et al. 2007, Culmsee et al. 2010a) with a variety of forest types of high conservation value (Le Saout et al. 2013). With a size of c. 2215 km² and 84% of its area at > 1000 m, it is the largest protected area of montane forest on Sulawesi. The parks' forests have been little affected by human activities until the end of the 19th century, but since then, impact has steadily increased (Weber 2006, Biagioni et al. 2015b), in particular in the valleys. We selected thirteen study sites of primary forest in LLNP at elevations between 700 and 2400 m a.s.l. (Appendix 4.1, Table 1) and carried out tree inventories from February 2011 to April 2012.

At each site, we censused all trees with diameter at breast height (dbh) ≥ 10 cm ('large trees') in a rectangular plot of 0.24 ha size (60 m x 40 m) and additionally all small trees (dbh 2 – 9.9 cm) in subplots totalling 0.06 ha. All censused trees were permanently marked with a number, measured (dbh and height), and pre-identified in the field; we collected extensive herbarium specimens for species identification. Also, we dug four soil-pits per plot and extracted soil samples from the mineral topsoil (0-10 cm) and the ectorganic layer, measured in both horizons pH (KCl) and the concentration of plant macro nutrients (C, N, Ca, Mg, K) and other cations (Na, Al, Fe, and Mn), and calculated the cation exchange capacity (CEC) and the base saturation (i.e. the proportion of Ca, K, Mg and Na in CEC). On all plots surveyed for the first time, we dug an additional pit to describe the soil profile and identify the soil type according to the WRB system (IUSS Working Group WRB 2014).

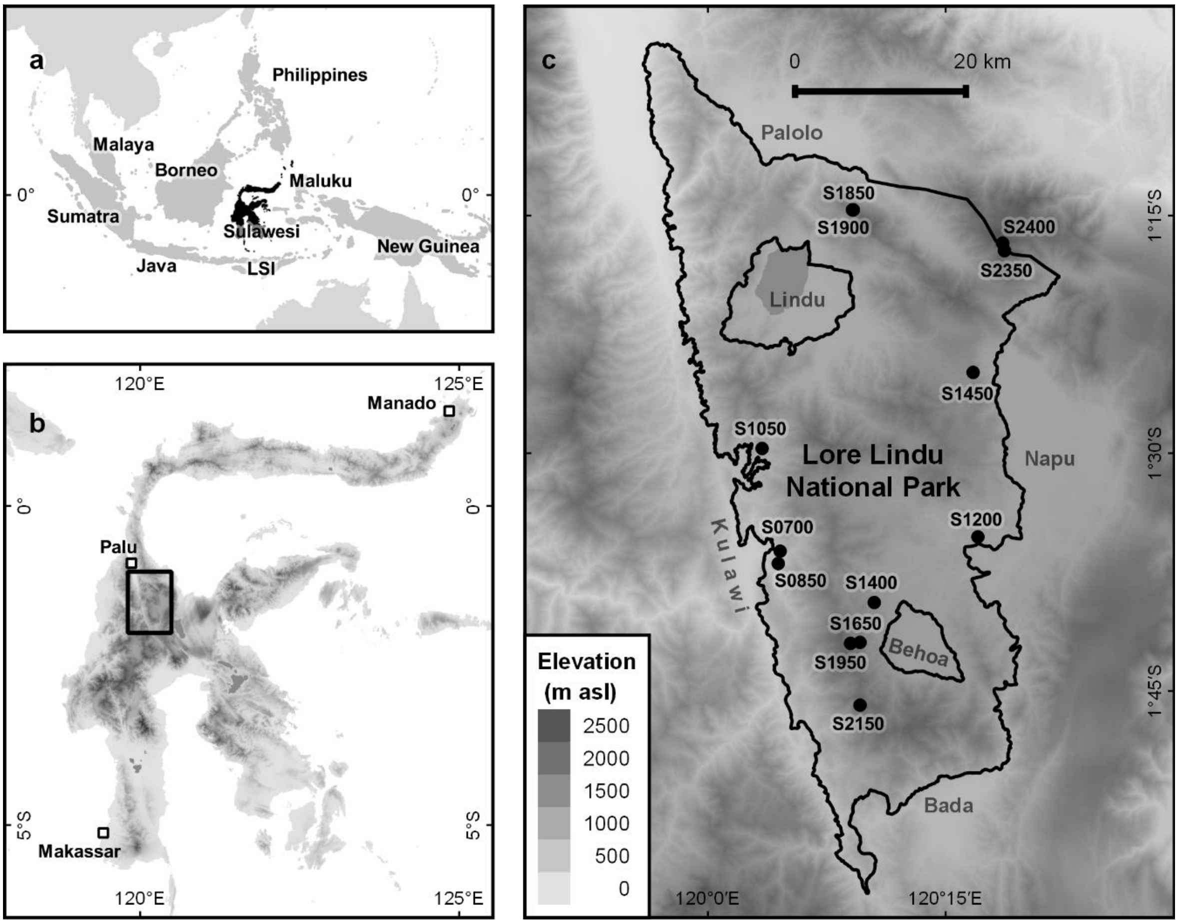

Figure 4.1 Location of study sites. **a** The island of Sulawesi (black) and its surrounding phytogeographical units within Malesia (dark grey, LSI = Lesser Sunda Islands). **b** The study area (rectangle) is located in the Central Sulawesi Mountains, south of the city of Palu. **c** Within the study area of Lore Lindu National Park (LLNP, black borderline), named after Lake Lindu (grey area) and bounded by four major valleys (grey names), 13 tree inventory plots were investigated; plot labels indicate elevation in m a.s.l. Created in QGIS (QGIS Development Team, 2016) using the digital elevation model from Jarvis et al. (2008).

Tree species identification was carried out by FB and HC from 2011–2014 based on the > 2000 collected specimens and additional photographs taken in the field using taxonomic literature (Appendix 4.2) and the reference collections in the herbaria of BO, GOET, K and L (Thiers, continuously updated: http://sweetgum.nybg.org/science/ih/). In total, we surveyed 3852 individuals (2284 trees, 1568 small trees), of which 95.7% were determined to species level. We recorded the distribution of each species (Appendix 4.2) to identify species endemic to the island of Sulawesi.

In each study plot, we performed analyses of diversity and composition for all trees (dbh ≥ 2 cm) and for the group of large trees (dbh ≥ 10 cm) separately. To estimate species alpha diversity, we calculated different measures: observed species richness ($^0D_{obs}$) and effective number of species ($^1D_{obs}$) as well as standardised species richness ($^0D_{210}$) and effective number of species ($^1D_{210}$, primary diversity measure) using a rarefaction/extrapolation approach with a base sample size (BSS) of 210 (Jost 2006, Chao et al. 2014); analogous indices were calculated for genera and families. Then, we used the primary diversity measure as response variable in linear regression models with elevation and seven soil parameters as explaining variables and used backward selection to obtain the minimum adequate models. For the relative number of endemic species per plot, we ran logistic regression models (LRM) with plot elevation as explanatory variable. To compare the diversity data of our plots with those of other Malesian islands, we compiled a list of Malesian tree-inventory plots and calculated their diversity measures, here using a BSS of 90 (Appendix 4.3). Next, to search for patterns related to community composition, we calculated the modified Bray-Curtis dissimilarity index which takes into account unseen shared species between sites (Chao et al. 2005) for all pairs of plots and used the resulting matrix as dependent variable for a multivariate analysis of variance (MANOVA) with different environmental parameters as explanatory variables and a Monte-Carlo permutation test with 500 permutations.

We also calculated the Family Importance Value (FIV; Mori et al. 1983) based on relative diversity, relative density and relative dominance of each family, to summarise the character of each plot's community composition. For the definition of elevational zones based on species composition, we performed a cluster analysis based on the modified Bray-Curtis dissimilarities between plots and an indicator species analysis (Dufrêne and Legendre 1997). Last, we assigned all species to one of two main tree guilds, canopy species or understorey species, using the maximum observed tree height in the plots and literature information on maximum tree height, if available. Species never exceeding 2/3 of canopy height in the plots were considered as understorey species, all others as canopy species. We computed the relative abundance of the guilds in a plot and calculated the respective mean values per elevational zone. For the 10 families with highest number of tree individuals, we ran LRM using plot elevation and guild as explanatory variables and relative abundance of the order as response variable and simplified the models stepwise. See Appendix 4.1 for detailed description of methods.

4.4 Results

4.4.1 Environmental gradients along the slope

Soils in the study region were generally acidic and nutrient-poor in the mineral soil as visible in the base saturation and C/N ratio data (Appendix 4.4: Table 1). Soil properties related to carbon storage (organic layer thickness and the C/N ratios of organic layer and mineral topsoil) increased with elevation indicating decreasing decomposition rates (Appendix 4.4: Table 1). Other parameters, i.e. the base cation concentration in the organic layer, the base saturation of the A-horizon, and the pH(KCl) value of organic layer and mineral topsoil showed no linear relation to elevation (Appendix 4.4: Table 2). The concentration of Ca, Mg and K (base cations) varied largely among the plots (Appendix 4.4: Table 1).

At low and middle elevations up to c. 1700 m, strongly weathered, mostly red, loamy soils with thin organic layers, classified as Ferralsols and Sideralic Cambisols (IUSS Working Group WRB, 2014) dominated. They were replaced by paler, sandy soils with well-developed A-horizons (Cambic Umbrisols) at c. 1800–2000 m. Frequent waterlogging and high accumulation of organic matter characterised the Gleysols and Histosols of the highest plots above c. 2000 m (Appendix 4.1, Table 1). Two plots (S1200 and S1450; Figure 4.1) fell outside this general pattern, having thick A-horizons, pale colours, and better nutrient supply despite occurring at rather low elevations (Appendix 4.1: Table 1, Appendix 4.4: Table 1).

4.4.2 Richness of the tree flora and new species records

We surveyed 3852 individuals (2284 large trees, 1568 small trees), which were assigned to 331 species (including morphospecies, henceforth referred to as “species”, 282 in the group of large trees ≥10 cm dbh, 250 small trees < 10 cm, Appendix 4.5) belonging to 166 genera (150 large trees, 131 small trees) in 78 families (74 large trees, 67 small trees). 201 species were present both as large trees and small trees, 81 only as large trees and 49 exclusively as small trees (Appendix 4.5). The most species-rich family was Lauraceae with 31 species, followed by Myrtaceae (27), Elaeocarpaceae, and Rubiaceae (16 each). Correspondingly, the most species-rich genera were *Syzygium* (Myrtaceae, 25 species), *Elaeocarpus* (Elaeocarpaceae, 15), and *Litsea* (Lauraceae, 11). Twenty (6.0%) hitherto undescribed tree species were collected, which now have been (Brambach et al., in press, 2016, 2013) or will be formally named and described. Furthermore, a large number of species was recorded for Sulawesi (n = 21; 6.3%) or the province of Central Sulawesi (n = 54; 16.3%) for the first time in the context of this study (Appendix 4.5).

4.4.3 Alpha diversity patterns and their association with elevation and soil parameters

Plot-level tree diversity (all trees of dbh ≥ 2 cm) varied from 27 to 78 species per 0.24 ha in the 13 plots. Species diversity declined monotonically with elevation, regardless of the diversity measure used ($^0D_{obs}$, $^1D_{obs}$, $^0D_{210}$, $^1D_{210}$; Figure 4.2a, Appendix 4.6: Table 1). However, some plots showed outliers with plots S0850 and S1850 having fewer and S1200 and S1450 more species than the neighbouring plots along the elevation gradient. The diversity of trees at higher taxonomic levels also declined monotonically with elevation, but the slopes were slightly (genera) or greatly (families) reduced (Figure 4.2b–c, Appendix 4.6: Table 1), reflecting higher numbers of species and genera per family at lower than at upper elevations. Alpha diversity patterns of large trees (dbh ≥ 10 cm) generally showed the same patterns as pooled data for all trees (Appendix 4.6: Figure 1, Table 2).

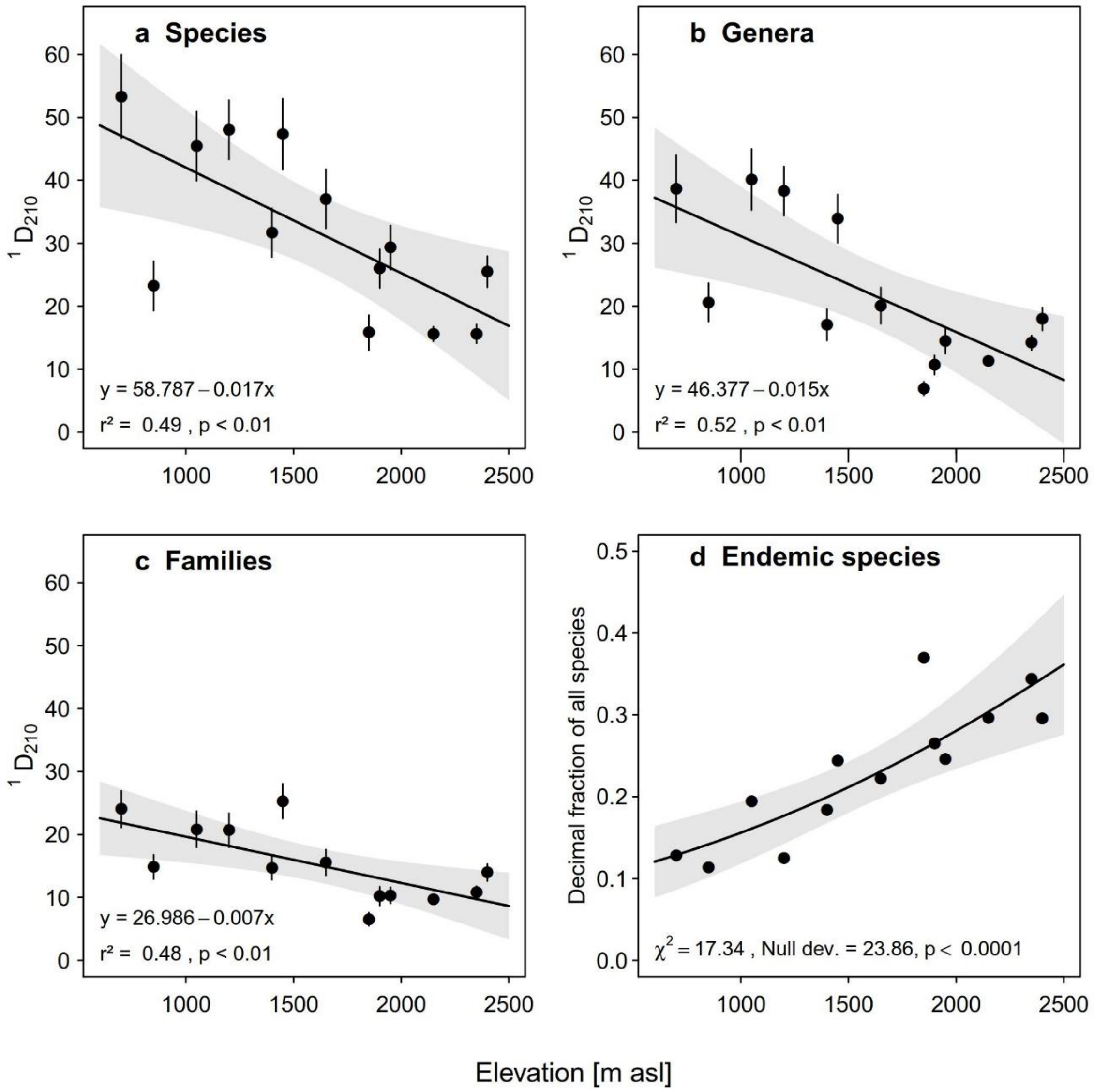

Figure 4.2 Changes in tree diversity at different taxonomic levels (**a-c**) and endemism (**d**) of all trees along the elevational gradient in Lore Lindu National Park. Tree diversity per plot (0.24 ha) is the standardised number of taxa per 210 individuals ($^1D_{210}$). Black lines are regression curves of linear regression models (**a-c**) and a logistic regression model with binomial error structure and logit link function (**d**). Grey areas represent the 95% confidence intervals of the models. Error bars show 95% confidence intervals of a rarefaction/extrapolation procedure using a bootstrap method with 500 replications. All data consider all trees with dbh ≥ 2cm; n = 13. See Appendix 4.1, Table 1 for plot details.

Of the seven soil parameters tested, the pH of the organic layer (pH_O) was the only one not correlated with elevation and having a significant effect on the diversity ($^1D_{210}$) of all trees ($y = -1.73 + 10.71x$, $r^2 = 0.38$, $p < 0.05$ for species; not significant for genera and families). However, at all tested taxonomic levels, the bivariate models with elevation as the only independent variable (Figure 4.2a–c) had higher explanatory power than any of the multiple models. The same pattern emerged when only the diversity ($^1D_{210}$) of large trees was considered ($y = -8.05 + 11.97x$, $r^2 = 0.38$, $p < 0.05$ for species; $y = -8.45 + 9.41x$, $r^2 = 0.31$, $p < 0.05$ for genera; not significant for families). Again, diversity was best explained by the bivariate model with elevation as only independent variable (Appendix 4.6, Figure 1a-c)

The tree species richness in Sulawesi was comparable to that on other Malesian islands (Figure 4.3; Borneo, Java and the Philippines with 7–17 plots; Sumatra and the Maluku Islands represented by only one plot each). Alpha diversity monotonically decreased with elevation in all regions and the magnitude of decrease was also comparable among the islands (c. −12.5 effective species per 1000 m in Sulawesi vs. c. −16.5 on all islands). However, a strong positive effect of plot size on diversity is apparent when comparing ${}^{1}D_{obs}$ of the assessed 51 Malesian plots (Appendix 4.3).

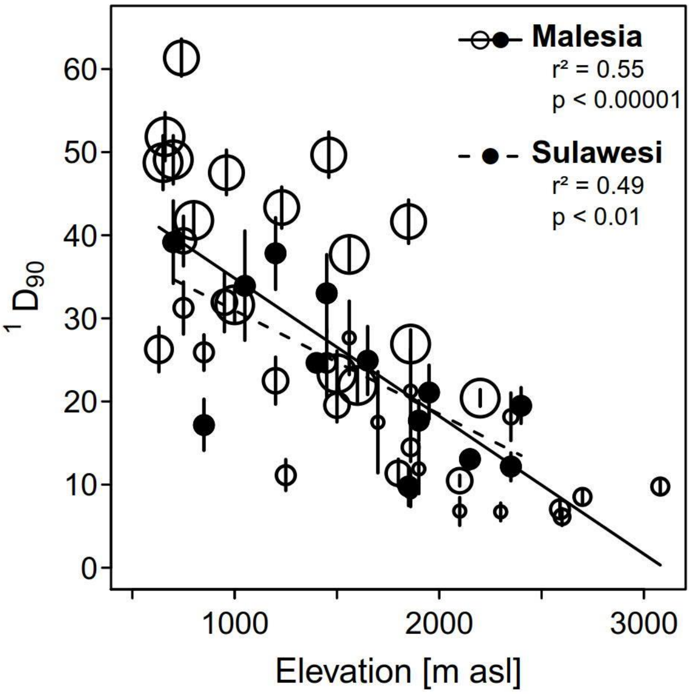

Figure 4.3 Species richness in 51 Malesian tree inventory plots in relation to elevation. Standardised number of species per 90 individuals (${}^{1}D_{90}$) are shown. Closed circles represent plots from Sulawesi (n = 13), open circles those from other Malesian areas (n = 38); the size of circles is proportional to plot size (0.1 – 1.0 ha). The solid regression line is based on all plots (n = 51); error bars show 95% confidence intervals of a rarefaction/ extrapolation procedure using a bootstrap method based on 500 replications. See Appendix 4.3 for plot details.

We found 73 endemic species (22.1%) in total, 58 (20.6%) among the trees ≥ 10 cm and an additional number of 15 species in the group of small trees. The Elaeocarpaceae (nine species of *Elaeocarpus*), Rubiaceae (eight species in six genera), Lauraceae (seven species in five genera) and Myrtaceae (seven species of *Syzygium*) were the most prominent families with endemic taxa. While the absolute number of endemic species per plot did not increase with elevation, the percentage contribution of endemics to total tree species richness significantly increased from c. 12% at 700 m to more than 30% at 2400 m a.s.l. (Figure 4.2d).

4.4.4 Elevational change in community composition

As for diversity, elevation had by far the largest influence on tree species composition of all investigated environmental parameters. According to a MANOVA based on the modified Bray-Curtis dissimilarity, the floristic composition of the tree assemblages (only trees ≥ 10 cm dbh) was significantly influenced by elevation ($r^2 = 0.39^{**}$), pH_O ($r^2 = 0.10^{*}$) and the interaction between them ($r^2 = 0.19^{**}$, residuals: $r^2 = 0.32$, see also ordination in Appendix 4.7: Figure 1). A MANOVA based on the composition of all trees yielded similar results (elevation: $r^2 = 0.43^{**}$, pH_O: $r^2 = 0.10^{*}$, interaction: $r^2 = 0.18^{**}$, residuals: $r^2 = 0.30$). The strong influence of elevation on community composition is also displayed by the marked turnover of dominant families (as expressed by their FIV) along the slope (Appendix 4.8).

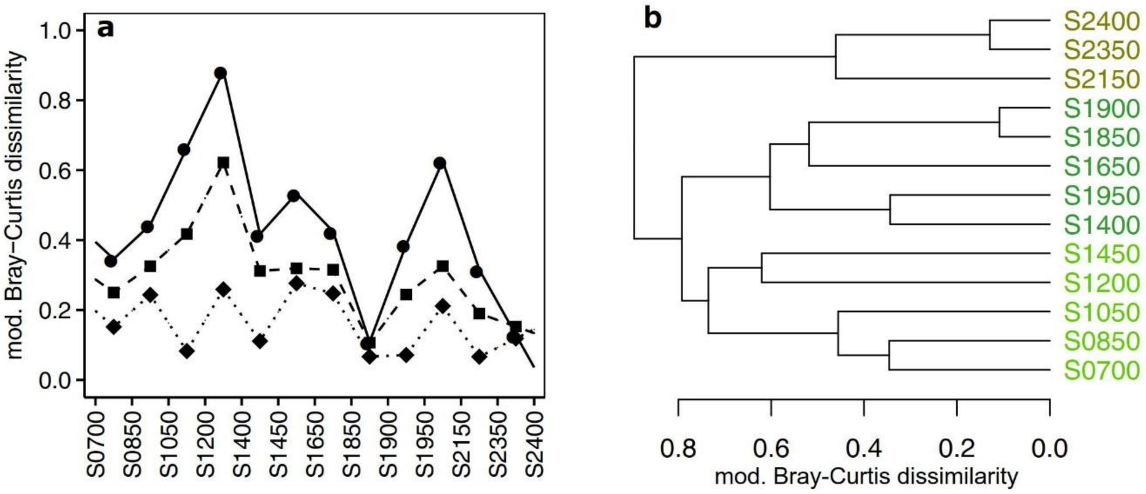

Figure 4.4 Floristic turnover of trees along the elevational gradient in Lore Lindu National Park. **a** Beta diversity, expressed as modified Bray-Curtis dissimilarity, between elevational 'adjacent' plots peaks around 1300 and 2000 m. Diversity is shown at different taxonomic levels: species (circles, solid line), genera (squares, dashed line) and families (diamonds, dotted line). **b** Dendrogram showing clusters of tree assemblages (plots) related to elevation. Clustering based on modified Bray-Curtis dissimilarity using hierarchic agglomerative clustering with the average linkage method (UPGMA). The plots are grouped into three elevational zones: submontane, lower montane and upper montane, consistent with the three main resolved clusters. Data shown for large trees (dbh ≥ 10 cm). See Appendix 4.1, Table 1 for plot details.

The beta diversity patterns of species and genera along the slope, measured by modified Bray-Curtis dissimilarity, showed major floristic turnovers at c. 1300 m and c. 2000 m elevation, pointing at well recognisable ecotones with marked floristic change at these elevations (Figure 4.4a). These ecotones were recognised for the group of all trees and the large trees ≥ 10 cm. The cluster analysis (Figure 4.4b) and the NMDS (Appendix 4.7: Figure 1), both conducted for large trees, also recognised a clear division at c. 2000 m, but further divided the remaining plots at about 1400 m, with plot S1450 more similar to lower-elevation sites and S1400 more to mid-elevation sites. Together, these results indicate three more or less distinct mountain forest belts in Central Sulawesi: (1) sub-montane forest (from < 700 to 1300–1450 m), (2) lower montane forest (from 1300–1450 to 2000 m), and (3) upper montane forest (from 2000 to 2400 m). While the sub-montane and upper montane forests were clearly distinguished and characterised by a unique set of indicator species in the large-tree group, the lower montane forest had a more transitional character and no indicator species at all (Table 4.1).

4.4.5 Diversity and distribution of understorey tree species

The dataset used for the analyses targeting understorey and canopy species contained 2187 individuals of 288 species, of which 689 individuals (133 species) belonged to the group of small-stature understorey species, and 1498 (155) to the canopy species. Hence, understorey trees provided less than a third (32%) of the individuals, but almost half (46%) of all tree species. At the plot level, between 27 and 51% (mean: 42%) of the tree species referred to the understorey guild. While the understorey trees displayed a similar diversity pattern along the elevation transect to the one observed in the canopy species (not shown), the floristic composition of the two guilds differed substantially. In several taxonomic groups, all taxa were confined either to the upper canopy layer (notably in the Fagales and Escalloniales (genus *Polyosma*)) or to the understorey (Gentianales with one exception, Arecales, and Cyatheales), irrespective of elevation. Other orders contained taxa with restriction to the upper canopy at certain elevations, e.g. as in the Mettenusiales (genus *Platea*) in the sub- and lower montane belt, in the Paracryphiales in the lower and upper montane belt, and in the Austrobaileyales (*Trimenia papuana*) only in the upper montane belt; all these orders occurred with only one or two species in the data set. In contrast, the Canellales (*Tasmannia piperita*) were almost exclusively recorded in the understorey of the upper montane forests (Figure 4.5).

Table 4.1 Indicator tree species of three elevational zones in Lore Lindu National Park, Sulawesi, Indonesia. Data shown for large trees (dbh ≥ 10 cm). See Appendix 4.5 for full names. Endemic species shaded grey.

Zone	Species	IndVal[1]
Upper montane	*Dicksonia blumei* (Dicks.)	100.0**
	Elaeocarpus firdausii (Elaeo.)	100.0**
	Quintinia apoensis (Paracr.)	100.0**
	Trimenia papuana (Trimen.)	100.0**
	Phyllocladus hypophyllus (Pod.)	99.0**
	Vaccinium cuneifolium (Eric.)	95.0**
	Prunus grisea (Ros.)	95.0**
	Areca sp. nov. (Arec.)	81.6*
	Elaeocarpus aff. *harunii* (Elaeo.)	81.6*
	Ilex sp. nov. (Aquifol.)	81.6*
	Myrsine minutifolia (Primul.)	81.6*
	Psychotria sp. nov. 2 (Rub.)	81.6*
	Symplocos cochinchinensis (Sympl.)	81.6*
	Syzygium sp. 2 (Myrt.)	81.6*
	Ternstroemia urdanetensis (Penta.)	81.6*
	Dacrycarpus imbricatus (Pod.)	80.6*
	Neolitsea cassia (Laur.)	80.1*
	Melicope maxii (Rut.)	79.1*
	Adinandra eymae (Penta.)	78.4*
	Sphenostemon papuanum (Paracr.)	75.6*
Lower montane	No indicator species	
Sub-montane	*Palaquium obovatum* (Sapot.)	89.4*
	Horsfieldia costulata (Myristic.)	86.3*
	Cryptocarya densiflora (Laur.)	84.0*

[1] Indicator value $p < 0.05$, ** $p < 0.01$

Most orders, however, contained species of both guilds (canopy species and understorey species), albeit with sometimes very different individual numbers. Four of the ten orders with highest individual numbers (Laurales, Magnoliales, Malpighiales, and Oxalidales) displayed no significant effect of guild affiliation on dominance in terms of present individuals; elevation was a more influential factor in the first three orders (Table 4.2, Figure 4.5). The number of individuals of the other six major orders was influenced by guild and elevation (Table 4.2), but the patterns varied individually: The number of species in the Sapindales dropped significantly with elevation with numbers of canopy species decreasing to a far greater extent than those of understorey species. The number of taxa in the Pinales (conifers), almost exclusively present as canopy species, rose exponentially with elevation reflecting their prominent role in the canopy of upper montane forests. Ericales remained relatively constant in the canopy, but increased strongly with elevation in the understorey, becoming the dominant order in the upper montane belt. Lastly, Myrtales, the most individual-rich order overall, were constantly present in rather small numbers in the understorey and increased in importance among the canopy species in the lower and upper montane zones (Table 4.2, Figure 4.5).

The resulting taxonomic structure of the understorey communities varied strongly between the altitudinal belts: The communities at sub-montane elevation consisted of 20 orders, with the species-rich orders Laurales (6.6% ± 1.5% standard error of all individuals in a plot), Gentianales (6.1 ± 2.5%), Magnoliales (3.9 ± 3.1%), and Malpighiales (4.0 ± 0.6%) as the principal components. Lower montane plots harboured 16 orders containing understorey species; here, Ericales (0.2 ± 3.0%), Myrtales (4.8 ± 1.8%), Laurales (3.1 ± 1.3%), and Gentianales (2.9 ± 1.2%) were most dominant. Only 15 orders of understorey species, dominated by Ericales (13.6 ± 0.6%) and Canellales (*Tasmannia piperita*, 6.8 ± 3.8%), occurred in the upper montane forests (Figure 4.5).

Table 4.2 Factors influencing the dominance of important taxonomic orders in Lore Lindu National Park. Effects table of logistic regression models (LRM) for the ten most individual-rich orders showing how guild (nominal; canopy species vs understorey species) and elevation (continuous; 700 – 2400 m) influence the relative number of each order's individuals per plot. Number of individuals per order in parentheses. Based on all trees with dbh ≥ 2 cm in 13 inventory plots with 0.06 ha size each.

Order	Variable	p	Dev. explained	
			Var.	Model
Myrtales (456)	Elevation	0.090<	0.06	0.57
	Guild	0.001	0.51	
Ericales (291)	Elevation	0.62	0.30	0.58
	Guild	0.046	0.14	
	Interaction	0.010	0.13	
Fagales (211)	Elevation	0.192	0.02	0.70
	Guild	0.994	0.68	
Laurales (149)	Elevation	0.006	0.28	0.28
Sapindales (144)	Elevation	<0.001	0.36	0.69
	Guild	<0.001	0.32	
Pinales (114)	Elevation	<0.001	0.49	0.88
	Guild	<0.001	0.39	
Malpighiales (96)	Elevation	0.002	0.41	0.41
Gentianales (73)	Elevation	0.024	0.09	0.64
	Guild	0.014	0.55	
Oxalidales (69)	-	-	-	-
Magnoliales (67)	Elevation	0.006	0.50	0.50

Dev. = Deviance; Var. = variable; Interaction = interaction effect Elevation:Guild

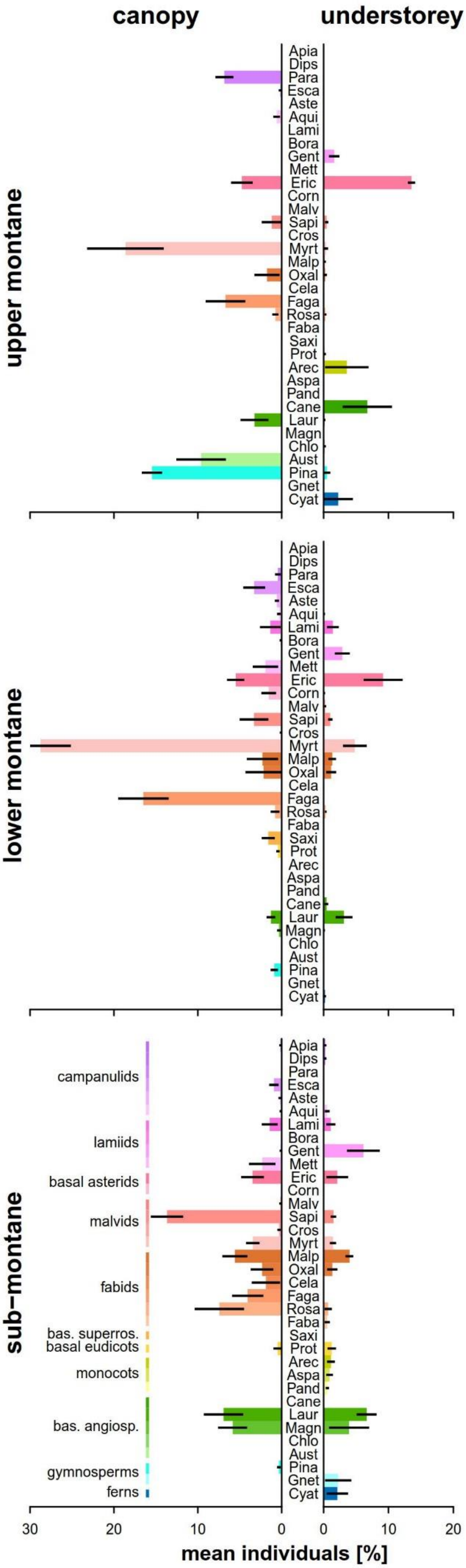

Figure 4.5 Taxonomic groups of trees (phanerogam orders) in Sulawesi’s Lore Lindu National Park mostly exhibit strong affinities with altitudinal belts and/or ecological guilds. The graph shows the mean percentage of tree individuals each order contributes to the communities in a given elevational zone: sub-montane (c. 700 to 1300–1450 m), lower montane (c. 1300–1450 to 2000 m), and upper montane (c. 2000 – 2400 m). The percentage values are given separately for the two guilds (canopy species left, understorey species right). In each elevational zone, the percentages of all orders over both guilds add up to 100. Orders are arranged according to APG IV (The Angiosperm Phylogeny Group, 2016) and colour-coded according to major clades (legend at bottom left; bas. angiosp. = basal angiosperms, bas. superros. = basal superrosids). Based on inventory data including all trees with dbh ≥ 2 cm in 13 inventory plots with plot size 0.06 ha. Error bars indicate one standard error.

4.5 Discussion

4.5.1 Factors controlling tree alpha diversity in Malesian TMF

Although several studies have addressed altitudinal patterns of tree diversity in TMF (e.g. Aiba and Kitayama 1999, Aiba et al. 2005, Slik et al. 2009, Homeier et al. 2010, Culmsee and Leuschner 2013), no fully consistent picture about the abiotic and biotic factors causing these patterns has emerged yet. This is partly caused by different elevation ranges and altitudinal belts covered by the studies (Rahbek 1995), different latitudes and floristic regions sampled (Rahbek 2005, Culmsee and Leuschner 2013), and regional contrasts in the size and connectivity of the elevational zones considered (Ackerly 2003, Bertuzzo et al. 2016). Progress in our understanding is also hampered by the often insufficient knowledge about TMF floras. The latter is the case in the more remote regions of the Malesian Archipelago, where forest inventory plots with thorough species identification are very scarce and records of climatic and edaphic parameters along the slope are lacking.

Our study fills a knowledge gap for the mountains of Sulawesi, which are situated about halfway between the mountains of Sundaland and the Philippines in the northwest and New Guinea in the east. Based on the inventory of all trees with dbh ≥ 2 cm in an elevation transect spanning 1700 m, our data show that the taxonomic richness of trees decreases linearly with elevation at all taxonomic levels. The richness decline is similarly rapid at the species and genus levels, confirming the observation that the floristic patterns of tropical tree genera in the Amazon are closely related to those of the species (Higgins and Ruokolainen 2004) for Southeast Asian TMF at different elevations. That other mountain regions in Malesia showed steeper diversity declines with elevation than Sulawesi (see Figure 4.3) may partly be explained by the fact that, in the former regions, larger plots have often been investigated at lower elevations, leading to potentially inflated diversity scores there. Rarefaction/extrapolation can reduce the plot size effect and thus results in more comparable diversity scores (${}^{0}D_{90}$, ${}^{1}D_{90}$ values).

Even though we studied seven important soil parameters along the slope, we found that elevation is the single most important factor explaining the variance in alpha diversity and also species composition among the 15 studied stands, while edaphic factors were of marginal influence. Height above sea level explained almost 50% of the variation in tree species richness, suggesting that the linear decrease in tree alpha diversity is mainly driven by the temperature decrease. Elevation was also the main factor controlling tree species composition (Figure 4.4b, Appendix 4.6) and it explained the dominance of the ten most abundant plant orders along the slope (Table 4.2). This result is in line with a study from Borneo, where elevation was also the most influential correlate for gradients in tree diversity and community composition (Slik et al. 2009).

Temperature can act on plant communities through multiple pathways, either directly by influencing photosynthesis and respiration rates and thus the carbon balance, or indirectly via effects on decomposition and mineralisation rates, nutrient supply and organic matter accumulation on top of the soil. Widening C/N ratios in the organic layer and the mineral topsoil with increasing elevation together with growing stores of organic material on top of the soil (Appendix 4.4) indicate that mineralisation rate and the availability of nitrogen (and likely of other nutrients) decrease with elevation in Sulawesi in a similar manner as it was found in other tropical mountains (e.g. Moser et al. 2011). This offers an alternative explanation for the observed alpha diversity decrease, independent of the direct effect of temperature reduction: reduced N availability might well exclude tree species of more fertile (and warmer) lowland habitats from colonising higher elevations due to a mechanism related to reduced nutrient supply. Other soil chemical properties such as soil acidity and the availability of base cations (Ca, Mg, K) did not vary systematically with elevation in our transect and thus cannot explain the variation in diversity and species composition. This contrasts with the situation in e.g. Borneo, where Slik et al. (2009) found a significant part of the variation in diversity explained by soil characteristics such soil texture, carbon content, pH, profile depth, soil drainage, and nutrient content. On Mt. Kinabalu on Borneo, Aiba & Kitayama (1999) found a much lower tree diversity in TMF on ultrabasic rock compared to forests on non-ultrabasic substrates. This suggests that elevation (and temperature) effects on diversity can be secondary to soil chemistry effects, when the soil contains high concentrations of toxic elements or very unfavourable element ratios, as is the case with ultrabasic soils which are characterised by high Ni concentrations and high Mg/Ca ratios (Proctor 2003). Such soils have the potential to limit tree productivity and they can thus function as effective environmental filters for colonizing tree species.

The study of Slik et al. (2009) in Borneo and our investigation in Sulawesi differ in that the former included a large number of lowland forests with dipterocarps, which have been found to vary in species richness largely dependent on soil chemistry or geology (Paoli et al. 2006). When elevation differences are small, diversity should depend on other factors than temperature, including soil chemistry and hydrology. Moreover, in the Sulawesi transect, geological variability was relatively low with acidic plutonic bedrocks dominating and only local occurrence of sedimentary and metamorphic rocks. However, even in regions of Malesia with much higher geological diversity, generic richness also correlated closely with elevation and not with soil parameters (Culmsee and Leuschner 2013). This is confirmed by our analysis of a sample of 51 Malesian plots on a wide range of bedrock types (Figure 4.3), where tree species diversity showed a relatively close relation to elevation as well ($r^2 = 0.55$, $p < 0.00001$).

4.5.2 Speciation and endemism along the slope

Lowland forests in South-east Asia have been found to contain a high number of species-rich genera, often with several closely related species co-occurring in a stand (Corlett and Primack 2011). We found a similar pattern in *Syzygium*, the most species-rich genus in our dataset and also the most species-rich woody genus worldwide (Syzygium Working Group et al. 2016). *Syzygium* and other diverse genera like *Lithocarpus* and *Symplocos* are most diverse at lower montane elevations in LLNP, occurring with up to 9 sympatric species (Appendix 4.5), suggesting recent radiations in Malesian TMF as reported for *Begonia* (Thomas et al. 2012) and

Rhododendron (Schwery et al. 2015). However, most genera were present with only one to a few species in our Sulawesi data set, resulting in an overall species : genus ratio of 1.2–1.6 with maximum values at lower montane elevation (Appendix 4.6).

The linear decline with elevation of the number of species and genera per family (see Figure 4.2b–c, Appendix 4.7: Table 1) suggests that speciation rates have been higher at lower elevations, resulting in a larger number of closely related taxa and hence a marked phylogenetic clustering in the community structure of these forests compared to tree assemblages at higher elevations (Cavender-Bares et al. 2004, Culmsee and Leuschner 2013). To coexist successfully in a community, the microhabitats of sympatric taxa must be sufficiently different (Chave 2008), as was demonstrated for montane forests rich in Fagaceae in Thailand (Noguchi et al. 2007). Our floristic data suggest that density-dependent interactions should play a more prominent role at lower than higher elevations in the Malesian TMF (Ricklefs 2008), while physical constraints such as low temperatures and associated impairment of nutrient supply must be important environmental filtering processes at higher altitudes (Körner 2007, Culmsee and Leuschner 2013).

In their revision of the vascular flora for the Flora Malesiana project, van Welzen et al. (2011) found 14% endemic taxa for the island of Sulawesi. Our plot-level tree data show on average a much higher endemism rate (22%) for this island. Endemism on the species level increased with elevation, both in upper canopy and understorey trees. Our higher endemism figures are in part a consequence of recent progress in our knowledge of Sulawesi's flora. However, it appears that endemism in the flora of this island has since long been underestimated, given that neighbouring islands, especially those that also possess high mountains, have higher endemism rates in general. For example, high endemism across multiple taxonomic groups was reported for Mount Kinabalu on Borneo (Merckx et al. 2015). This biodiversity hotspot of relatively recent origin (less than 10 Ma old) has accumulated many neo-endemics in its mountain forests. The mountains of Central Sulawesi are even younger (ca. 5 Ma; Hall 2013), but despite the habitat's young age, most endemic plant taxa belong to old families (according to Davies et al. 2004) with a distribution centre in the Tropics, such as the Lauraceae (family age 100 Ma), Myrtaceae (81 Ma) and Rubiaceae (77 Ma), as predicted by Qian and Ricklefs (2016); only the Elaeocarpaceae with several endemics are a relatively young family (53 Ma).

4.5.3 Elevational zonation of Malesian TMF

Ashton (2014, fig. 4.10) summarised the forest zonation on major mountains in the wet Asian tropics by distinguishing four main altitudinal belts: lowland evergreen forest, lower montane forest, upper montane forest and sub-alpine forest. Our data suggest a major turnover in tree species composition around 1400–1450 m, i.e. between two vegetation zones that emerged from our data as a distinct sub-montane and lower montane belt. The forests at c. 700–1450 m altitude, which we termed sub-montane forest, represent a transition between lowland and lower montane forests which have also been recognized along other Asian mountain slope (Ohsawa 1993, Ashton 2003b). The sub-montane forests of Sulawesi are characterised by a number of indicator tree species of tropical families (cf. Table 4.1, Appendix 4.8) such as Sapotaceae and Myristicaceae, which are absent from the lower montane forest higher upslope. Similarly, sub-montane forests at 700 m on Mt Kinabalu (Borneo) also contain many lowland taxa and thereby differ from the forests in higher altitudinal belts (Aiba and Kitayama 1999).

The lower montane forests of Sulawesi at c. 1400–2000 m altitude lack any own indicator species, pointing to the transitional character of this belt between the sub-montane forests below that contain mostly true tropical taxa, and the upper montane zone above containing truly montane elements including many endemics. However, even though the lower montane forests do not contain a set of differentiating species, they are distinguished by the fact that Fagaceae and Myrtaceae dominate the stands both in terms of individuals and species numbers (see Appendices 4.5, 4.8). Myrtaceae may occur with up to nine species per plot and Fagaceae with up to five and, due to the relatively high wood density found in both families, the stands reach high biomasses, which exceed those of tropical montane forests in South America (Culmsee et al. 2010a).

The boundary between sub-montane and lower montane zone could not exactly be deduced from our data. The slightly different results on the floristic turnover along the slope (Figure 4.4a, Appendix 4.7: Figure 1) and of the cluster analysis indicated that, rather than a sharp boundary, there seems to be a gradual transition between the vegetation belts. In the cluster analysis, plot S1450 grouped with the sub-montane sites, while the lower-lying S1400 was more similar to the plots at 1600–2000 m. As Ashton (2003b) noted, boundaries between thermal elevation zones in tropical mountains are usually overlain by specific effects of local topography, exposition climate, and soil physics and chemistry. The plot S1450 is indeed peculiar for its elevation because tropical elements like Annonaceae and Sapotaceae are relatively abundant there (Appendices 4.5, 4.8). Due to its location in vicinity of the adjacent Napu valley (see Figure 4.1), the plot's regional climate may deviate somewhat from that of the other plots.

Upper montane forests, which were studied between 2150 m and the summits at about 2500 m, occur above c. 2000 m. In Sulawesi, they are largely dominated by the conifer family Podocarpaceae with Fagaceae, Myrtaceae, Elaeocarpaceae, Trimeniaceae, and Paracryphiaceae being co-dominant (Appendices 4.5, 4.8). These forests are more clearly distinguished from the lower montane forest belt by the occurrence of 21 indicator species, of which 10 were endemic to Sulawesi (Table 4.1). This is largely a consequence of the geographical isolation of high mountain peaks (Körner 2000), which may be colonized by species from lower elevations (Ackerly 2003), but which pose a strict environmental filter on possible invaders due to their specific climatic and edaphic conditions. This is supported by the argument that the higher-order taxa of high-elevation forests largely evolved specific adaptations for these conditions a long time ago (Qian and Ricklefs 2016). Podocarpaceae with their fleshy seed-receptacles are well suited for long-distance dispersal between these isolated mountain peaks (Keppel et al. 2011).

4.5.4 Floristic composition and diversity of the understorey

Most of the data available for pan-tropical comparisons of forest structure and composition is based on samplings of mature trees with dbh ≥ 10 or 7 cm. Much less is known about the free-standing woody plants of the understorey with stem diameter < 10 cm, which typically dominate in numbers and may also be more species-rich than the large- and medium-sized trees (LaFrankie et al. 2006, Tchouto et al. 2006, Lü and Tang 2010). This group of woody plants includes the offspring of larger trees but it may also contain tree species with small stature at maturity and high shade tolerance throughout their life, which flower and reproduce in the lower strata of the forest. Species belonging to the latter group pursue a different strategy than the canopy trees, as they rarely receive full sunlight and are exposed to the specific microclimate of the forest interior for their entire lifespan. In our transect, 133 species belonged to this specialised guild, although we assume that the number of true understorey species must be slightly smaller, as several of these species (for which no maximum height is indicated in the literature) may occur in larger size outside of our plots. In fact, assignment of tree species to different categories of size at maturity may be biased in particular in the case of rare species and when the number of plots is limited as in our study.

Despite this uncertainty, our data suggest that, even though the guild of true understorey tree species represents only about a third of all individuals and contributes even less to tree biomass, it comprises almost half of the regional tree species flora in our study area. Forty-four species of this group (33%) may represent endemics to Sulawesi. Furthermore, this group is quite diverse at the order and family level, including all tree fern and monocot families of the study region as well as several dicot families with well-recognized understorey trees (e.g. Chloranthaceae, Ericaceae, Gesneriaceae, Melastomataceae, Monimiaceae, Rubiaceae, and Winteraceae). Our data suggest that there is considerable species turnover in the understorey species along the slope, in a similar manner as is found in the upper canopy. Species of the orders Laurales and Gentianales were the most frequent understorey species of the sub-montane forest plots, while Ericales species gained in importance toward the upper montane plots. Species of Myrtales were present at all elevations in both the understorey and the upper canopy, possibly offering an explanation for their overall high species-richness in Sulawesi's TMF. Since forest height decreases and light penetration to the understorey tends to increase with elevation (e.g. Moser et al. 2008), it is likely that the understorey species of lower elevations are adapted to deeper shade than those at higher elevations and are in fact representing different tree functional types. Comparative physiological measurements are needed to characterize the ecology of tree species in the understorey guild at different elevations.

The few existing studies on tropical understorey trees have investigated only a limited number of lowland and lower montane forest stands across the Tropics. The available data suggested that true understorey tree species are much more frequent and diverse in neotropical forests, while the understorey of Southeast Asian forests to a high percentage consists of saplings of large- and medium-sized trees of the upper canopy with the obvious consequence that flowering and fruiting woody plants are much less common in the understorey of Asian tropical forests (Janzen 1977, LaFrankie et al. 2006, Corlett 2007). These authors hypothesized that the dominance of dipterocarps with periodic mass flowering may be responsible for the apparently striking difference. In support of this assumption, Lü and Tang (Lü and Tang 2010) found the understorey of non-dipterocarp forests in SW China to be mainly composed of trees with small and medium size at maturity, indicating that the absence of dipterocarps in Asian forests may result in a higher species diversity of understorey trees.

With 25 to 51% of all tree species in a plot never reaching the upper canopy, our data from non-dipterocarp forests east of Wallace's line point to a considerable species richness in this guild, contradicting the hypothesis put forward by LaFrankie et al. (2006) that Southeast Asian forest understoreys are generally dominated by saplings of large canopy trees. However, we found no decrease in the relative species richness in this guild when moving upslope from sub-montane to lower montane elevation (c. 1300 – 1950 m), where Fagaceae, another family with periodic mass flowering, dominate. We expected that Dipterocarpaceae and Fagaceae should have a similar effect on the understorey trees. A possible explanation for the existence of a relatively species-rich true understorey vegetation in the forests with abundant *Castanopsis* and *Lithocarpus* in Central Sulawesi could be that the germination success of Fagaceae species after mass flowering is less in the cooler lower montane forests than that of Dipterocarpaceae species in the hot lowlands, or seed predator satiation is less effective in promoting the density of viable seeds in Fagaceae. Also, we observed that mature trees of *Castanopsis* usually secure their sustained survival by growing basal sprouts; hence they may be less reliant on offspring from generative reproduction. Finally, it is possible that dipterocarp saplings are generally reaching higher abundances in the understorey of the respective forests than tropical Fagaceae, as LaFrankie et al. (2006) found in Pasoh, Lambir and Palanan (Malaysia and Philippines) more than 50% of the plants in the smallest diameter class being dipterocarps, which is much higher than the frequency of Fagaceae offspring in our forests.

It is obvious that identifying true understorey tree species is not a trivial task, and percentages given for understorey species may be biased, as the definition of stature at maturity varies among studies; furthermore, low numbers of plots and individuals surveyed may lead to overestimation. A better criterion for identifying true understorey trees than a diameter threshold may be the observation of flowering of small-sized trees in the lower canopy. However, such information is at best available for a few permanently monitored tropical forest plots.

4.6 Conclusions

The tropical mountain forests of Central Sulawesi harbour a species-rich and unique tree flora, which contains more endemic species than previously thought. The understorey, as well, is surprisingly rich in species and genera, in apparent contrast with South-east Asian lowland forests dominated by dipterocarps. We present a delimitation of altitudinal forest zones based on species diversity, taxonomic composition and levels of endemism, distinguishing submontane, lower montane and upper montane forests, which does not fully match earlier zonation schemes. While soil properties may determine species composition and diversity in certain lowland forest regions, elevation is the main determinant of vegetation patterns in submontane to upper montane forests in the study region.

The unique species composition and relatively high endemism give the TMF of Sulawesi and other mountainous islands in the Malesian Archipelago high priority in conservation, even though their taxonomic diversity is smaller than that of lowland forests. The few existing data suggest that even different summits on the same island may harbour clearly recognizable and unique forest communities, which calls for concerted conservation action for the remaining lower montane and upper montane forests of this region.

5 Predominant colonization of Malesian mountains by Australian tree lineages

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5.1 Abstract

Aim: Massive biota mixing due to plate-tectonic movement has shaped the biogeography of Malesia and during the colonization process, Asian plant lineages have presumably been more successful than their Australian counterparts. We aim to gain a deeper understanding of this colonization asymmetry and its underlying mechanisms by analyzing how species richness and abundance of Asian versus Australian tree lineages in three Malesian subregions change along environmental gradients. We hypothesize that differing environmental histories of Asia and Australia, and their relation to habitats in Malesia, have been important factors driving assembly patterns of the Malesian flora.

Location: Malesia, particularly Sundaland, the Philippines, and Wallacea.

Taxa studied: Seed plants (trees).

Methods: We compiled plot-level data of environmental variables and tree abundances from three Malesian subregions. For each species, we inferred its geographic ancestry (Asian or Australian) based on published phylogenetic studies and the fossil record. We used proportions of Australian versus Asian species and individuals per plot to test how they are related to environmental parameters and geographic position using logistic regression models.

Results: Proportionally more Australian (and fewer Asian) tree species and individuals occurred (1) at higher elevations, (2) on sites over ultramafic parent material, and (3) closer to their source region Australia with a significant increase of Australian elements east of Wallace's line. The trend was stronger for individuals than for species.

Main conclusions: Long-term environmental similarities between source and sink habitats have shaped the assembly of the Malesian flora: Tree lineages from tropical Southeast Asia predominantly colonized the Malesian lowlands and rich soils whereas trees from montane refuges in Australia were more successful in the newly emerging Malesian mountains and on poorer soils. The biogeographic patterns caused by the Malesian Floristic Interchange point to the importance of phylogenetic biome conservatism in biotic interchanges and resemble those resulting from the Great American Biotic Interchange in the Neotropics.

5.2 Introduction

The distribution of terrestrial life on earth is spatially structured into biogeographic regions with more or less homogeneous biota, separated by biogeographic boundaries (Wallace 1876a, Cox 2001, Holt et al. 2012). Long-term geographic isolation has shaped the deepest boundaries between these regions (Ficetola et al. 2017) by limiting dispersal to and from other land masses, thus leading to the independent evolution of biotas (e.g. Madagascar, Australia) for millions of years. Rare but frequent long-distance dispersal events followed by successful establishment can lead to the exchange of organisms even between distant landmasses (Crisp et al. 2009). Events where landmasses approach each other due to sea-level changes and/or collision of moving tectonic plates are much less frequent than long-distance dispersal but cause massive biotic exchange with profound impacts on biotas (Vermeij 1991, Antonelli et al. 2018a). Examples include the collision of the Indian continent with Asia in the Eocene (Dutta et al. 2011, 20) and the repeated presence of the Bering Land Bridge between East Asia and North America during the Tertiary (Donoghue and Smith 2004, Graham 2018). Much more recently, transport of organisms by humans has been accelerating the mixing of biotas, causing massive environmental and economic impacts (van Kleunen et al. 2015). Understanding the patterns of past biotic exchanges and their underlying processes can help predict future impacts due to anthropogenic biotic interchange (Vermeij 1991, Heberling et al. 2017).

One of the best studied of such events was the successive establishment of the Central American land bridge (Montes et al. 2015, Graham 2018), which culminated in the Great American Biotic Interchange (GABI; Wallace 1876b, Marshall et al. 1982), the extensive mixing of South American and North American faunas and floras in the late Miocene to Pliocene. Much of our current understanding of tropical biotic exchange resulting from geologic processes stems from the intense study of the GABI. The past isolation of landmasses, availability of different habitats in space and time, and taxon-specific traits like dispersal capability have all had an influence on the interchange patterns, but their relative importance is debated (Simpson 1980, Marshall et al. 1982, Webb 2006, Woodburne 2010, Faurby and Svenning 2016). Furthermore, it remains unclear whether the mechanisms of biota mixing unravelled from the study of the GABI are of universal validity throughout the tropics or largely specific to the Neotropical realm.

Another striking example of geology-driven biota mixing in the tropics is the Indo-Australian or Malay Archipelago. This part of the Paleotropics encompasses the insular region between Asia and Australia (plus the Malay Peninsula) and is usually referred to as Malesia in botanical research (Zollinger 1857, Raes and van Welzen 2009). Similar to the situation in Central America before the closure of the Central American land bridge, the extensions of the Asian continent on the Sunda shelf and of the Australian continent on the Sahul shelf have never had a continuous land bridge connecting them. Today, they are separated by narrow stretches of ocean and the islands referred to as Wallacea (Hall 2017). Already in the Paleogene, when the continents were still far apart from each other, sporadic long-distance dispersal events by plants occurred from Asia to Australia and vice versa. However, biotic interchange, termed the Malesian Floristic Interchange (MFI) or Sahul-Sunda floristic exchange, sharply intensified in the Early Neogene when the two land masses approached each other and the Wallacean islands emerged in between (20–25 Ma; Lohman et al. 2011, Sniderman and Jordan 2011, Richardson et al. 2012, Crayn et al. 2015). Hence, we can generally assume that the species present today in Malesia belong to lineages that were present on either of the two continents before the Neogene but did not occur on both of them.

Today, the fauna of Malesia shows strong geographic structure and includes numerous taxa endemic to the region's diverse subregions. This pattern, known since the initial observations by Wallace (1860) and consistent with relatively low dispersal capabilities in many animal taxa, indicates dispersal filters from Asia to Australia and vice versa. The situation in plants, however, is different: Malesia is a well-defined floristic region, albeit with internal geographic structuring (Raes and van Welzen 2009, Culmsee and Leuschner 2013). Among the most diverse floras worldwide (Slik et al. 2015), the Malesian flora is furthermore said to be derived predominantly from Asian ancestors, indicating asymmetric colonization (Richardson et al. 2012). This assumption is mainly based on the fast-growing number of phylogeographic studies of single plant taxa (e.g. Thomas et al. 2012, Grudinski et al. 2014). These studies have proven highly valuable to understand the evolutionary history and biogeography of numerous Malesian taxa and have allowed insights into more general patterns of colonization (summarized in Crayn et al. 2015).

While the available information suggests that overall, Asian lineages dominate the Malesian flora today (e.g. Richardson et al. 2012), detailed phylogeographic studies are still lacking for many species-rich taxa and the mechanisms of the MFI are generally much less understood than those of its Neotropical counterpart GABI. In particular, the colonization patterns of plants since the onset of the MFI under different environmental conditions have not received sufficient attention (but see Yap et al. 2018). Earlier phytogeographic research has highlighted the abundance of Australian elements in certain Malesian forest habitats, such as in mountains and areas with ultramafic parent material (van Steenis 1935b). Attempts to quantify the contribution of plant lineages of different origins to habitat-wise floral assembly have so far been limited to case studies using few forest plots available on a regional level (Culmsee et al. 2011, Aiba et al. 2015). Furthermore, previous studies have predominantly used species richness as a measure for evolutionary success (e.g. Richardson et al. 2012) neglecting other quantitative measures like abundance or biomass due to lack of adequate data (but see Culmsee et al. 2010a). These other parameters are needed, however, to comprehensively describe patterns of colonization and dominance. Tropical mountain forests are well suited to study colonization processes in the distant geological past. They possess bioclimatic belts with a steep turnover in tree community composition (Körner et al. 2011), are typically less affected by anthropogenic disturbance and their tree floras are often more natural than those of remaining lowland forests (Cannon et al. 2007).

Malesia and the MFI can serve as an independent model to test hypotheses resulting from decades of research on the GABI. If long isolation leads to lower competitiveness (Simpson 1980, Faurby and Svenning 2016), then Australian lineages should be less successful in the colonization of Malesia than their Asian counterparts, regardless of habitat suitability (in the following we speak of Asia and Australia instead of Sunda shelf and Sahul shelf, as Asian species dispersed into Malesia not only from Sundaland, but also via the Philippines (see van Steenis 1935a)). Alternatively, if colonization depends strongly on the available habitat (Cody et al. 2010, Woodburne 2010), colonization asymmetry will vary between habitats and relate to the environmental history of the source and sink regions. Trees with ancestors in continental Southeast Asia and Sundaland, where rainforest has been present since at least the mid-Eocene (Morley 2012, Hall 2013), may possess adaptations to hotter and moister climates than taxa from clades that originated on the Australian continent. The latter underwent strong aridification in the Neogene after its separation from Antarctica when mesic biomes remained confined to mountain areas along the eastern coast of Australia and in parts of New Guinea (Quarles van Ufford and Cloos 2005, Byrne et al. 2011, Sniderman and Jordan 2011, Kooyman et al. 2014). Furthermore, the large extent of nutrient-poor soils on the Australian continent could have favoured plant lineages adapted to these soils (van Steenis 1979, Hill 2004).

Dispersal filters such as stretches of ocean between suitable terrestrial habitats limit biotic exchange (Woodburne 2010, Bacon et al. 2015, Graham 2018). However, plants have comparatively high dispersal capabilities, so that the filter function of ocean barriers may be less-important to them than to many animal taxa, as exemplified by the relative commonness of long-distance dispersal in plants (Donoghue and Smith 2004, Sanmartín et al. 2004, Bacon et al. 2015). During the MFI, newly emerging islands in Wallacea likely facilitated stepping-stone dispersal, so that the occurrence of plant lineages in Malesia may be only weakly dependent on distance from their host region, i.e. the land masses of Asia and Australia, whereas suitable habitat may play a larger role.

In the present study, we attempt to close the knowledge gap about colonization asymmetry in the MFI. More specifically, we try to quantify the proportion of tree species and individuals with Asian versus Australian ancestry in Malesian forests by adopting a mixed approach. First, we compiled plot-level data of trees from the three major Malesian subregions and biodiversity hotspots Sundaland, the Philippines, and Wallacea, to establish a dataset with > 15 800 tree individuals of ca 1640 species from a wide phylogenetic range (ca 35% of all vascular plant families containing trees). The dataset further contains information on species abundances and environmental variables for each plot. Second, we inferred the geographic ancestry (Asian or Australian) for each species by building on the wealth of phylogenetic information that has become available in the last three decades supplemented by relevant fossil records. This allows us to quantify for the first time the contribution of Asian versus Australian lineages to community composition in Malesian forests under different environmental conditions and to test the following hypotheses regarding biotic interchanges:

1. The contribution of Asian versus Australian tree lineages to community composition in Malesian forests differs between habitats.
2. Asian lineages are more dominant in lowland rain forests, while Australian lineages strive better in mountains and on nutrient-poor soils.
3. Habitat, rather than distance to the source region (Asia or Australia), drives the differences in community composition.

5.3 Methods

5.3.1 Malesian tree inventory data

We compiled a dataset of 55 tree inventory plots (all trees with diameter at breast height ≥ 10 cm) in old-growth forests (Figure 5.1), including 42 plots from published studies and 13 plots of our own work on Sulawesi, Indonesia (Table 5.1, Appendix 5.1). We classified the western and central parts of Malesia covered by our dataset into three phytogeographical areas, Sundaland, the Philippines, and Wallacea, following the nomenclature of biodiversity hotspots of Myers et al. (2000). Sundaland was represented by plots in Sumatra (n = 1), Borneo (n =19), and Java (n = 10) spanning an elevational gradient from 250–3080 m a.s.l., the Philippines by plots on four islands (n = 11) from 750–2200 m, and Wallacea by two areas, each one in the subregions Sulawesi (n = 13) and Maluku Islands (n = 1) from 630–2400 m. Plot size varied within and among the studies (0.1–1.0 ha; data sources in Appendix 5.1). We selected only such studies that provided species identification to genus or species level with a high taxonomic standard, including the deposition of voucher specimens in herbaria and a full list of the recorded species per plot with their abundances, i.e. the per-plot number of individuals per species.

5.3.2 Assignment of biogeographic origin

We checked the inventory lists of the original studies and excluded tree ferns (208 individuals from ten species) because we were not sure whether all original studies had included them in their inventories; we also removed non-tree taxa (24 individuals from four species). Then we combined the lists of species and their abundances from all plots (16 131 individuals in total) and standardized the plant names with the help of taxonomic literature and web tools (van Steenis et al. 1948-2019, Soepadmo et al. 1995-2014, IPNI 2015, The Plant List 2019, WCSP 2019). We pruned the original names to species level and manually corrected spelling errors. We removed cf.- and aff.-qualifiers but retained the following epithets unless the purportedly similar species did not occur naturally in the respective biogeographical region (in that case we used ‘sp.’). We treated morphospecies as different species when they were clearly distinguished as such in the original sources (e.g. as sp.1, sp.2, etc., see Appendix 5.1). In addition, we assumed that morphospecies in the same genus but from different original studies represented different species. The total number of species in our dataset (see Appendix 5.3) is thus probably inflated and should be seen as an estimate. However, since our main results are based on calculated percentages on a plot basis, this possible bias does not affect our analyses.

Table 5.1 Dataset of 55 tree inventory plots from 12 Malesian areas in the three phytogeographic regions of Sundaland, the Philippines, and Wallacea with physiographic information (geographic coordinates, distance from the Sahul Shelf, and elevation), geological substrate, plot sizes and numbers, and original sources. All data sources are listed in Appendix 5.1.

Location	Sahul dist. (km)	Data source	Parent material	Elevation (m a.s.l.)	Plot size (ha)	Plots (n)
Sundaland						
Batang Gadis NP, N Sumatra (N 0.6°, E 99.5°)	3050	Kartawinata et al. 2004	sedimentary	660	1.00	1
Batu Apoi NP, Brunei, Borneo (N 4.5°, E 115.2°)	1760	Poulsen et al. 1996	sedimentary	250	1.00	1
Apo Kayan FR, E Kalimantan, Borneo (N 2.7°, E 115.5°)	1640	Bratawinata 1986	sedimentary	740–1850	0.80	5
Mt Kinabalu, Sabah, Borneo (N 6.1°, E 116.6°)	1690	Aiba et al. 2002	sedimentary	650–3080	0.20–1.00	5
			ultramafic	700–2700	0.20–1.00	3
		Takyu et al. 2002	sedimentary	1560–1860	0.10	2
			ultramafic	1860	0.10	1
		Kitayama 1995	sedimentary	2350–2600	0.14–0.17	2
Mt. Wilis, E Java (S 7.9°, E 111.8°)	1410	Purwaningsih et al. 2017	volcanic	1300–1500	0.25	3
Mt Gede-Pangrango NP, W Java (S 6.8°, E 107.0°)	1960	Helmi et al. 2009	volcanic	800	1.00	1
		Meijer 1959	volcanic	1500	1.00	1
		Yamada 1975	volcanic	1600	1.00	1
		Yamada 1977	volcanic	1700–2300	0.10	4
Philippines						
Mt Banahao, Luzon (N 14.5°, E 121.5°)	1980	Aragones 1991	volcanic	750–2100	0.42	6
Mt Giting-Giting, Sibuyan (N 12.4°, E 122.6°)	1730	Proctor et al. 1998	ultramafic	770–1240	0.25	3
Mt Mandalagan, Negros (N 10.7°, E 123.2°)	1530	Hamann et al. 1999	volcanic	1000	1.00	1
Mt Kinasalapi, Mindanao (N 8.0°, E 125.5°)	1140	Pipoly & Madulid 1998	volcanic	2200	1.00	1
Wallacea						
Lore Lindu NP, Sulawesi (S 1.5°, E 120.2°)	1040	Brambach et al. 2017	acid plutonic	700–2400	0.24	13
Tapayo, Halmahera, Maluku Islands (N 0.8°, E 128.0°)	330	Whitmore et al. 1987	sedimentary	630	0.50	1

FR = Forest Reserve, NP = National Park, Sahul dist. = Distance from Sahul Shelf

Assuming that each species or its ancestor was present in only one continent – Asia or Australia – before the intensification of the MFI in the early Neogene (Crayn et al. 2015), we separated the species into two groups: those with Asian ancestry (hereafter: Asian species) versus those with Australian origin (Australian species). To compile this information, we carried out an exhaustive literature search for phylogeographic studies (e.g. phylogenetic studies including direct reconstruction of ancestral areas), other dated and undated phylogenetic studies, relevant fossil data, and taxonomic literature, using in total ca 300 published sources (see references in Appendix 5.2 in the Supplementary Information). As most phylogenetic studies use incomplete taxon sampling, many of our species were not directly represented in the references. We therefore assumed that all species of a genus shared the same biogeographic ancestry (Asian or Australian) unless the results of studies indicated otherwise. In the latter cases (e.g. *Macaranga*, *Ficus*), we attempted to match our species to infrageneric clades, mostly based on systematic studies and morphological characters. Likewise, we attempted to assign species of polyphyletic genera to the correct clades in the phylogenetic studies. When phylogeographic studies were not available, we resorted to other phylogenetic sources. These often did not explicitly contain information on biogeographic history, but with the distribution of sampled species taken from floristic accounts and databases, we could usually infer the geographic ancestry nonetheless, especially when the phylogenies were dated. Tree individuals which could not be assigned to one of these ancestry groups were excluded from further analyses ($n = 245$). The majority of those ambiguous individuals belonged to morphospecies which did not have sufficient taxonomic resolution to infer their geographic origin, but we also included alien species here (eleven individuals in four species), as they do not convey any meaningful biogeographic information in the context or our study. The percentages of individuals with ambiguous ancestry per plot ranged from 0% to 11.8% (median 0%, mean 1.3%). Plots on ultramafic parent material contained a significantly higher proportion of individuals with unknown geographic origin than plots on other substrates (logistic regression model with quasi-binomial error structure: $D^2 = 0.16$, $p < 0.0001$), possibly highlighting the high number of insufficiently known endemics expected to occur there; the other variables did not have any significant effects (Appendix 5.2: Figure 1). Most of the trees that lack information on their geographic origin do so because of insufficient taxonomic resolution (i.e. completely unidentified or identified to family level only). We consider it unlikely that species with Australian ancestry are generally more difficult to identify than those from Asia or vice versa. Therefore, despite the unequal representation of trees with ambiguous geographic origin per plot, deleting these records prior to the main analyses is unlikely to add a significant bias to our results.

The final dataset contained 15 886 individuals assigned to 1636 species and morphospecies. We were able to classify the majority of individuals (73%) using phylogeographic studies or a combination of these with information on fossils. For most of the rest, we found dated (17%) or undated phylogenies (9%) without direct inference of geographic origin and combined these with information on the fossil record and/or distribution data to infer the respective ancestral regions from other sources. Only for the remaining 2% of individuals, we used fossil record and/or distribution data alone. Details regarding the methods, references and specifications of species' assignation to their geographic ancestry are summarized in Appendix S1. A list of all species with their respective inferred origin is given in Appendix S2. Finally, we calculated the proportion of Australian species per plot and the proportion of individuals belonging to these species (Australian individuals) per plot. The Australian and Asian proportions per plot amount to 100%.

5.3.3 Data analysis

To link the occurrence of Australian versus Asian lineages in Malesia to geography and environmental factors, we employed the per-plot proportions of Australian species and individuals as response variables in multiple logistic regression models (LRM) using the *glm* function in RStudio (RStudio Team 2016, based on R; R Core Team 2017).

To select suitable explanatory variables, we extracted plot elevation, geological parent material, and (approximate) geographic position from the original studies (). We followed two strategies to account for the geographic position: first, we calculated the distance of each plot to the nearest border of the Sahul Shelf (displayed in Figure 5.1a) using the ruler tool in QGIS (QGIS Development Team 2016). Second, we used the three phytogeographic regions Sundaland, the Philippines, and Wallacea to define the plots' regional affiliations.

We then tested for correlation between the environmental parameters elevation, parent material (geology), distance from the Sahul Shelf (Sahul distance) and phytogeographic region (phytoregion). Geology was strongly correlated with phytoregion (Chi² test: Chi² = 62.5, $p < 0.00001$) and with Sahul distance (Kruskal-Wallis test: Chi² = 31.5, $p < 0.00001$). We explain this by the uneven distribution of different parent materials between the studied locations, e.g. volcanic material only occurred on Java, while acid plutonic rock was exclusively found on Sulawesi (Table 5.1). We therefore simplified the geology classification to have only two categories: ultramafic versus non-ultramafic. The resulting binary geology showed no significant correlation with phytoregion (Chi² test: Chi² = 4.1, $p = 0.13$) or Sahul distance (Kruskal-Wallis test: Chi² = 1.3, $p = 0.25$) and was used for all further analyses. Phytoregion and Sahul distance were also highly correlated (Kruskal-Wallis test: Chi² = 34.5, $p < 0.00001$), while elevation was independent of all other parameters. We decided to start the model selection with two separate models for each response variable, one employing elevation, geology and phytoregion (hereafter referred to as phytoregion model), the other using elevation, geology and Sahul distance (hereafter: distance model) as explanatory variables. Hence, we computed four different models: A phytoregion model for Australian species (model 1), a distance model for Australian species (model 2), a phytoregion model for Australian individuals (model 3), and a distance model for Australian individuals (model 4).

For the proportion of Australian species, we started with a full model with binomial error structure and logit link function containing all three explanatory variables and their interaction effects. Using the *dredge* function of the MuMIn package (Bartoń 2018), we then computed all possible nested models and sorted them according to their Bayesian information criterion (BIC) to select the best model. BIC penalizes model complexity more strongly than the commonly used Akaike information criterion (AIC). We chose BIC because we wanted to avoid multiple interaction effects, which would be difficult to interpret ecologically. We successively discarded all models with $\Delta\text{BIC} \geq 2$ compared to the model with the lowest BIC. Among the remaining ones, we discarded those with the most parameters. For both the phytoregion model and the distance model, the best model included all three independent variables but no interaction effects. For the proportion of Australian individuals, we employed a similar model selection process, but due to large data overdispersion, here we used the LRM with a quasi-binomial error structure and performed the model selection based on quasi-BIC (qBIC). The resulting best models also included all three independent variables without interaction effects. To test whether spatial autocorrelation between plots played a role beyond the tested parameters, we calculated Moran's I for the residuals of all four best models (models 1–4, see Table 2) using the *lm.morantest* function of the *spdep* package (Bivand et al. 2019). All models contained non-spatially correlated residuals (Moran's I = 0.45–0.60, p = 0.27–0.33).

5.4 Results

5.4.1 Biogeographical patterns in the Malesian subregions

In the 12 analysed Malesian areas taken together, Asian lineages strongly dominated, representing 76% of all investigated tree species and 67% of all tree individuals. The dominance decreased from Sundaland in the west (80% of species, 69% of individuals) over the Philippines (75%, 68%) to Wallacea in the east (64%, 53%). Asian lineages were more dominant on sites over non-ultramafic (78% of species, 69% of individuals) than on those with ultramafic parent material (65%, 54%).

Correspondingly, the mean per-plot percentage of Australian tree species was higher in Wallacea (39%, n = 14) than in the Philippines (31%, n = 11) and Sundaland (30%, n = 30). Similarly, Wallacean plots had the highest mean number of Australian individuals (43%) compared to the Philippines (32%) and Sundaland (34%). Plots on ultramafic parent material on average had more Australian species (43%, n = 7) and individuals (51%) than non-ultramafic plots (31% of species and 34% of individuals, n = 48).

5.4.2 Environmental conditions driving biogeographical patterns

Multiple logistic regression models (LRM) uncovered significant differences in the proportion of both Australian species and Australian individuals between the 55 plots from 12 Malesian areas in relation to all investigated environmental variables (Table 5.2). For the proportion of Australian species per plot, the model with elevation, parent material, and phytogeographic region as independent variables (model 1, D^2_{adj} = 0.71***) performed better than the one using elevation, parent material and distance from the Sahul shelf (model 2, D^2_{adj} = 0.66***). In both models, plots at higher elevation had higher percentages of Australian species and this factor accounted for about half of the deviance. Australian species were also better represented on plots with ultramafic parent material compared to non-ultramafic localities but the explanatory power of the parent material was much lower (D^2 = 0.12***) compared to elevation. In the phytoregion model (model 1), phytoregion was the second most explanatory variable (D^2_{adj} = 0.16). Here, Wallacean plots had significantly more Australian species than those from the

Philippines and Sundaland. In the distance model (model 2), the explanatory power of distance to the Sahul shelf (D^2_{adj} = 0.08**) was lower than that of parent material (Table 5.2, Figure 5.1b–d).

Table 5.2 Elevation, geology, and geographic position determine the proportion of tree species and individuals with Australian ancestry in Malesian forest plots. Results of multiple logistic regression models (LRM) of the per-plot (n = 55) proportion of Australian tree species and individuals in 12 Malesian areas. Models include the independent environmental factors elevation, geology (ultramafic vs non-ultramafic) and geographic location. Geographic location (see Table 5.1) was included as the position in one of three phytoregions (Sundaland, the Philippines, and Wallacea; models 1 and 3) or the distance to the Sahul shelf (models 2 and 4). Error structure is binomial in models 1 and 2 and quasi-binomial due to overdispersion in models 3 and 4.

	Proportion of							
	Australian species plot^{-1}				Australian individuals plot^{-1}			
	Model 1 (Phytoregion)		Model 2 (Sahul distance)		Model 3 (Phytoregion)		Model 4 (Sahul distance)	
BIC/qBIC		285.28		298.48		103.89		105.63
D^2_{adj}		0.71 ***		0.66 ***		0.69 ***		0.67 ***
Variable	**D^2**	**Coefficient**	**D^2**	**Coefficient**	**D^2**	**Coefficient**	**D^2**	**Coefficient**
Elevation	0.42	0.0007 ***	0.47	0.0007 ***	0.51	0.0010 ***	0.51	0.0009 ***
Geology (ultramafic)	0.12	0.7133 ***	0.12	0.6625 ***	0.12	1.0595 ***	0.12	0.9942 ***
Sahul distance	-	-	0.08	-0.0004 ***	-	-	0.06	-0.0006 ***
Phytoregion	0.16		-	-	0.06		-	-
Sundaland		-0.1814				-0.0065		
Philippines		0				0		
Wallacea		0.4246 **				0.7102 **		

BIC = Bayesian information criterion (models 1 and 2). D^2 = proportion of deviance explained. D^2_{adj} = adjusted D^2 (Guisan & Zimmermann, 2000). qBIC = quasi-BIC based on a quasi-binomial error structure (models 3 and 4). Sahul distance = Distance from Sahul Shelf. ** $p < 0.01$, *** $p < 0.001$

For the proportion of Australian tree individuals in a plot, differences between phytoregion model (model 3, D^2adj = 0.69***) and the distance model (model 4, D^2adj = 0.67***) were negligible. Again, elevation explained more than half of the deviance (D^2adj = 0.54***) with an increasing proportion of trees from Australian lineages towards higher elevations. The patterns of higher proportions of Australian trees in ultramafic than in non-ultramafic parent materials remained constant (models 3 and 4, D^2adj = 0.12***). Phytoregion (model 3) and the distance to the Sahul shelf (model 4) both explained a similar proportion of the respective model deviance, and in model 3, there was again a significant difference between the Wallacean plots with more and those from Sundaland and the Philippines with fewer Australian tree individuals (Table 5.2, Figure 5.1e–g).

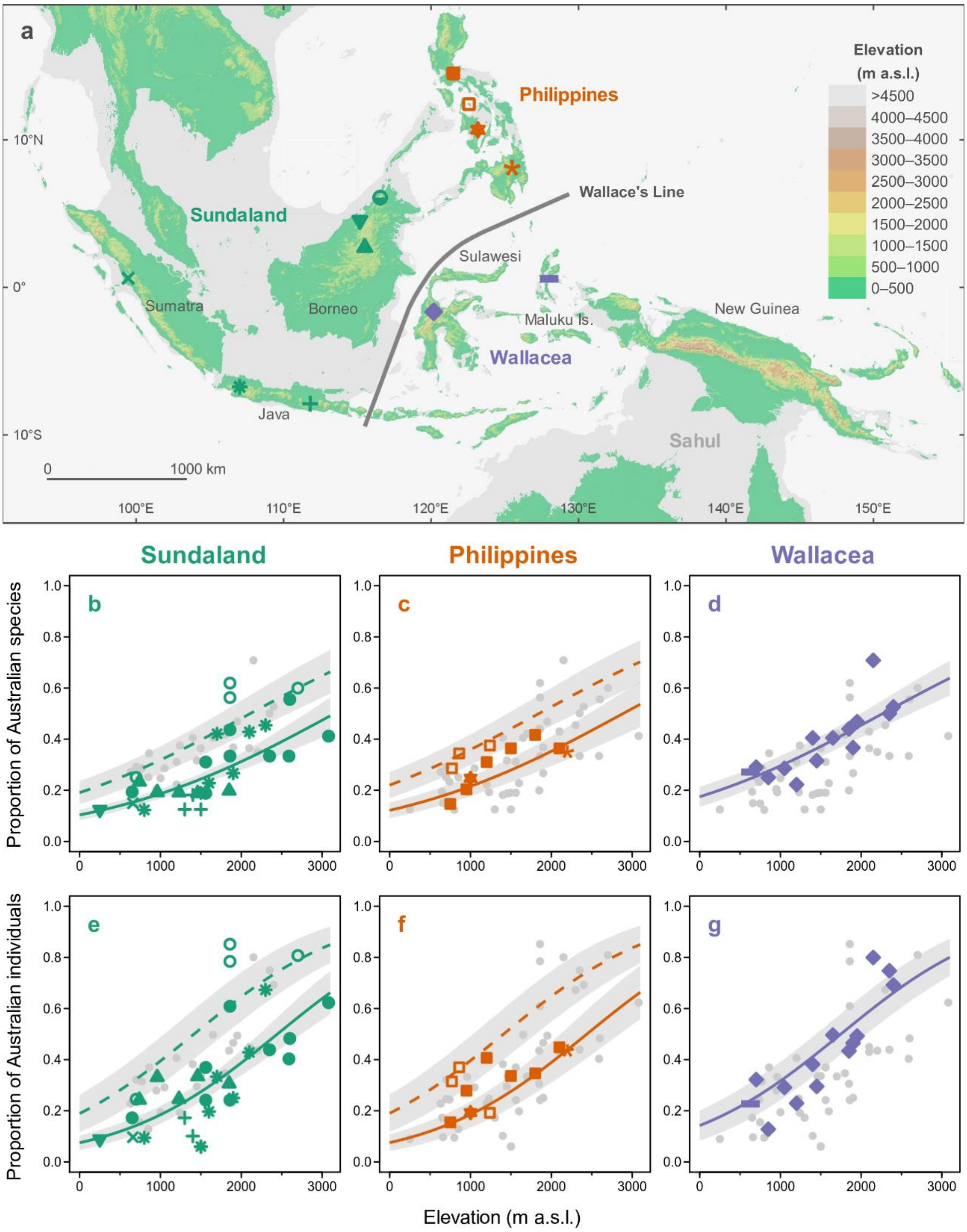

Figure 5.1 Diversity and abundance of Australian tree lineages in Malesian forest plots are higher at higher elevations, on ultramafic soils, and east of Wallace's line. Shown are the locations of 55 old-growth forest plots in 12 Malesian areas in the phytoregions Sundaland, the Philippines and Wallacea (**a**) and the per-plot proportions of tree species (**b-d**) and individuals (**e-g**) with Australian ancestry in relation to elevation, parent material, and phytoregion. Regression lines show significant results based on multiple logistic regression models (model 1 for **b-d**, model 3 for **e-g**; see Table 5.2 for details). Symbols represent the 12 studied Malesian areas (**a**), each with 1–16 forest plots (**b-g**). Plots on non-ultramafic parent material are represented by closed symbols and continuous regression lines and plots on ultramafic parent material by open symbols and dashed regression lines (the Mt Kinabalu site in N Borneo contains plots with both types of parent material). Grey dots show plots of other phytoregions for comparison and light grey shadows indicate the 95% CI of the regression models. Map in WGS1984, Mercator projection, created with QGIS 3.4.9 showing shelf areas in grey (200-m bathymetric contours from Natural Earth: www.naturalearthdata.com).

The patterns retrieved for the elevational distribution of Australian species and tree individuals were remarkably similar but the increase with elevation was stronger for individuals than species. Likewise, the increase of Australian individuals from non-ultramafic to ultramafic plots was larger than that of Australian species (Table 5.2, Figure 5.1b–g).

On non-ultramafic parent materials, our models predicted ca 35–55% Australian species at an elevation of 2500 m in the three phytoregions (Figure 5.1b–d), while the proportion of Australian individuals at the same elevation varied between 50 and 75% (Figure 5.1e–g).

5.4.3 Elevational tipping points

On non-ultramafic substrates, the elevational tipping point with a 50%-share of Australian species was reached at 2270 m in Wallacea (Figure 5.2a), but at 2890 m and 3150 m in the Philippines and Sundaland, respectively, according to model 1. On ultramafic soils, the 50%-tipping points occurred at much lower elevations: 1850 m in the Philippines and 2110 m in Sundaland (Figure 5.2a).

In all areas, elevational tipping points with half of the individuals having Australian ancestry according to model 3 were much lower than those based on species, but patterns between phytoregions and parent materials were similar: the 50%-individuals tipping point was reached at the lowest elevations on ultramafics (1410 m in the Philippines, 1420 in Sundaland) followed by non-ultramafic areas in Wallacea (1750 m), the Philippines (2440 m), and Sundaland (2450 m, Figure 5.2b).

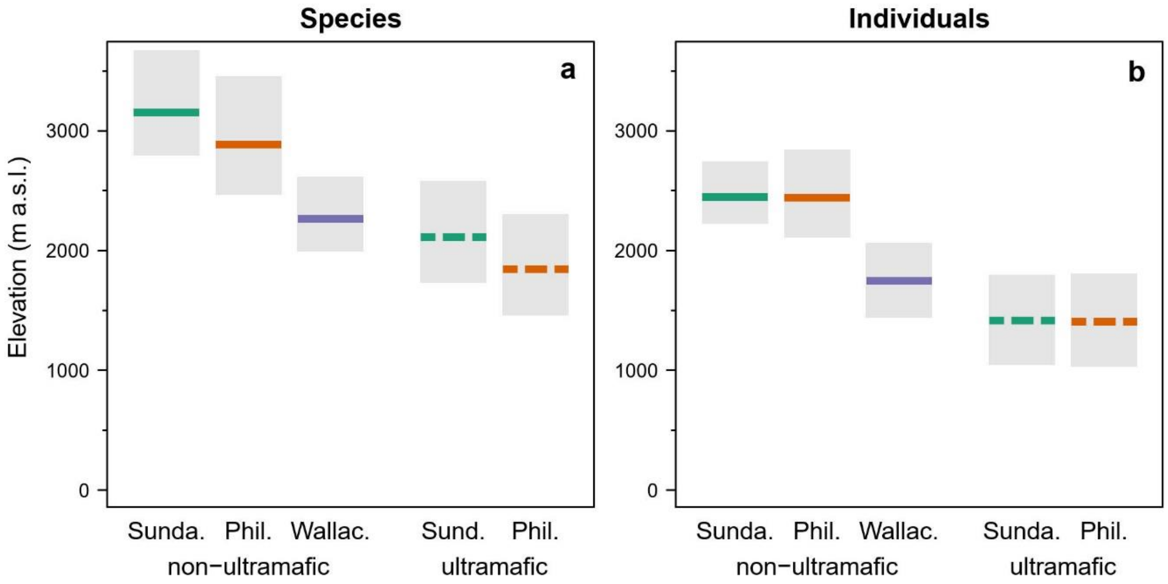

Figure 5.2 Elevational tipping points with a 50%-share of Australian tree species showing the transition from Asian-dominated forests below the coloured lines to Australian-dominated forests above them. Data show the 50%-tipping points for species (a) and individuals (b) in forests of the Malesian phytoregions Sundaland (Sunda.), the Philippines (Phil.), and Wallacea (Wallac.) on non-ultramafic (solid lines) and ultramafic (dashed lines) parent materials. Values from multiple logistic regression models with elevation, parent material, and phytoregion as independent variables (model 1 for a, model 3 for b; see Table 5.2 for details), based on 55 old-growth forest plots in 12 Malesian areas. Grey boxes correspond to the elevational range of the 95%-CI at a 50%-proportion of Australian trees/individuals.

5.4.4 Dominant Australian taxa in Malesian forests

Four taxa largely drove the proportion of Australian individuals: Myrtaceae, southern hemisphere conifers (Podocarpaceae and Araucariaceae), *Polyosma* (Escalloniaceae), and *Elaeocarpus* (Elaeocarpaceae) accounted for 70% of all recorded Australian individuals. They provided at least half of the individuals in 44 (80%) and two-thirds or more in 28 (51%) of all 55 plots. While Myrtaceae were present in most plots (although less so in Java), conifers attained high dominances at higher elevations and over ultramafic parent material. *Elaeocarpus*, on the other hand, was absent from ultramafic soils and rather poorly represented in the Philippines. Compared to the other subregions, Java stood out in the low percentages of Myrtaceae and conifers at higher elevations; instead *Polyosma* and *Elaeocarpus* were more dominant there (Figure 5.3).

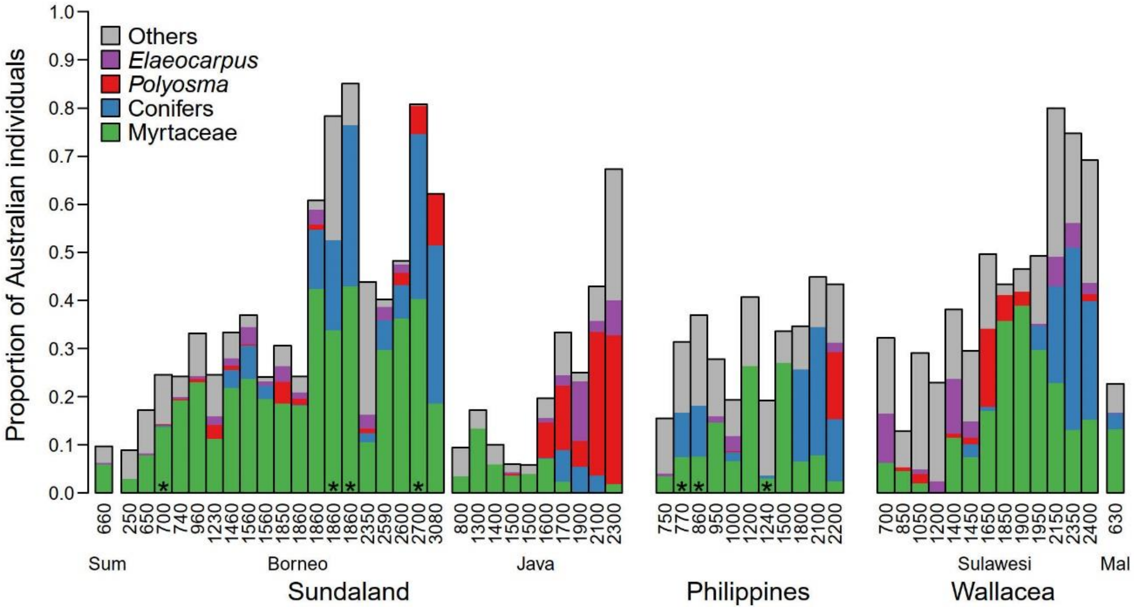

Figure 5.3 Four taxa drive the proportion of tree individuals with Australian ancestry in most of 55 Malesian forest plots. Plots are grouped by their geographic location and sorted by ascending elevation (m.a.s.l). Conifers include the Gondwanan families Podocarpaceae and Araucariaceae but not the Laurasian Taxaceae. Plots with ultramafic parent material are marked with an asterisk. Proportions of Australian and Asian trees per plot amount to 1. Sum = Sumatra, Mal = Maluku Islands.

5.5 Discussion

5.5.1 Contrasting biogeographical patterns in Malesia

Our results demonstrate that in Malesia proportionally more Australian (and conversely fewer Asian) tree species and individuals occur (1) at higher elevations, (2) in forests over ultramafic parent material, and (3) closer to their source region Australia with a significant increase east of Wallace's line, i.e. the boundary between Sundaland plus the Philippines and Wallacea. The trend is stronger for tree individuals than for species. Our estimates for the overall contribution of Asian species to the floras of Malesian subregions are generally lower than in previous studies, especially for Wallacea. This is unsurprising, since we focused on tree inventory plots along environmental gradients, giving more weight to azonal and less-diverse habitats like montane forests and those over ultramafic soils and less to lowland rain forest, the most widespread and diverse habitat. In contrast, previous results were based on flora treatments and checklists (Richardson et al. 2012), which rely on collected herbarium specimens. Especially in the underexplored areas of Wallacea, there may be a strong collection bias towards more accessible lowland sites (Cannon et al. 2007).

Due to lack of available data, we did not include plots from New Guinea in our study. However, previous studies have suggested that even in New Guinea and tropical northern Australia, Asian lineages contribute more to regional floras than their Australian counterparts (Richardson et al. 2012, Yap et al. 2018, 2018). Thus, the available information indicates that Asian lineages generally dominate the Malesian flora today. However, the picture changes, if one considers different habitats in a similar way has has been done in tropical northern Australia (Yap et al. 2018). Our results indicate that above a certain elevational tipping point, Australian lineages dominate Malesian forests. The exact elevation of the tipping point varied strongly (ca 1700 m elevation distance); it occurred at lower elevations on over ultramafic bedrock than over other parent materials. In Wallacea, east of Wallace's line, where only non-ultramafic sites were included, the proportions of Australian species and individuals per plot were comparable to those on ultramafic soils in the other two regions. The dominance of plants with Australian origin in montane areas and on poor soils in Malesia has long been acknowledged (Wallace 1869, van Steenis 1935b, Morley 1998, Culmsee et al. 2011, Culmsee and Leuschner 2013, Aiba et al. 2015) but here, we show for the first time that this pattern is consistent throughout western and central Malesia based on a large dataset of 55 plots including all major woody seed plant clades.

5.5.2 Plate tectonics, climate, and the Malesian Floristic Interchange

We used a dataset of tree inventory plots in three Malesian biodiversity hotspots in combination with the phylogeographic affinities of the present tree species from an extensive literature review to demonstrate that environmental conditions and – to a lesser degree – geographic position must have had a strong effect on biota mixing during the MFI. We explain patterns of contrasting colonization trajectories of Asian and Australian tree lineages in the context of the complex geologic and climatic history of Malesia and its adjacent regions Southeast Asia and Australia: Southeast Asia including Sundaland was assembled by the accretion of different continental fragments to the Asian plate in the Late Triassic and Cretaceous. Today, Sundaland consists of the Malay Peninsula and the islands Sumatra, Borneo, and Java, but only shallow seas over the continental Sunda Shelf separate these land areas. They formed a more or less continuous land mass connected to Eurasia during most of the Cenozoic and throughout that period, Sundaland remained near the equator (Hall 2013, 2017). Despite intervals of strong climatic oscillations, since the middle Eocene, tropical rain forests have covered parts of Sundaland, especially in what today is the island of Borneo. Hence, since the large-scale onset of the MFI ca 23 Ma, there has been a large source population of plants adapted to tropical rainforest habitats in Sundaland (Morley 2012, Hall 2013). On the other hand, Australia, together with the southern portion of present-day New Guinea, separated from Antarctica in the late Eocene to early Oligocene (40–33 Ma; Lawver et al. 2013) and started rafting north towards Asia. It also supported extensive tropical rain forest until the end of the separation at the Eocene-Oligocene-boundary when temperatures dropped, leading to a shift to temperate rain forests and widespread extinction of warm-adapted lineages. After ca 10 My of isolation, the Australian plate started to collide with the Southeast Asian plate and island arcs from several Pacific plates around the Oligocene-Miocene boundary (ca 25–20 Ma). The exact geological processes involved were complex both in time and space but, together, caused extensive uplifting at the northern margin of the Sahul Shelf in what is today New Guinea, and shaped the young islands comprising Wallacea (Sulawesi, Maluku Islands, Lesser Sunda Islands) including some of the largest areas of ultramafic bedrock worldwide (Hall 2013, 2017, Galey et al. 2017). At the same time, temperatures rose again and moist tropical habitats expanded in Australia until the mid-Miocene climatic optimum. Global cooling since the mid-Miocene (ca 14 Ma) was offset in Australia by the continued rafting towards the equator, at least in the north, but intensive aridification occurred leading to an overall contraction of mesic biomes, which remained mostly in montane refugial areas along the eastern coast of the continent (Martin 2006, Byrne et al. 2011, Bryant and Krosch 2016) and in eastern New Guinea, where mountains had been present since the early Oligocene (Quarles van Ufford and Cloos 2005, Martin 2006, 200, Macphail 2007, Byrne et al. 2011, Bryant and Krosch 2016).

The emergence of Wallacea greatly reduced the distances of open sea between Asia and Australia and coincided with the dramatic intensification of the MFI (Crayn et al. 2015) likely due to the facilitation of, facilitating stepping-stone dispersal between the continents (van Welzen et al. 2011, Richardson et al. 2012). The dominance of plants with Asian ancestors observed today in most of Malesia derives from the high colonization success of these lineages in the newly emerging nutrient-rich and moist tropical habitats. The colonization success can be explained by the large and diverse source populations adapted to similar climatic and edaphic conditions that existed in Sundaland. Conversely, the Australian wet tropics have been a sink for Southeast Asian rain forest plants migrating through Malesia (Sniderman and Jordan 2011, Yap et al. 2018). Because the Australian flora had suffered widespread extinction of typical tropical rain forest taxa before the intensification of the MFI, source populations for the colonization of Malesian lowlands were probably small, when rain forest habitats expanded in the early Miocene (Byrne et al. 2011, Sniderman and Jordan 2011, Richardson et al. 2012).

Nevertheless, our results show that some Australian lineages were highly successful in colonizing Malesia from the east, especially in azonal habitats with poor soils including ultramafics and on mountains. Taxa adapted to poor soils and/or colder upland habitats were widely present in Australia at the onset of the MFI (van Steenis 1979, Hill 2004, Bryant and Krosch 2016) and were presumably able to colonize the newly emerging extensive ultramafic areas in New Guinea and Wallacea in due time (Galey et al. 2017). Malesian mountain building has mainly occurred in the last 10 My but the highest ranges like the New Guinea Highlands, Central Sulawesi Mountains, Barisan Mountains in Sumatra, or Mt. Kinabalu in Borneo were only formed in the Plio-Pleistocene (Baldwin et al. 2012, Hall 2013, Merckx et al. 2015, Nugraha and Hall 2017). As montane habitats in Malesia were formed and aridification intensified in Australia, species spread from refugia along the eastern Australian coast and in already existing mountain ranges of New Gunea to the large montane areas in New Guinea, Wallacea, and Sundaland (Morley 1998, Hill 2004, Sniderman and Jordan 2011, Kooyman et al. 2014). This scenario is consistent with the retrieved recent timing of disjunction between Australian and Malesian montane taxa for most lineages we assessed, including the dominant Australian lineages in Malesia today (see below and Appendix 5.2). The late influx of Australian plants to Malesian mountains had a profound impact, essentially providing today's dominant components of the tree assemblages there (Figure 5.1e-g, 5.3).

5.5.3 Dominant Australian taxa differ in their history and ecology

Four taxa mostly drove the dominance of Australian elements in montane and ultramafic areas: Myrtaceae, southern-hemisphere conifers (Podocarpaceae and Araucariaceae), *Polyosma* (Escalloniaceae), and *Elaeocarpus* (Elaeocarpaceae). The myrtle genus *Syzygium* started to diversify in the mid-Oligocene in eastern Australia, presumably in the prevalent temperate rain forests there, and dispersed into Malesia at least four times between 12.4 and 6.8 Ma. The genus underwent a spectacular radiation, possibly linked to the innovation of fleshy fruits (Biffin et al. 2010). Today it is the most species-rich genus of Malesian trees, occurring in a variety of moist forest ecosystems, especially dominant on nutrient-poor soils and in montane areas (Aiba et al. 2015). *Elaeocarpus* shows a similar spatial and temporal pattern of diversification (crown age ca 30 Ma, dispersal into Malesia ca 14 Ma; Crayn et al. 2006) and is widespread geographically and ecologically in Malesia. In contrast, southern conifers are old Gondwanan lineages that, however, mostly reached Wallacea and Sundaland only in the Plio-Pleistocene and remained largely confined to upland areas (Morley 1998, Kooyman et al. 2014). Notably, conifers with Asian affinities (Pinaceae) were common in mountains of Borneo until the Miocene, but Podocarpaceae apparently replaced them afterwards (Muller 1966). In upper montane forest throughout Malesia, podocarps are often extremely dominant, although not particularly species-rich (Aiba et al. 2015, Brambach et al. 2017). An exception is Java with its seasonal climate, where far fewer of the particularly drought-sensitive southern conifers occur (van Welzen et al. 2011). Instead, *Polyosma* and *Elaeocarpus* as well as Asian lineages like Fagaceae and Ericales dominate Javanese montane forests (Figure 5.3).

5.5.4 Habitat-suitability is more important than distance

We found evidence that Asian species predominantly colonized lowland habitats and medium to rich soils during the MFI, while Australian species were more successful in the colonization of montane areas and poorer (ultramafic) soils. This pattern across Malesia, one of the major tropical regions of the world, is remarkable given the region's large extension and archipelagic nature.

Geographic distance from the source regions (Asia and Australia) only had a minor influence on the colonization success compared to habitat. This influence was best explained using Malesian subregions as categorical variables, indicating a non-linear relationship (Table 5.2).

Newly emerging tropical lowland habitats in Malesia were predominantly colonized by lineages from Sundaland, where similar ecological conditions prevailed and large source populations existed (Richardson et al. 2012, Zobel 2016). The nature of habitats containing the lineages that came to colonize Malesian mountains and nutrient-poor soils, is more obscure because of the complex plate-tectonic and climatic history of Australia since the Oligocene that caused recurrent expansions and contractions of different forest types. Nevertheless, there are indications that moist habitats were mostly present in colder upland areas, a least since the middle Miocene (Martin 2006, Byrne et al. 2011, Bryant and Krosch 2016), providing the nearest source population of plants adapted to Malesian mountain habitats.

We therefore interpret the colonization pattern found here in the light of similar ecological conditions between source and sink areas, Sundaland as a source area for lowland Malesia on the one hand and Australia as a source area for montane Malesia on the other. This likely points to the importance of phylogenetic biome conservatism (Crisp et al. 2009, Crisp and Cook 2012), i.e. the tendency of lineages to retain their ancestral ecology over long time spans and continental scales, in the assembly of the Malesian vegetation (Grudinski et al. 2014, Kooyman et al. 2014). Notably, Asian immigrants have also been relatively successful in the colonization of tropical lowland habitats in northern Australia but not in temperate habitats further south due to environmental filtering (Yap et al. 2018). However, speciation events including biome shifts between montane and lowland forest and vice versa must have occurred in numerous clades, as indicated by species-rich genera spanning wide environmental gradients today like *Syzygium*, *Lithocarpus* (Fagaceae), *Litsea* (Lauraceae), *Elaeocarpus*, and *Symplocos* (Symplocaceae). Biome shifts between tropical lowland and montane forests have received relatively little attention, possibly due to the blurred boundaries and close spatial inter-connectedness between the two (Donoghue and Edwards 2014, Antonelli et al. 2018b). Nevertheless, tropical mountain areas with their close proximity of widely differing habitats are known to be cradles of diversity with strong species turnover along the elevational gradient, facilitating speciation and associated niche evolution (Merckx et al. 2015, Sanín et al. 2016). The dynamic history of Malesia since the onset of the MFI together with two ecologically and geographically different source regions may thus have contributed to the exceptionally high plant diversity in Malesia today (Slik et al. 2015). Malesian montane forests, while less species-rich than their lowland counterparts, today harbour many survivors of dramatic extinction events in Australia during the Tertiary (Kooyman et al. 2014) as well as elements of originally tropical Asian families. Their unique evolutionary history and associated higher phylogenetic diversity (Slik et al. 2009, Culmsee and Leuschner 2013) attest to their exceptional conservation value.

5.5.5 Patterns resembling the Great American Biotic Interchange

The patterns uncovered in this study allow the assessment of several hypotheses regarding biota mixing that have been postulated based on studies of the GABI, the mixing of North American and South American biotas during the Neogene and Quaternary. Malesia presents an independent model system, which has similarities to the Neotropics but also shows some differences. In both regions, tectonic movement and climatic changes have led to the mixing of biotas between Gondwanan fragments that had long been isolated before (Australia and South America) and Laurasian regions, which had repeatedly been connected to each other during the Tertiary (Eurasia and North America; Donoghue and Smith 2004, Lawver et al. 2013). No land bridge connects Asia and Australia, which is similar to the situation before the closure of the CALB in the Americas, but the absence of a land connection is less important to plants, which have relatively high dispersal capabilities compared to many animal groups (Sanmartín et al. 2004, Bacon et al. 2015). More importantly, before the GABI began, the largest source population of lowland rainforest plants was located in the Amazon basin, i.e. on the formerly isolated continent of South America. In contrast, Australia, had not only undergone a 10 My-long isolation before the onset of the MFI, but also large-scale extinction of rainforest plants due to continent-wide cooling and aridification (Byrne et al. 2011), while large tropical rainforests persisted in Sundaland. The dominance of Australian plants in Malesian mountain habitats today adds to the growing evidence against the isolation hypothesis (Cody et al. 2010, Bacon et al. 2015, Antonelli et al. 2018b), which states that biotas are less successful in events of biotic interchange after long isolation due to lower competitiveness or higher susceptibility to predators (Simpson 1980, Faurby and Svenning 2016). Instead, our results are in line with studies that have highlighted the importance of habitat similarities between source and sink areas during the GABI and, hence, phylogenetic biome conservatism in biotic interchanges. During the MFI, tropical Asian tree lineages spread through Malesia to tropical Australia in a similar manner as Amazonian lineages colonized tropical Central America. Conversely, Australian plants, adapted to upland habitats, had great colonization success in Malesian mountains as Nearctic lineages had in the Andes (Cody et al. 2010, Woodburne 2010, Bacon et al. 2015, Antonelli et al. 2018b, Graham 2018). While our results have to be viewed with caution due to the persisting lack of data from a key area, New Guinea, the congruence of scenarios from the MFI and the GABI shown here provide support to the idea that patterns and mechanisms that have been found through decades of studying the GABI are not specific to the Neotropics but have more universal validity.

General Discussion

Taxonomic contributions and baseline data

With my thesis, I close some of the knowledge gaps about the little-known tropical mountain forests (TMF) of Sulawesi regarding the Linnean, Wallacean, Prestonian, Hutchinsonian, and Darwinian shortfalls (Hortal et al. 2015). I contribute to a better taxonomic knowledge about the tree flora of the island by rigorous species identification and the discovery of new species. Seven species in three different families are already described and published (Chapters 1–3) while for thirteen other species in eight families the description is in progress or planned. In recent years, the flora of Sulawesi has become the focus of a small number of dedicated taxonomists from different academic institutions in- and outside of Indonesia. Their efforts are mostly targeting species-rich taxa of herbs like *Begonia* (Doorenbos 2000, Hoover et al. 2004, Hughes 2006, Thomas and Hughes 2008, Girmansyah et al. 2009, Thomas et al. 2009a, 2009b, 2011, 2018, Wiriadinata 2013, Lin et al. 2017, Ardi et al. 2018) and Zingiberaceae (Poulsen 2012, Ardi and Ardiyani 2016, Ardiyani et al. 2017, de Boer et al. 2018, Poulsen et al. 2018, Trimanto and Hapsari 2018) or climbers and shrubs like Gesneriaceaea (Hilliard and Burtt 2002b, 2002a, Atkins 2003, Mendum 2003, Mendum and Atkins 2003, Mendum et al. 2006, Middleton and Scott 2008, Kartonegoro 2012, Atkins et al. 2013, Bone and Atkins 2013, Kartonegoro and Potter 2014, Kartonegoro et al. 2018) and Apocynaceae subfamily Asclepiadoideae (Kleijn and van Donkelaar 2001, Rodda and Omlor 2013, Rodda 2016, Rodda and Simonsson Juhonewe 2016). Much less attention has been directed to trees (e.g. Coode 1995, 2001a, 2007, Bramley 2012, Kiew 2016) although many species-rich and ecologically important tree families in Sulawesi are in urgent need of taxonomic revision (Arifiani 2001, Keßler et al. 2002, Ng 2005b, Syzygium Working Group et al. 2016). Funding for alpha-taxonomical work is not keeping pace to speed up the discovery of new species before they become extinct (Wägele et al. 2011, Pimm and Raven 2017). Hence, the discovery of new species by researchers from other disciplines, including plant ecologists, becomes more important and can even improve species descriptions through live examination of the plants in the field. The ‘accidental’ species discoveries in the context of this thesis thus complement the more targeted work by the taxonomists mentioned above.

Besides the detection of undescribed species, in my thesis I present a large number of new occurrence records, i.e. range extensions of known tree species. Almost one quarter of the tree species encountered had previously not been recorded from Sulawesi or the province of Central Sulawesi. Importantly, the records include spatially explicit abundances for each species, which can be related to environmental variables measured in the field (Chapter 4) or derived from models (e.g. Fan et al. 2013, Hengl et al. 2017, Karger et al. 2017) and be used to inform species distribution models (Raes et al. 2009). For these means, the occurrence records need to possess high data quality, i.e. be correctly identified and vouchered by herbarium specimens to enable re-identification as species concepts change. Species identification in a megadiverse and generally insufficiently known flora like that of Malesia is a challenging and time-consuming task. In my thesis, I put much emphasis on correct species identification, including collaboration with taxonomic specialists from major international herbaria (Chapters 1–3) to provide this kind of high-quality data. The tree-inventory data have been included in collaborative databases like Forestplots.net (Lopez-Gonzalez et al. 2011) and filled critical gaps for research projects investigating global patterns of tree diversity (Slik et al. 2018). Especially for large-scale analyses that use aggregated datasets, data quality of the original studies is critical, as potential errors are unlikely to be detected.

Tree diversity and composition

Beyond the localized provision of baseline data and detection of new species, I explored more general patterns of tree diversity along environmental gradients (Chapter 4). I show that species diversity of trees in Sulawesi is mostly controlled by elevation while soil parameters have only a marginal importance. The diversity declined monotonically with elevation from 700 to 2500 m. This pattern has been repeatedly found in other TMF from all major tropical regions (Aiba and Kitayama 1999, Aiba et al. 2005, Raes et al. 2009, Homeier et al. 2010, Peters et al. 2016) and had also been reported for Sulawesi, but based on a fewer study sites (Culmsee and Pitopang 2009, Culmsee et al. 2011) and less-complete species identification.

Height above sea level explained almost 50% of the variation in tree species richness, while seven important soil parameters had only marginal influence. This result is generally in line with a study from Borneo, where elevation was also the most influential correlate for gradients in tree diversity (Slik et al., 2009). However, in the latter study, which included mostly lowland and lower montane sites, soil characteristics also explained a significant portion of tree diversity. Dipterocarps, the main structural components of Sundaland lowland forests have been shown to vary in species richness largely dependent on soil chemistry or geology (Paoli et al., 2006). When elevation differences are small, diversity should depend on other factors than elevation, including soil chemistry and hydrology. On the other hand, the transect studied for this thesis, had only low geological variability, with most sites dominated by acid plutonic bedrocks. Sulawesi is one of the geologically most complex and diverse islands on Earth (Hall and Wilson 2000); it would therefore highly desirable to cover this geological diversity (e.g. volcanic, ultramafic, and limestone areas) in future studies to unravel the interplay between topographic and soil characteristics on tree diversity. Nevertheless, diversity in geologically diverse regions of Malesia at the genus level were shown to be correlated closely with elevation and not with soil parameters (Culmsee and Leuschner 2013). My comparison of 51 Malesian plots along a wide range of bedrock types, where tree species diversity showed a relatively close and highly significant relation to elevation, extends this pattern to species-level diversity.

Elevation drives site conditions for plants through different pathways. Temperature decrease and differences in cloud cover are closely correlated with elevation and can act on plant communities directly by influencing photosynthesis and respiration rates and thus the carbon balance (Malhi et al. 2017). However, there are also indirect effects mediated by soil characteristics such as decomposition and mineralisation rates, nutrient supply and organic matter accumulation. With increasing elevation, I found widening C/N ratios in the organic layer and the mineral topsoil as well as growing stocks of organic matter in the organic layer, indicating that mineralisation rate and the availability of nitrogen decrease with elevation in Sulawesi in a similar manner as it was found in other tropical mountains (e.g. Moser et al., 2011). In addition to temperature reduction and increased cloud cover with elevation, the reduced N availability might also exclude tree species of more fertile (and warmer) lowland habitats from colonising higher elevations because of lower nutrient supply. On mount Kinabalu, where ultramafic and non-ultramafic bedrock occurs in close proximity, tree diversity is much lower in TMF on soils derived from ultramafic material (Aiba and Kitayama 1999). This suggests that elevation effects on diversity can be secondary to soil chemistry effects, in cases where concentrations of toxic elements are and high element ratios unfavourable, as in ultrabasic soils which are characterised by high Ni concentrations and high Mg/Ca ratios (Proctor, 2003). Ultramafic soils are widespread in central and eastern Malesia with one of the largest areas of ultramafic bedrock occurring in Sulawesi's eastern and southeastern peninsulas (Galey et al. 2017). Comparative studies along an elevational gradient on ultramafics in Sulawesi would therefore be of great interest to elucidate to what degree unfavourable soils can act as environmental filters for colonizing tree species and how this filter mechanism interacts with elevation.

Regardless of the exact environmental factors driving tree species richness, previous studies have suggested that Sulawesi and other parts of Wallacea harbour a less-diverse flora compared to the Greater Sunda Islands to the west and New Guinea to the east (Barthlott et al. 2007, Kier et al. 2009). The results of this thesis, based on rigorous sampling and species identification, do not confirm that assumption, as levels of species diversity did not differ significantly between Sulawesi and other Malesian areas, at least at the level of forest communities between 700 and 2400 m elevation. While large islands like New Guinea, Borneo, and Sumatra are overall richer due to area effects (Roos et al. 2004), the supposedly more diverse floras of the Philippines and Java are likely to be artefacts of the greater attention botanists have given these areas (Merrill 1923a, 1923b, Backer and Bakhuizen van den Brink Jr. 1963c, 1965b, 1968) as compared to Sulawesi. The high number of new occurrence records in Sulawesi of my thesis supports this claim.

I also found a considerably higher rate of endemic tree species for Sulawesi (22% in my dataset) than the previously reported numbers of 12–14% (van Balgooy 1987, Roos et al. 2004, van Welzen and Slik 2009, van Welzen et al. 2011). Again, this discrepancy can be explained by the incomplete botanical knowledge of Sulawesi. While species diversity decreased with elevation, the number of endemic species remained constant throughout the elevational transect of Lore Lindu National Park, resulting in a relative increase in endemic species towards higher elevations. Historically, most botanical explorations in Sulawesi have focused on easily accessible areas while higher elevations have – with few exceptions – been neglected, resulting in underestimations of the endemic element of Sulawesi's flora. High levels of endemism in mountain areas are a globally consistent pattern (Steinbauer et al. 2016) and have been found in other Malesian islands, especially those that also possess high mountains which have been botanically explored. For example, Mt Kinabalu on Borneo has been a centre of speciation resulting in numerous endemic species across many different plant and animal taxa during its uplift in the last 10 My (Merckx et al. 2015). Mt Kinabalu's geological history is no exception in Malesia: all major mountain areas are the result of the recent collision of the Indo-Australian, Eurasian, and several Pacific plates and were created in the last 10 My, with major uplifts only in the Plio-Pleistocene (Hall and Wilson 2000, Hall 2013, Nugraha and Hall 2017). Because of the similar geological history, processes of speciation should also have been similar among Malesian mountains, resulting in comparable levels of endemism and overall species richness. In contrast to Borneo, Sulawesi possesses a much higher area of TMF and this area is spread over all parts of the island, but only a small fraction of this TMF has been explored. Taxonomic research from single taxa has shown that there are many narrow endemics restricted to only one mountain range or even only one peak (Coode 1995, Atkins 2003, Bone and Atkins 2013), suggesting that large parts of the endemic flora of Sulawesi's TMF are yet to be found.

Again, correct species identification is crucial here. As endemic species are usually less known than widespread ones, they are often more difficult to identify (or even undescribed). Hence, endemic species will tend to be overrepresented in the individuals which are often only identified to morphospecies in many ecological studies in tropical forests. The pattern of a linear increase of endemism among trees with elevation retrieved in my analyses only became apparent after identification was complete. At an earlier stage, with ca. 75% of all individuals identified (and many endemic species from higher elevations still missing), I retrieved a hump-shaped relationship with highest endemism rates at medium elevations (results not shown), i.e. an incorrect pattern because of incomplete data. As patterns of endemism are important for conservation efforts (Myers et al. 2000, Kier et al. 2009), such incorrectly retrieved patterns can have detrimental effects on efficient conservation planning. Extensive additional sampling of isolated mountain areas with rigorous identification – and description of new – species will therefore be necessary to fully appreciate the contribution of endemic species to Sulawesi's flora and hence the conservation value of Sulawesi's TMF.

While detailed knowledge of plant species distribution patterns in Sulawesi is still missing, spatially coarser information about the vegetation can also inform information efforts (Cannon et al. 2007). I found that elevation was the main factor controlling tree species composition, including the dominance of the ten most abundant plant orders along the slope, and that there are major turnovers in tree species composition around 1500 m and around 2000 m. Vegetation belts between these ecotones in Lore Lindu National Park can be classified based on floristics: Submontane forest (700 – ca. 1500 m) contains a high number of elements from tropical lowland forest, as in other tropical mountains (Aiba and Kitayama 1999, Ashton 2014) and indicated by the indicator species from the families Sapotaceae, and Myristicaceae. Lower montane forest (ca. 1500–2000m) does not have any indicator species, but is distinguished by the dominance of Fagaceae and Myrtaceae in terms of individuals and species numbers, resulting in high biomass compared to montane forests in other regions without these families (Culmsee et al. 2010a). Upper montane forest, occurring above c. 2000 m, is dominated by the conifer family Podocarpaceae and contains numerous indicator species, mostly of families with Australian biogeographic affinities (Myrtaceae, Elaeocarpaceae, Trimeniaceae, and Paracryphiaceae). The exact elevational boundary between the sub- and the lower montane forest zones is difficult to define. This is partly because both zones themselves have a transitional character from tropical lowland elements on one hand to more temperate ones on the other. Also, the elevational boundary is mediated by other factors including topography and soil characteristics, resulting in a transition rather than a sharp boundary (Ashton 2003a). While the latter is also true for the boundary between lower and upper montane forest, the floristic transition there is much sharper as indicated by the high number of indicator species. Despite these caveats, tropical mountain forests can be classified into elevational zones that are relatively easy to recognize based on few indicator species or the dominance of well-known tree families. This classification can serve to inform conservation efforts in the absence of more detailed floristic knowledge (Cannon et al. 2007).

Upper montane forest, is clearly distinguished from the forest types further downslope in terms of floristics and soil characteristics. In addition, levels of cloud cover and structural parameters are also known to distinguish these forest communities (Ashton 2014). The unique environmental conditions and flora of upper montane forests suggest that because of phylogenetic niche conservatism (Wiens et al. 2010), enrichment through immigration and establishment from plants further downslope plays a limited role, although it does occur (Merckx et al. 2015). Indeed, the studied upper montane forest communities in Sulawesi are mostly dominated by taxa with southern temperate affinities (Kooyman et al. 2014). Detailed data about dispersal syndromes in Sulawesi's upper montane forests are lacking, but the dominance of taxa with small fleshy, likely bird-dispersed, propagules such as Podocarpaceae, Myrtaceae, *Elaeocarpus*, *Quintinia*, and *Trimenia* points to the importance of long-distance dispersal between mountain tops. Due to the stronger geographic isolation, as compared to lower-elevation forests, sporadic long-distance dispersal and subsequent establishment in upper montane forests is then likely to be followed by speciation, resulting in high levels of endemism (Steinbauer et al. 2016) as observed in this study.

Most tree inventories are based on samplings of mature trees with dbh ≥ 10 cm. Much less is known about the free-standing woody plants of the understorey with stem diameter < 10 cm, which typically dominate in numbers and may also be more species-rich than the large- and medium-sized trees (LaFrankie et al. 2006, Lü and Tang 2010). These smaller trees comprise juveniles of large canopy trees but also mature individuals of a different guild, that of species which are adapted to the shady forest interior throughout their life cycle and never reach the canopy. In Chapter 4, I show that although these understorey tree species contribute relatively little to total biomass and number of individuals, they comprise almost half of the regional tree species flora. And a much higher proportion of them is endemic to Sulawesi, as compared to canopy species. This neglected group shows considerable turnover along the elevational gradient, both at species level and that of higher taxa. Previous studies have suggested that true understorey tree species are more frequent and diverse in neotropical forests, while the understorey of Southeast Asian forests to a high percentage consists of saplings of large- and medium-sized trees of the upper canopy, resulting in lower availability of fruits and flowers in the understorey (Janzen 1977, LaFrankie et al. 2006, Corlett 2007). These studies invoked the mass fruiting of Dipterocarpaceae, the dominant family in Sundaland lowland forests, as an explanation for this phenomenon. It was later shown that in Asian forests, which are not dominated by dipterocarps, indeed trees with small and medium size at maturity dominated the understorey (Lü and Tang 2010). Notably, at lower montane elevations in Sulawesi, where another mass-fruiting family, Fagaceae, was dominant, understorey diversity remained high. My results from forests each of Wallace's line rich in true understorey tree species thus contribute to a more nuanced view of Southeast Asian forests in terms of understorey composition.

Biogeographic context of Sulawesi's tree flora

Regardless of scale, patterns of tree diversity and composition are shaped by a combination of environmental factors and the available species pool, i.e. the combined evolutionary history of the constituting species (Keil and Chase 2019). After investigating the effects of present environmental factors in Chapter 4, I therefore investigated how tree lineages with different geographic origins, i.e. evolutionary histories have colonized Sulawesi and adjacent Malesian islands in Chapter 5. Investigating the evolutionary history is an attempt to diminish the Darwinian shortfall for this little known tropical biodiversity hotspot. As the other islands in Wallacea, Sulawesi is geologically young, having been shaped in the last ca. 25 My and all plant life present today on the island must have colonized it during that time span in a process called the Malesian Floristic Interchange (MFI; Richardson et al. 2012) or Sahul–Sunda floristic exchange (Crayn et al. 2015). Because of its position in the is located in the centre of Malesia, halfway between Asia and Australia, the biogeographical history of Sulawesi's tree flora is closely linked to that of other Malesian areas. Therefore, I expanded the scope of Chapter 5 beyond Sulawesi to include the three Malesian biodiversity hotspots Sundaland, the Philippines, and Wallacea.

Previous research has indicated that at the island scale, the majority of the Malesian flora originated in Asia (Sniderman and Jordan 2011, Richardson et al. 2012, Crayn et al. 2015). In this thesis, I confirm this overall pattern but also reveal strong differences depending on habitat. Using a dataset of tree inventory plots in combination with phylogeographic data on the present tree species, I show that the environmental conditions and – to a lesser degree – geographic position have had a strong effect on biota mixing during the MFI. More specifically, proportionally more Australian (and conversely fewer Asian) tree species and individuals occur (1) at higher elevations, (2) on sites over ultramafic parent material, and (3) closer to their source region Australia with a significant drop at Wallace's line, i.e. the boundary between Wallacea and Sundaland plus the Philippines. The trend is stronger for tree individuals than for species, resulting in forest communities dominated by Australian trees above elevational tipping points, which however differ between regions and depending on the parent material. Several previous researchers have acknowledged the dominance of plants with Australian origin in montane areas and on poor soils in Malesia (Aiba et al., 2015; Culmsee & Leuschner, 2013; Culmsee et al., 2011; Morley, 1998; van Steenis, 1935b; Wallace, 1869) but in this thesis, I show for the first time that this pattern is consistent throughout Malesia based on a large dataset including all major woody plant clades.

This pattern across Malesia, one of the major tropical regions of the world is remarkable given the region's large extension and archipelagic nature. It is consistent with a scenario, in which plant lineages adapted to tropical lowland rainforest conditions were present in large numbers in Southeast Asia including Sundaland before the onset of the MFI (Morley 1998, 2001) and were therefore most successful in colonizing the newly emerging lowland habitats in Central and East Malesia during the MFI. The Australian flora on the other hand suffered widespread extinction of typical rainforest taxa due to continent-wide cooling and drying since the beginning of the Oligocene. Most Australian plant lineages around the Oligocene-Miocene boundary (ca. 23 Ma) were probably adapted to either arid or moist and cool upland habitats as well as to the widespread poor soils in Australia (Hill 2004, Martin 2006, Byrne et al. 2011, Bryant and Krosch 2016). When Wallacea emerged and the MFI started, Australian lineages were apparently highly successful in colonizing newly established habitats with similar environmental conditions as their ancestral habitats: poor soils and moist upland sites (Byrne et al. 2011, Sniderman and Jordan 2011, Richardson et al. 2012). Mountain building in Malesia has mainly occurred in the last 10 My but the highest ranges like the New Guinea Highlands, Central Sulawesi Mountains, or Mt. Kinabalu were only formed in the Plio-Pleistocene (Hall 2013, Merckx et al. 2015, Nugraha and Hall 2017). As montane habitats in Malesia were formed and aridification intensified in Australia, species spread from refugia along the eastern Australian coast to the large montane areas in New Guinea and further west into Wallacea and Sundaland. Indeed, most Australian lineages common in Malesian mountains today have diversified in the last 10 My, as indicated by the literature review of phylogenetic studies. This late influx of Australian plants to Malesian mountains has had a profound impact, essentially providing today's dominant components of the unique tree assemblages there. Interestingly, few taxa disproportionally to this dominance of Australian elements in Malesian mountains: Myrtaceae, southern-hemisphere conifers, *Polyosma* and *Elaeocarpus*. Interestingly, the overwhelming majority of species in these four taxa have small, fleshy, and often showy propagules fit to be dispersed by birds and possibly bats. Dispersal is an important yet understudied factor (Pannell 2018) to understand the biogeographical history of the archipelagic region Malesia. Wallace's line has been shown to be an – albeit permeable – dispersal filter for many lowland taxa originating in Sundaland

(Nauheimer et al. 2012, Thomas et al. 2012, Grudinski et al. 2014). It has, however much less importance for montane plant lineages which are relatively homogeneous throughout Sundaland, the Philippines, and Wallacea (Culmsee and Leuschner 2013), and mostly originated in Australia as shown here. This pattern makes sense, when dispersal is taken into account: Australian lineages, which were able to leave Sahul (Australia and New Guinea) by crossing the stretches of sea separating the Wallacean islands by bird-facilitated dispersal, would also be able to continue into Sundaland. For Australian lineages, the strongest dispersal filter should therefore not be Wallace's, but Lydekker's line, the boundary of the Sahul Shelf. To answer these questions and gain a better understanding about how dispersal limitations shaped the Malesian flora, it would be highly desirable to compile dispersal-related plant traits and incorporate additional plot data along environmental gradients in New Guinea and Australia.

However, my results suggest that biogeographical patterns in the Malesian flora were not primarily influenced by processes related to dispersal limitations, but rather by the availability of suitable habitat, i.e. similar environmental conditions between the source- and sink regions during the floristic interchange. This is reflected in the dominance of southern temperate lineages in upper montane forests of Sulawesi (see above) and likely points to the importance of phylogenetic biome conservatism in the assembly of the Malesian vegetation (Crisp et al. 2009). It also shows that not only present environmental conditions affect the assembly of plant communities but also past environmental conditions that have shaped the available species pool at different temporal scales. Despite the importance of phylogenetic biome conservatism that is reflected in my results, there are also clear indications that some biome shifts (Donoghue and Edwards 2014) must have occurred and that these have had considerable consequences. This is indicated by species-rich genera spanning wide environmental gradients in Malesia today. Biome shifts between tropical lowland and montane forest communities at different elevations have received relatively little attention, possibly they are often difficult to separate clearly and occur close together (Antonelli et al. 2018b). This is unfortunate, since tropical mountain areas with their close proximity of widely differing habitats are known to be cradles of diversity with strong species-turnover along the elevational gradient, facilitating speciation and associated niche evolution (Merckx et al. 2015, Sanín et al. 2016). Malesia's exceptionally diverse flora has been assembled over at least the last 25 My by a complex interplay of migration, speciation, and extinction that is closely associated with the regions dynamic geological history. To unravel the exact processes at play and their relative contributions, clearly more detailed phylogeographic studies of species-rich and ecologically variable taxa which originated in Australia, such as *Syzygium* and *Elaeocarpus* are needed. These studies should ideally include reconstructions of ancestral habitats to model niche evolution. Regardless of these continuing knowledge gaps, it is clear that Malesian montane forests, while less species-rich than their lowland counterparts, have a unique evolutionary history and associated higher phylogenetic diversity and hence exceptional conservation values (Culmsee and Leuschner 2013).

Conclusions

The TMF of Central Sulawesi harbour a species-rich and unique tree flora, with high proportions of endemic species, surprisingly important contributions by small understorey species, and a unique biogeographical history with a transition from dominance of Asian to Australian elements with increasing elevation. These properties give the TMF of Sulawesi and other mountainous islands in the Malesian Archipelago high priority in conservation, even though their taxonomic diversity is smaller than that of lowland forests. The few existing data suggest that even different summits on the same island may harbour unique forest communities full of endemic species. Large knowledge gaps regarding all shortfalls of biodiversity knowledge remain about the flora and vegetation of Sulawesi. The gaps are more pronounced in some geographical areas, e.g. the eastern and southeastern peninsulas and the western part of the northern peninsula, but also in some forest habitats like those on ultramafic parent material and limestone or the few remaining swamp areas. Repeated biodiversity inventories in these especially underexplored areas will be necessary to improve our baseline knowledge about plant diversity patterns in Sulawesi. In the last decade, several botanical expeditions have collected numerous plant specimens from tropical hinterland forests in Sulawesi. This is an encouraging sign but needs to be matched with a concerted effort of research on biodiversity and ecology including phylogenetic and functional approaches to overcome the continuing lack of knowledge.

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Chapter 1 – *Magnolia sulawesiana* described, and a key to the species of *Magnolia* (Magnoliaceae) occurring in Sulawesi.

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Chapter 2 – *Elaeocarpus firdausii* (Elaeocarpaceae), a new species from tropical mountain forests of Sulawesi

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FB and HC collected the data. SB conducted the pollen laboratory work and analysed the pollen data. FB analysed all other data and HC produced the line drawing. FB led the writing with major contributions from all authors.

Chapter 3 – Five new species of *Syzygium* (Myrtaceae) from Sulawesi, Indonesia

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Chapter 4 – Diversity, endemism, and composition of tropical mountain forest communities in Sulawesi, Indonesia, in relation to elevation and soil properties

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Chapter 5 – Predominant colonization of Malesian mountains by Australian tree lineages

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Appendices

Appendix 1.1 Examined *Magnolia* specimens

Numbers in the list of examined specimens for the construction of the Sulawesi-key refer to the following species:

1. *M. angatensis* Blanco,
2. *M. bintuluensis* (A.Agostini) Noot.,
3. *M. carsonii* Dandy ex Noot. var. *carsonii*,
4. *M. champaca* (L.) Baill. ex Pierre var. *champaca*,
5. *M. liliifera* (L.) Baill. var. *liliifera*,
6. *M. sulawesiana* Brambach, Noot. & Culmsee
7. *M. sumatrana* (Miq.) Figlar & Noot. var. *glauca* (Blume) Figlar & Noot.,
8. *M. tsiampacca* (L.) Figlar. & Noot. var. *tsiampacca*,
9. *M. utilis* (Dandy) V.S.Kumar
10. *M. villosa* (Miq.) H.Keng and
11. *M. vrieseana* (Miq.) Baill. ex Pierre.

Afriastini 2112: 11; 2881: 5 – Alston 15937: 11; 16539: 8 – Anonymous s.n. (barcode L 0450378): 8; s.n. (Hort. Bog. IV F 38, Bogor Acc. No. BO-1330147, BO-1330148, BO-1330151): 11; s.n. (Bogor Acc. No. 1324097, BO-1743441, BO 1743443): 8.

Bish 123 (= NIFS bb 18128): 11; 254 (= NIFS bb 21987): 8 – Bloembergen 201 (= NIFS bb 28241): 8; 288 (= NIFS bb 28268): 3 – Brambach et al. 0047: 3; 0086: 5; 0109: 6; 0136: 3; 0145: 5; 0149: 3; 0444: 11; 0632: 11; 0662: 11; 0666: 11; 0892: 5; 1113: 8; 1334: 6; 1512: 3; 1519: 3; 1531: 5; 1554: 5; 1584: 3; 1589: 3 –Bünnemeijer 11567: 5; 12581: 4 – Burki 53 (= NIFS bb 24079): 5; 92 (= NIFS bb 24169): 8; 95 (= NIFS bb 24172): 3; 139 (= NIFS 26276): 3 – Burley et al. 3576: 5; 3618: 11; 3837: 5; 3864: 5; 3930: 11; 4080: 10.

Culmsee 39: 5; 191: 5; 975; 5; 2581: 6; 2945: 6; 3153: 6; 3154: 6; D2-2: 8; r2196: 5.

de Vogel 2531: 5; 5176: 5; 6052: 5 – de Vogel & Vermeulen 6619: 5, 6726: 5; 6811: 11; 6054: 11; 7054: 11; 7064: 11 – de Vriese & Teijsmann 131: 4; s.n. (barcode L 0038327): 5; s.n. (barcode L 0038297): 11; s.n. (barcode L 0450311): 7; s.n. (barcode L 0450314): 7; s.n. (barcode L 0450327): 11; s.n. (barcode L 0450328): 11; s.n. (barcode L 0450332): 11; s.n. (barcode L 0450333): 11; s.n. (barcode L 0450354): 11; s.n. (barcode L 0450357): 8; s.n. (barcode L 0450358): 8; s.n. (barcode L 0450359): 8; s.n. (barcode L 0450360): 8; s.n. (barcode L 0450367): 8; s.n. (barcode L 0450381): 5; s.n. (barcode L 0450382): 5; s.n. (U Acc. No. 000184): 8; s.n. (U Acc. No. 000185): 8; s.n. (U Acc. No. 000200): 5; s.n. (U Acc. No. 000220); s.n. (BO Acc. No. BO-1364647): 5; s.n. (BO Acc. No. BO-1324098): 8.

Forman 202: 11 – Forsten 355: 5; s.n. (barcode L 0038296): 11: 11; s.n. (barcode L 0450299): 5; s.n. (barcode L 0450301): 5; s.n. (barcode L 0450333): 11; s.n. (U Acc. No. 000219): 11; s.n. (BO Acc. No. BO-1364650: 5.

Ganggrijp 21 (= NIFS Cel./ II-420): 5.

Halidjeng 11 H (= NIFS bb 20908): 7 – Hoornstra 54 (= NIFS bb 13487): 11.

Irot 4 (= NIFS bb 26296): 3; 12 (= NIFS bb 26637): 3.

Kamang 1 (=NIFS bb 31912): 5 – Kessler et al. PK 3008: 11; PK 3009: 5 – Kjellberg 1839: 5; Koorders 17768: 11; 17769: 11; 17770: 8; 17771: 8; 17772: 8; 17773: 8; 17774: 8; 17775: 817776: 8; 17777: 8; 17778: 8; 17779: 11; 17782: 11; 17783: 5; 17784: 5; 17785: 5; 17787: 11; 17788: 11; 17789: 11; 17790: 11; 17791: 5; 17792: 5; 17793: 11; 17794: 5; 17795: 5; 17796: 5; 17797: 11; 24081: 11.

Lam 2430: 11; 3121: 1 – Linggi 1 (= NIFS bb 32803): 8; Luntungan 1 (= NIFS bb 20000): 8.

McDonald & Ismail 3874: 5 – Meijer 9360: 5; 9584: 11; 9611: 11; 9628: 11; 9726: 11; 9811: 8; 10010: 9; 10016: 8; 10080: 11; 11006: 8 – Moningka 1 (= NIFS bb 19979): 11; 2 (= NIFS bb 19980): 11.

Netherland Indies Forest Service (NIFS) bb 12385 (= Warouw 1): 5; bb 12386: 11; bb 13487 (= Hoornstra 54): 11; bb 13512 (= Wullur 11): 11; bb 14217 (= Wullur 55): 5; bb 15701 (= Soekarman 12): 11; bb 17121 (Roringpandej 22): 11; bb 18128 (= Bish 123): 11; bb 18195: 3; bb 19581 (= Waturandang E 65): 3; bb 19605 (= Verhoef 121): 5; bb 19703: 7; bb 19726 (= Tumbel 1): 8; bb 19576 (= Waturandang E 60): 8; bb 19979 (= Mongingka 1): 11; bb 19980 (= Moningka 2): 11; bb 20000 (= Luntungan 1): 8; bb 20200 (= von Werner 3): 11; bb 20908 (= Halidjeng 11 H): 7; bb 21615 (= Waturandang 178): 11; bb 21987 (= Bish 254): 8; bb 21988 (= Patabang 1): 8; bb 21989 (= Patabang 2): 8; bb 23355: 6; bb 24079 (= Burki 53): 5; bb 24169 (= Burki 92): 8; bb 24172 (= Burki 95): 3; bb 24510 (= Rantegaoe E 296): 11; bb 26276: 3; bb 26296 (= Irot 4): 3; bb 28241 (= Bloembergen 201): 8; bb 28295: 3; bb 29194 (= Togas 22): 3; bb 26637 (= Irot 12): 3; bb 28268 (= Bloembergen 228): 3; bb 28295 (= Silo 4): 3; bb 31815 (= Pello 1): 11; bb 31863 (= Politon 38): 11; bb 32323 (= Rantegaoe 19): 11; bb 32459 (= Reppie 19): 11; bb 32472 (= Politon 76): 11; bb 32567 (= Polei 1): 8; bb 32568 (= Polei 2): 5; bb 32803 (= Linggi 1): 8; bb 33115 (= Tangkilisan 1): 8; Cel./ II-201 (= Waturandang 640): 5; Cel./ II-420 (= Ganggrijp 21): 5; Cel./ III-8 (= Waturandang 8, 55, 158): 11; Cel./ III-100 (= Reppie 300): 11; Cel./ III-101 (= Reppie 301: 11; Cel./ III-102 (= Reppie 302):11; Cel./ V-308 (= Reppie 527): 11 – Niswan 85: 8 – Noerkas 257: 5; 467: 11.

Patabang 1 (= NIFS bb 21988): 8; 2 (= NIFS bb 21989): 8 – Pello 1 (= NIFS bb 31815): 11; Pitopang et al. RP 347: 7; RP 359: 11; RP 1005: 5 – Polei 1 (= bb 32567): 8; 2 (= bb 32568): 5;bb 24079: 5; bb 31912 (= Kamang 1): 5 – Politon 38 (= NIFS bb 31863): 11; 76 (= NIFS bb 32472): 11 – Prawioratmodjo & Maskuri 1310: 5 – Prawioratmodjo & Soewoko 1707: 5; 1961: 5;

Rachmat 266: 4 – Ramlanto 227: 5 – Rantegaoe E 296 (= NIFS bb 24510): 11; 19 (= NIFS bb 32323): 11 – Reppie 19 (= NIFS bb 32459): 11;300 (= NIFS Cel./ III-100): 11; 301 (= NIFS Cel./ III-101: 11; 302 (= NIFS Cel./ III-102): 11; 527 (= NIFS Cel./ V-308: 11 – Riedel s.n.: 5 – Roringpandej 22 (= NIFS bb 17121): 11.

Sabir et al. 174 N: 5; B2 109: 6 – Silo 4 (= NIFS bb 28295): 3 – Soekarman 12 (= NIFS bb 15701: 11.

Tangkilisan 1 (= NIFS bb 33115): 8 – Tantra 1509: 11; 1546: 5; 1603: 5; 1766: 5 – Teijsmann 5325 HB: 8; 5781 HB: 5 – Togas 22 (= NIFS bb 29194): 3 – Tumbel 1 (= NIFS bb 19726): 8.

van Balgooy 3430: 11 – Verhoef 121 (= NIFS bb 19605): 5 – von Werner 3 (= NIFS bb 20200): 11.

Warouw 1 (= NIFS bb 12385): 5 – Waturandang E 60 (= NIFS bb 19576): 8; E 65 (= NIFS bb 19581): 3; 8 (= NIFS Cel./ III-8): 11; 55 (= NIFS Cel./ III-8): 11; 158 (= NIFS Cel./ III-8): 11;178 (= NIFS bb 21615): 11; 640 (= NIFS Cel./ II-201): 5 – Webb et al. s.n. (CEB Acc. No. 0000707): 11 – Weber sn (L Acc. No): 4 – Wen & Kartonegoro 10261: 9; 10276: 9; 10288: 11 – Whitmore & Sidiyasa TCW 2288: 5; Widjaja EAW 182: 8; EAW 9619: 11; Wullur 11 (= NIFS bb 13512): 11; 55 (= NIFS bb 14217): 5.

Yusuf & Wahyono 166: 11.

Appendix 4.1 Detailed description of methods

Study area

The complex, geologically young mountain region of Central Sulawesi consists of the West Sulawesi plutono-volcanic arc, mostly dominated by granite and other acid plutonic rocks and the Central Sulawesi metamorphic belt (Geological Research and Development Centre 1993, Hall and Wilson 2000, Hall 2013). The wide variety of soil types is due to variation in parent material, topography, elevation and climate; Acrisols, Cambisols, Ferralsols, Gleysols, Lixisols, Luvisols, Nitisols, and Regosols have been reported for LLNP (Dechert 2003, Häring et al. 2005, Culmsee et al. 2010b, Leitner 2010). According to climate data from 12 stations in and around LLNP (period 2002-2008; Kreilein, unpubl.), the climate of the study region is perhumid with most rainfall falling during April-May and November-December and a slightly drier period from July to October. At elevations below 1500 m in the inter-montane valleys, 1-3 drier months (<100 mm rainfall) do occur (Gunawan 2006). Humid north-westerly winds prevail from November to May and drier south-easterly winds during the rest of the year. ENSO-related droughts occur at irregular intervals (Gunawan 2006, Wündsch et al. 2014). While the populated valleys surrounding the park have a long history of human occupation and land use dating back at least 2.000 years (Henley 2005, Kirleis et al. 2011), most of LLNP itself has only been slightly affected by human activities like swidden agriculture, hunting and small-scale extraction of timber and non-timber forest products (NTFP) until the end of the 19th century. Since then, human impact has steadily increased and conflicts over resources and conservation efforts have appeared (Adiwibowo 2005, Weber 2006, Wündsch et al. 2014, Biagioni et al. 2015a).

Tree inventories

Criteria for study site selection were the presence of primary forest without major natural and human disturbance on level terrain (<10° inclination) without groundwater influence. The minimum distance between sites was 1 km except for sites N1 and N2 (c. 250 m distance). Five sites (S1050, S1400, S1850, S1900, S2400) had previously been surveyed in 2006/2007 (Culmsee and Pitopang 2009, Culmsee et al. 2010b, 2011) and were here censused a second time. Areas with any signs of logging or rattan-extraction were excluded. However, two NTFP, damar-resin from *Agathis dammara* (see Appendix 4.5 for full species names) and agarwood from *Gyrinops* sp., are collected by local inhabitants at elevations of c. 1700 – 2000 m throughout the study region and might have a slight, but unknown effect on forest structure and species composition. We established 13 inventory plots (see Table 1, 0.24 ha size, 40 m × 60 m, without slope correction) and divided each plot into a 10 m x 10 m grid using plastic poles and string. Within the plot, we permanently tagged and pre-identified all trees with dbh (measured at 1.3 m) ≥ 10 cm, recorded their position and collected information relevant for species identification (habit, presence of sap, bark characters, etc.). Tree height was measured with an ultrasound clinometer (Vertex IV with T3-Transponder; Haglöf, Langsele, Sweden) and diameter at breast height (dbh) with a diameter tape. Epiphytes and lianas were removed from the trunk before measuring dbh. The diameter of buttressed or stilt-rooted trees was measured above the buttresses (if these were taller than 1.3 m) and the measurement height recorded. For the measurement of multi-stemmed trees and strangler-trees, we employed the protocol described in Culmsee et al. (2010b). The same procedure was followed in a 5 m × 5 m subplot in each of the 24 grid-cells of 10 m × 10 m (altogether 0.06 ha per plot) for small trees (dbh: 2 – 9.9 cm). The survey data of all plots will be made available through the repository ForestPlots.net (Lopez-Gonzalez et al. 2009).

Table 1 Characteristics of the 13 inventory plots in old-growth mountain rain forests in Lore Lindu National Park, Sulawesi, Indonesia. Temperature and rainfall data modelled for the time period 1950–2000 from WorldClim (2014). Soils according to IUSS Working Group WRB (2014). Data on bedrock material from Geological Research and Development Centre (1993).

Plot	Elevational belt[1]	Elev.	Locality	Latitude/ longitude	Topography	Rain[2]	T[3]	Soil and bedrock type
S0700	Colline	700	Rantena	1°36.2' S 120°04.5' E	Gently sloping ridge	1990	23.0	Sideralic Cambisol on acid plutonic rocks
S0850	Colline	850	Tokepangana	1°36.9' S 120°04.4' E	Level terrace	1990	23.0	Sideralic Cambisol on acid plutonic rocks
S1050	Sub-montane	1050	Pono Valley	1°29.7' S 120°03.4' E	Level terrace	1900	21.0	Sideralic Cambisol on metamorphic rocks
S1200	Sub-montane	1200	Tarara	1°35.3' S 120°17.0' E	Up-slope plateau	1890	20.7	Stagnic Acrisol / Mollic Umbrisol on mixed sedimentary rocks
S1400	Sub-montane	1400	Bariri Forest (Baba Haleka)	1°39.4' S 120°10.5' E	Mid-slope terrace	1970	19.5	Rhodic Ferralsol on acid plutonic rocks
S1450	Sub-montane	1450	Torongkilo	1°24.9' S 120°16.7' E	Mid-slope terrace	1870	19.1	Folic Cambisol on mixed sedimentary rocks
S1650	Lower montane	1650	Balamba	1°41.9' S 120°09.6' E	Lower-slope terrace	2020	17.8	Xanthic Ferralsol on acid plutonic rocks
S1850	Lower montane	1850	Mount Nokilalaki	1°14.6' S 120°09.1' E	Mid-slope terrace	1950	16.8	Cambic Umbrisol on acid plutonic rocks
S1900	Lower montane	1900	Mount Nokilalaki	1°14.7' S 120°09.2' E	Mid-slope terrace	1950	16.8	Cambic Umbrisol on acid plutonic rocks
S1950	Lower montane	1950	Pantakleabae	1°42.0' S 120°09.0' E	Gently sloping ridge	2080	16.7	Cambic Umbrisol on acid plutonic rocks
S2150	Upper montane	2150	Tutu Malemo	1°45.9' S 120°09.6' E	Upslope plateau	2170	15.5	Folic Gleysol / Folic Cambisol on acid plutonic rocks
S2350	Upper montane	2350	Bulu Torenali	1°17.2' S 120°18.7' E	Upslope plateau	2080	14.8	Folic Histosol on acid plutonic rocks
S2400	Upper montane	2400	Mount Rorekautimbu	1°16.7' S 120°18.6' E	Mid-slope-terrace	2130	14.1	Folic Gleysol on acid plutonic rocks

[1] after van Steenis (1984), modified. [2] Mean annual rainfall (mm yr^{-1}). [3]Mean annual temperature (°C). Elev. = Elevation (m a.s.l.)

Soil analysis

To characterise the availability of plant macro-nutrients and the chemical status of the soil, we dug four soil pits of ≥ 50 cm per plot. In each pit we took 100 cm3-samples from the mineral soil at 10 and 40 cm depth and from the lowermost organic layer (OF and OH horizons) to obtain volume-related nutrient contents. The samples were air-dried and transported to Göttingen for nutrient analysis. The pH of the fresh soil was measured in the lab at Tadulako University, Palu, in a suspension of 10 g fresh soil in 1 M KCl. The concentrations of total C and N were measured by gas chromatography (vario EL, elementar, Hanau, Germany) from samples dried at 70°C (N) and corrected for moisture content.

Since no limestone occurs as bedrock in the study region, we assumed that all carbon was of organic origin. The total contents of Ca, K, Mg and Na, Al, Fe, and Mn in the organic layer material was measured by HNO_3 digestion and subsequent ICP-OES analysis (Perkin Elmer Optima 5300 DV), and the concentrations of exchangeable Ca, Mg, K, Na, Al, Fe, and Mn in the mineral soil by $BaCl_2$ extraction and subsequent element analysis in the percolate by ICP-OES. The observed pH change during the percolation process was used to calculate the concentration of hydrogen ions at the cation exchangers. Cation exchange capacity (CEC; in $\mu mol_c\ g^{-1}$) was obtained by adding the charge of K, Mg, Ca, Na, Al, Mn, Fe, and H measured in the percolate; we defined base saturation as the percentage of K, Mg, Ca, and Na ions (expressed as μmol_c) in CEC. One sample from S1200 showed unrealistically high values for Ca and was excluded from the analysis. In the additional soil pits, we collect soil samples from their main detectable horizons and described the soils according to FAO (2006). We then complemented the soil descriptions with literature information (Dechert 2003, Häring et al. 2005, Culmsee et al. 2010b, Leitner 2010) to identify the soil type according to the WRB system (IUSS Working Group WRB 2014).

Collection of specimens.

In the plots that were surveyed for the first time, we generally collected herbarium specimens from each individual. From morphospecies that were easily recognized in the field (e.g. palms, *Dracaena* spp.), we collected at least one specimen per plot. In the plots that had previously been surveyed, we collected only trees that were either in flower or fruit, had not been determined to species level previously (Culmsee and Pitopang 2009, Culmsee et al. 2011), or were recorded for the first time in our survey. In addition, we collected specimens of flowering and/or fruiting trees growing outside all plots. We used a telescopic pruner for smaller trees; for large individuals, we employed a slingshot (Big Shot, Sherrill Tree, Greensboro, USA) and hand chainsaw attached to strings. In a few cases, we used rope-climbing technique to access trees that were difficult to sample otherwise. Specimens were conserved in 70% denatured alcohol in the field until drying at the facilities of Tadulako University in Palu. In total, 2156 numbers were collected with at least three duplicates each, of which 16% were fertile, representing 51% of all morphospecies. Full sets of collections were deposited at CEB and GOET; duplicates of fertile specimens have been sent to BO and will be sent to K and L (Thiers 2018). A small number was sent to the specialists of single families at E, KEP, MO and STU. See Appendix 4.2 for details on species identification.

Data analyses

All calculations were performed using the software RStudio, Version 0.99.491 (RStudio Team 2015) based on R, Version 3.2.3 (R Core Team 2015). First, we investigated the correlation between plot elevation and seven soil parameters with Pearson's r using the *rcorr* function of the *Hmisc* library (Harrell Jr. 2015). We did not use precipitation data due to a lack of reliable data with high resolution at different elevations.

The diversity measures observed species richness ($^0D_{obs}$) and effective number of species ($^1D_{obs}$), are expressions of so-called Hill numbers (Hill 1973):, the latter incorporating abundance without favouring common or rare species (Jost 2006). Both measures are sensitive to undersampling, especially in species-rich ecosystems like tropical forests. We therefore also calculated the rarefied/extrapolated values based on a base sample size (BSS) of twice the number of individuals of the plot with the smallest number of individuals (BSS = 210; see Chao et al. 2014) and used the resulting effective number of species per BSS ($^1D_{210}$) as primary measure of diversity. The same procedure was applied for genera and families. We used the *iNEXT* package for R (Hsieh et al. 2014) for the calculation of diversity measures and rarefaction-extrapolation curves. The primary diversity measure was then applied as response variable in linear regression models with elevation and seven soil parameters as explaining variables. First, we ran bivariate linear regressions and sorted the environmental variables by their explanatory power (r^2). Then, we excluded all variables, which were significantly ($p \leq 0.05$) correlated with the most explanatory variable, and repeated the process until only mutually uncorrelated variables remained. The resulting environmental variables were used in multiple linear regression models with the diversity measures as response variable. The models were then simplified by a backward selection procedure using F-tests until obtaining the minimum adequate models. For the relative number of endemic species per plot, we ran logistic regression models (LRM) using the function *glm* with binomial error structure and logit link function in R with plot elevation as explanatory variable.

We conducted a literature search for plot-based tree inventories in Malesia and recorded their locality, elevation, the number of individuals, the number of species and environmental information, where available. We then chose all plots from sources with reliable species identification (incl. deposition of voucher specimens in herbaria), a full list of the recorded species and their abundances and a plot size of 0.1-1.0 ha (n = 38, see Appendix 4.3) for comparison with our 13 plots. Here again, we used the *iNEXT* package for R (Hsieh et al. 2014) to produce rarefaction-extrapolation curves. As BSS, we also defined twice the number of individuals of the sampling unit with the smallest number of individuals (n = 90).

To search for patterns related to community composition, we also calculated the abundance-based index of Bray-Curtis dissimilarity (Bray and Curtis 1957) for all pairs of plots and used the resulting matrix as dependent variable for a multivariate analysis of variance (MANOVA) using the *adonis* function in the vegan library for R (Oksanen et al. 2016) with single environmental parameters (Appendix 4.4, Table 1) as explanatory variables and a Monte-Carlo permutation test with 500 permutations. We then sorted the environmental parameters according to their explanatory power (highest r^2) and assessed the autocorrelation of these parameters using Pearson's r. All environmental parameters significantly related to elevation, the variable with the highest explanatory power, were excluded. The practice was repeated with the most explanatory of the remaining variables. The resulting, mutually independent variables, elevation and pH of the organic layer (pH_O), were both used for a second MANOVA, again with 500 permutations. Furthermore we used non-metric multidimensional scaling (NMDS, function *metaMDS* in the *vegan* package) to graphically display the influence of elevation and pH_O on tree species composition.

Since the elevational gradient was most pronounced for both diversity and composition, we attempted to define distinct elevational zones based on species composition. We used the matrix of Bray-Curtis dissimilarities for all plot-pairs to conduct a cluster analysis using the *hclust* function of the *vegan* package for R (Oksanen et al. 2016) with the average linkage (UPGMA) method and plotted the results in a dendrogram. Subsequently, we performed an indicator species analysis (Dufrêne and Legendre 1997, De Cáceres et al. 2010) using the *indicspecies* package for R (De Cáceres and Jansen 2015) and tested the statistical significance of the associations using a permutation test (999 random permutations) to show all species having a significant ($p < 0.05$) association with any elevational zone.

To explore the affiliation of the tree species in the plots with main tree guilds, we pooled all trees with dbh ≥ 10 cm and small trees (dbh 2 – 9.9 cm) recorded in the 5 m × 5 m subplots (0.06 ha per plot; small trees were not recorded outside of these subplots) and assigned them to two guilds based on the observed maximum height of the species relative to forest canopy height using our measured tree heights and literature data. The canopy height of a plot was defined as the mean height of the 10% tallest individuals. All species reaching a maximum height of ≥ 2/3 of the respective canopy height in any of the plots were classified as 'canopy species'. Species not reaching this threshold height but which attained heights > 25 m according to the literature (e.g. van Steenis et al. 1948-2014), were also scored as canopy species. All remaining species were assigned to the guild of understorey species' assuming that they possess special adaptations to the forest understorey environment and are more restricted in their height growth.

We then assigned the species in the two guilds to 35 orders according to APG IV (The Angiosperm Phylogeny Group 2016) , calculated the relative abundance of each order and guild per plot, and took the mean values for each elevational zone. For the 10 families with highest number of tree individuals, we ran logistic regression models (LRM) using the function *glm* with binomial error structure and logit link function using plot elevation and guild as explanatory variables and relative abundance of the order as response variable. We simplified the models stepwise by removing first non-significant ($p \geq 0.05$) interaction effects and then variables until reaching minimum adequate models with only significant terms remaining or further simplification causing a significant ($p < 0.05$) increase in deviance as measured by an F-test.

Appendix 4.2 Taxonomy and species identification

We followed Korall et al. (2007) in recognising three separate genera of scaly tree ferns (*Alsophila*, *Cyathea* s.s. and *Sphaeropteris*); for gymnosperms we followed the WCSP (2019). For angiosperms, we generally used the taxonomic concepts of APG IV (The Angiosperm Phylogeny Group 2016) and Stevens (2017) at family and genus levels except for a few taxa, where we chose to take into account recent revisions or phylogenetic studies to accurately reflect systematic relationships: *Ehretia* (Luebert et al. 2016), *Lasjia* P.H.Weston & A.R.Mast (Mast et al. 2008), *Machilus* Nees (Li et al. 2011), *Pleioluma* (Swenson et al. 2013), *Polyspora* (Orel et al. 2013), and *Utania* (Wong and Sugumaran 2012). For general identification we mainly relied on van Balgooy (1997, 1998, 2010) and the Interactive Key to Seed Plants of Malesia and Indo-China (The Malesian Key Group 2004). At species level, we used regional floristic accounts like (e.g. Flora Malesiana, The Tree Flora of Sabah and Sarawak, Flora of Jawa) and other taxonomic literature (see Table 1 for details).

Of the total 3852 examined individuals (2284 big trees with dbh ≥ 10 cm / 1568 small trees with dbh 2 – 9.9 cm) we dermined 90.4% (91.7% of big trees / 88.6% of small trees) to species level and a further 5.3% (4.8% / 5.9%) close to published species using "cf." or "aff." qualifiers. The remaining individuals were determined to genus level, but distinguished as separate morphospecies and treated like species in subsequent analyses unless indicated otherwise (Appendix 4.5).

For each species, we assessed whether it naturally occurs in the phytogeographical regions of China, the Indian subcontinent, Indochina, Malesia, Papuasia, Australia, and the Southwestern Pacific. Within the focal regions of Malesia and Papuasia, we further assessed the species' occurrence in the respective subregions (Fig. 1; Brummitt et al. 2001). Morphospecies which could not be assigned to published species names were not assessed. Where possible (79% of species), we used regional floristic accounts and databases (e.g. Merrill 1923a–1925, van Steenis et al. 1948–2016, Soepadmo et al. 1995–2014, Slik 2009, Pelser et al. 2011, WCSP 2019) and/or other taxonomic literature. Taxa without recent taxonomic revision were assessed searching the online databases of L/U (Wieringa 2015) and those of other major herbaria (mostly A, B, K, MO, NY, P, S, US using GBIF 2015) and species new to science were assumed to occur only in Sulawesi after careful scanning of relevant herbarium specimens. Taxa (i.e. species, subspecies, or varieties) occurring only in Sulawesi were defined as endemic species (Appendix 4.5). For the relative number of endemic species, we compared the number of endemic species to the total number of species occurring in each plot.

Table 1 Taxonomic literature used for species identification.

Family	Literature
Adoxaceae	(Kern and van Steenis 1951)
Anacardiaceae	(Hou 1978)
Annonaceae	(Keßler 1993, 1995, Mols and Keßler 2000, Saunders 2002, 2003, Wang and Saunders 2006a, 2006b, Surveswaran et al. 2010, Weerasooriya and Saunders 2010, Couvreur et al. 2012)
Apocynaceae	(Middleton 2007)
Aquifoliaceae	(Loesener 1901, 1908, 1924, Capitaine 1910, Backer and Bakhuizen van den Brink Jr. 1965a, Andrews 2002, Hicks 2006)
Araliaceae	(Philipson 1977, 1978, 1979, Lowry and Plunkett 2010)
Araucariaceae	(Whitmore 1980, de Laubenfels 1988, Farjon 2010)
Arecaceae	(Dransfield 1988, Mogea 2002, Dransfield et al. 2008, Heatubun et al. 2012)
Asparagaceae	(Jankalski 2008)
Asteraceae	(Robinson 1999, Robinson et al. 2008)
Burseraceae	(Kalkman 1954, Leenhouts et al. 1956, Leenhouts 1959, Kochummen 1995, Daly et al. 2010)
Calophyllaceae	(Stevens 1980)
Cannabaceae	(Soepadmo 1977)
Cardiopteridaceae	(Howard 1942, Sleumer 1971b, Utteridge and Schori 2011)
Celastraceae	(Hou 1962, 1964)
Chloranthaceae	(Verdcourt 1986)
Chrysobalanaceae	(Prance 1989, 1995)
Clethraceae	(Sleumer 1971a, Berhaman 1995)
Clusiaceae	(Lauterbach 1924, Kostermans 1956, Backer and Bakhuizen van den Brink Jr. 1963a, Stevens 2007)
Cunoniaceae	(Fortune Hopkins and Hoogland 2002)
Cyatheaceae	(Holttum 1963, Hovenkamp and de Joncheere 1988)
Dicksoniaceae	(Holttum 1963)
Ebenaceae	(Bakhuizen van den Brink 1933, 1936, Kostermans 1977, Wallnöfer 2001, 2004, Ng 2004)
Ehretiaceae	(Riedl 1997, Gottschling et al. 2016, Luebert et al. 2016)
Elaeocarpaceae	(Coode 1978, 1995, 1996a, 1996b, 1996c, 1998, 2001b, 2001a, 2001c, 2004, 2007, 2010, Coode and Weibel 1994)
Ericaceae	(Sleumer 1961, 1966, Stevens et al. 2004b, Vander Kloet 2005, Vander Kloet and Dickinson 2009)
Escalloniaceae	(Backer and Bakhuizen van den Brink Jr. 1963b)
Euphorbiaceae	(Shaw 1982, van Welzen 1994, Webster 1994, 2014, Esser 1997, Sierra and van Welzen 2005, Whitmore 2008, van Welzen et al. 2010)
Fabaceae	(Nielsen et al. 1984, Nielsen 1992)
Fagaceae	(Camus 1952, Soepadmo 1970, 2000, Soepadmo and van Steenis 1972)
Gentianaceae	(Leenhouts 1962, 1981, Wong and Sugumaran 2012)
Gesneriaceae	(Atkins 2003, Mendum and Atkins 2003, Bone and Atkins 2013)
Gnetaceae	(Markgraf 1951)
Hamamelidaceae	(Vink 1955)
Himantandraceae	(Bailey et al. 1943, van Royen 1962)
Hydrangeaceae	(Backer and Bakhuizen van den Brink Jr. 1963c, Hufford 2004)
Ixonanthaceae	(Kool 1980, 1988, Kubitzki 2014b)
Juglandaceae	(Jacobs 1960, Campbell-Gasis 1995, Vomberg 2004)
Lamiaceae	(Kok 2008, Bramley 2012)
Lauraceae	(Kostermans 1962, 1968, 1969, 1970, 1973, 1986, 1988, Rohwer 1993, Arifiani 2001, van der Werff 2001, Julia 2005, Ng 2005b, 2005a, Nishida 2008)
Loganiaceae	(Leenhouts 1962, Conn 1980)
Magnoliaceae	(Nooteboom 1985, 1987, 1988, Kim et al. 2002, Figlar and Nooteboom 2004)
Malvaceae	(Tantra 1976, Wilkie and Ahmad 2011)
Melastomataceae	(Maxwell and Veldkamp 1990b, 1990a)

Table 1 (cont.)

Family	Literature
Meliaceae	(Mabberley 1985, 2010, Pannell 1992, Mabberley et al. 1995, Culmsee 2008)
Metteniusaceae	(Sleumer 1971b)
Monimiaceae	(Philipson 1980, 1982, 1984, 1985, 1986)
Moraceae	(Berg and Corner 2005, Berg et al. 2006, Berg and Culmsee 2011, Berg 2012)
Myricaceae	(Backer 1951, Herbert 2005)
Myristicaceae	(de Wilde 2002)
Myrtaceae	(Blume 1850, Robinson 1909, Elmer 1914, Merrill 1921, Merrill and Perry 1937, 1939, Amshoff 1945, 1963, Hartley and Perry 1973, Hartley and Craven 1977, Scott 1979, Hyland 1983, Thompson 1989, Bean 1992, Craven et al. 2003, 2006, Biffin et al. 2005, Craven and Biffin 2010, Ashton 2011, Widodo 2012, Soh and Parnell 2015)
Nyssaceae	(Matthew 1976, 1977)
Oleaceae	(Kiew 1978, 1998, 2016)
Pandanaceae	(Stone 1983a, 1983b)
Paracryphiaceae	(Schlechter 1914, van Steenis 1986)
Pentaphylacaceae	(Kobuski 1947, 1953, 1961a, 1961b, 1963, Barker 1980, Weitzman et al. 2004)
Peraceae	(van Welzen et al. 1995, van Welzen and Esser 2013)
Phyllanthaceae	(Shaw 1972, 1981, 1982, Webster 1994, 2014)
Podocarpaceae	(Keng 1978b, de Laubenfels 1988, 2015, Farjon 2010)
Primulaceae	(Sleumer 1988b, 1988a, Stone 1989, 1990, Hu 1999, Takeuchi and Pipoly 2009)
Proteaceae	(Sleumer 1955, McDonald and Ismail R. 1995, Mast et al. 2008)
Putranjivaceae	(Shaw 1982, Webster 1994, Levin 2014)
Rosaceae	(Kalkman 1965, 1993)
Rubiaceae	(Bremekamp 1937, 1940a, 1940b, 1940c, Ridsdale 1978, 1989, Sohmer 1988, Ali and Robbrecht 1991, Davis and Bridson 2004, Zahid 2004, Sohmer and Davis 2007, Darwin 2010, Zahid and Wong 2010, Barrabé et al. 2012, Low 2013, Chen et al. 2015)
Rutaceae	(Hartley 1974, 1979, 1981, 2000, Appelhans and Wen 2016)
Sabiaceae	(van Beusekom 1971, van Beusekom and van de Water 1984)
Salicaceae	(Sleumer 1954)
Sapindaceae	(Bloembergen 1948, van der Ham 1977, van Welzen 1988, Adema et al. 1994, Noorsiha 1995)
Sapotaceae	(Lam 1948, Lam and van Royen 1952, Hermann-Erlee and van Royen 1957, van Royen 1957, 1960, Chai and Yii 2002, Pennington 2004)
Simaroubaceae	(Nooteboom 1962, Kulip and Wong 1995)
Staphyleaceae	(van der Linden 1960, Pereira 1995)
Stemonuraceae	(Sleumer 1971b, Utteridge 2011, Utteridge and Schori 2011)
Styracaceae	(van Steenis 1949)
Symplocaceae	(Nooteboom 1975, 1977)
Theaceae	(Barker 1980, Keng 1984, 1990, Yang et al. 2004)
Thymelaeaceae	(Hou 1960)
Trimeniaceae	(Rodenburg 1971, Philipson 1986)
Winteraceae	(Smith 1969, Vink 1970, Doust and Drinnan 2004)

Appendix 4.3 Malesian inventory plots

Nr	Plot Code	Phytog. unit[1]	Location	Long. [°]	Lat. [°]	Elev. [m]	Rainfall [mm/a]	Substrate	Forest type²	Forest condition[3]	Area [ha]	Ind. / plot	$^0D_{obs}$	$^1D_{obs}$	$^0D_{90}$	$^1D_{90}$	Original source
1	BOR_Kin07S	BOR	Mt Kinabalu, Sabah	116.55	6.08	650	2509	sediment	lowland	old growth	1.00	464	148	93.20	58.21	48.72	(Aiba et al. 2002)
2	BOR_Kin07U	BOR	Mt Kinabalu, Sabah	116.55	6.08	700	2509	ultramafic	lowland	old growth	1.00	510	148	93.69	57.87	49.07	(Aiba et al. 2002)
3	BOR_Kin17Q	BOR	Mt Kinabalu, Sabah	116.55	6.08	1860	2714	sediment	l.-mont. l. slope	old growth	1.00	874	81	38.75	37.14	26.90	(Aiba et al. 2002)
4	BOR_Kin17QM	BOR	Mt Kinabalu, Sabah	116.55	6.08	1860	2714	sediment	l.-mont. mid-slope	old growth	0.10	102	35	21.96	32.68	21.25	(Takyu et al. 2002)
5	BOR_Kin17S	BOR	Mt Kinabalu, Sabah	116.55	6.08	1560	2714	sediment	l.-mont. l. slope	old growth	1.00	838	109	62.09	47.12	37.71	(Aiba et al. 2002)
6	BOR_Kin17TM	BOR	Mt Kinabalu, Sabah	116.55	6.08	1560	2714	sediment	l.-mont. mid-slope	old growth	0.10	120	44	30.21	37.90	27.65	(Takyu et al. 2002)
7	BOR_Kin17U	BOR	Mt Kinabalu, Sabah	116.55	6.08	1860	2714	ultramafic	l.-mont. l. slope	old growth	0.20	282	32	16.56	22.64	14.51	(Aiba et al. 2002)
8	BOR_Kin17UM	BOR	Mt Kinabalu, Sabah	116.55	6.08	1860	2714	ultramafic	l.-mont. mid-slope	old growth	0.10	162	22	9.79	18.12	9.16	(Takyu et al. 2002)
9	BOR_Kin24	BOR	Mt Kinabalu, Sabah	116.55	6.08	2350	2085	sediment	upper montane	old growth	0.14	120	29	19.15	26.63	18.16	(Kitayama 1995)
10	BOR_Kin26	BOR	Mt Kinabalu, Sabah	116.55	6.08	2600	2085	sediment	upper montane	old growth	0.17	93	10	6.17	9.78	6.10	(Kitayama 1995)
11	BOR_Kin27S	BOR	Mt Kinabalu, Sabah	116.55	6.08	2590	2085	sediment	upper montane	old growth	0.25	246	15	7.44	12.02	7.04	(Aiba et al. 2002)
12	BOR_Kin27U	BOR	Mt Kinabalu, Sabah	116.55	6.08	2700	2085	ultramafic	upper montane	old growth	0.20	271	15	9.05	12.37	8.53	(Aiba et al. 2002)
13	BOR_Kin31S	BOR	Mt Kinabalu, Sabah	116.55	6.08	3080	3285	sediment	sub-alpine	old growth	0.20	389	17	10.56	14.79	9.79	(Aiba et al. 2002)
14	BOR_SP1	BOR	Apo Kayan FR, Kalim.	115.50	2.70	740	4500	sediment	Fagaceae forest	[undist.]	0.80	575	179	138.52	67.64	61.38	(Bratawinata 1986)
15	BOR_SP3	BOR	Apo Kayan FR, Kalim.	115.50	2.70	960	4500	sediment	mixed valley forest	[undist.]	0.80	631	157	93.53	57.00	47.57	(Bratawinata 1986)
16	BOR_SP4	BOR	Apo Kayan FR, Kalim.	115.50	2.70	1230	4500	sediment	dipterocarp ridge	[undist.]	0.80	518	117	73.57	52.31	43.32	(Bratawinata 1986)
17	BOR_SP5	BOR	Apo Kayan FR, Kalim.	115.50	2.70	1460	4500	sediment	Agathis forest	[undist.]	0.80	628	156	98.29	58.23	49.69	(Bratawinata 1986)
18	BOR_SP6	BOR	Apo Kayan FR, Kalim.	115.50	2.70	1850	4500	sediment	Ericaceae forest	[undist.]	0.80	509	106	67.82	50.47	41.63	(Bratawinata 1986)
19	JAW_GP0	JAW	Mt Gede-Pangrango	107.02	-6.75	1500	3380	volcanic	montane	old growth	1.00	283	59	30.07	34.62	23.33	(Meijer 1959)
20	JAW_GP1	JAW	Mt Gede-Pangrango	107.02	-6.75	1600	3380	alluvial	montane	old growth	1.00	427	57	28.54	31.81	21.95	(Yamada 1975)
21	JAW_GP2	JAW	Mt Gede-Pangrango	107.02	-6.75	1700	3380	volcanic	montane	old growth	0.10	45	19	14.26	26.44	17.50	(Yamada 1977)
22	JAW_GP3	JAW	Mt Gede-Pangrango	107.02	-6.75	1900	3380	volcanic	montane	old growth	0.10	56	15	10.76	16.57	11.93	(Yamada 1977)
23	JAW_GP4	JAW	Mt Gede-Pangrango	107.02	-6.75	2100	3380	volcanic	montane	old growth	0.10	84	14	6.72	14.35	6.77	(Yamada 1977)
24	JAW_GP5	JAW	Mt Gede-Pangrango	107.02	-6.75	2300	3380	volcanic	montane	old growth	0.10	110	11	6.80	10.57	6.71	(Yamada 1977)
25	JAW_GPB	JAW	Mt Gede-Pangrango	107.02	-6.75	800	2090	volcanic	mixed dipterocarp.	[undist.]	1.00	352	70	58.86	48.82	41.79	(Helmi et al. 2009)
26	MOL_Hal	MOL	Tapayo, Halmahera	128.00	0.75	630	2250	sediment	colline	undist.	0.50	383	77	36.62	36.97	26.25	(Whitmore et al. 1987)

Nr	Plot Code	Phytog. unit[1]	Location	Long. [°]	Lat. [°]	Elev. [m]	Rainfall [mm/a]	Substrate	Forest type[2]	Forest condition[3]	Area [ha]	Ind. / plot	$^0D_{obs}$	$^1D_{obs}$	$^0D_{90}$	$^1D_{90}$	Original source
27	PHI_B08	PHI	Mt Banahao	121.50	14.50	750	4000	volcanic	colline	n/a	0.42	300	75	55.47	47.93	39.30	(Aragones 1991)
28	PHI_B10	PHI	Mt Banahao	121.50	14.50	950	4000	volcanic	sub-montane	n/a	0.42	158	49	37.26	40.28	31.97	(Aragones 1991)
29	PHI_B12	PHI	Mt Banahao	121.50	14.50	1200	4000	volcanic	sub-montane	n/a	0.42	119	30	23.65	28.69	22.50	(Aragones 1991)
30	PHI_B15	PHI	Mt Banahao	121.50	14.50	1500	4000	volcanic	lower montane	n/a	0.42	124	24	20.36	23.14	19.52	(Aragones 1991)
31	PHI_B18	PHI	Mt Banahao	121.50	14.50	1800	4000	volcanic	mid-montane	n/a	0.42	78	12	10.59	12.00	11.39	(Aragones 1991)
32	PHI_B21	PHI	Mt Banahao	121.50	14.50	2100	4000	volcanic	upper montane	n/a	0.42	116	11	10.62	11.00	10.48	(Aragones 1991)
33	PHI_G2a	PHI	Mt Giting-Giting	122.57	12.42	750	2100	ultramafic	lower montane	unlogged	0.25	457	95	47.69	44.01	31.24	(Proctor et al. 1998)
34	PHI_G2b	PHI	Mt Giting-Giting	122.57	12.42	850	2100	ultramafic	lower montane	unlogged	0.25	545	75	36.23	36.63	25.88	(Proctor et al. 1998)
35	PHI_G3a	PHI	Mt Giting-Giting	122.57	12.42	1250	2100	ultramafic	upper montane	unlogged	0.25	217	28	12.30	21.00	11.15	(Proctor et al. 1998)
36	PHI_Min	PHI	Mt Kinasalapi	125.50	8.00	2200	3000	volcanic	montane	old growth	1.00	1061	43	25.15	27.14	20.43	(Pipoly and Madulid 1998)
37	PHI_Neg	PHI	Mt Mandalagan	123.18	10.68	1000	4650	volcanic	sub-montane	unlogged	1.00	645	92	47.56	41.40	31.61	(Hamann et al. 1999)
38	S0700	SUL	Lore Lindu NP	120.08	-1.60	700	1990	acid plut.	sub-montane	old growth	0.24	146	62	47.08	48.20	39.17	this study
39	S0850	SUL	Lore Lindu NP	120.07	-1.62	850	1990	acid plut.	sub-montane	old growth	0.24	133	32	18.59	26.89	17.20	this study
40	S1050	SUL	Lore Lindu NP	120.06	-1.50	1050	1900	mixed	sub-montane	old growth	0.24	105	50	36.13	45.53	33.94	this study
41	S1200	SUL	Lore Lindu NP	120.28	-1.59	1200	1890	mixed	sub-montane	old growth	0.24	170	63	46.96	46.24	37.80	this study
42	S1400	SUL	Lore Lindu NP	120.18	-1.66	1400	1970	acid plut.	lower montane	old growth	0.24	131	42	27.25	35.00	24.61	this study
43	S1450	SUL	Lore Lindu NP	120.28	-1.42	1450	1870	mixed	lower montane	old growth	0.24	155	59	39.80	44.36	33.00	this study
44	S1650	SUL	Lore Lindu NP	120.16	-1.70	1650	2020	acid plut.	lower montane	old growth	0.24	129	42	27.51	35.49	24.93	this study
45	S1850	SUL	Lore Lindu NP	120.15	-1.24	1850	1950	mixed	lower montane	old growth	0.24	129	25	10.36	20.87	9.78	this study
46	S1900	SUL	Lore Lindu NP	120.15	-1.24	1900	1950	mixed	lower montane	old growth	0.24	171	31	19.55	24.81	17.69	this study
47	S1950	SUL	Lore Lindu NP	120.15	-1.70	1950	2080	acid plut.	lower montane	old growth	0.24	200	48	25.34	32.98	21.13	this study
48	S2150	SUL	Lore Lindu NP	120.16	-1.77	2150	2170	acid plut.	upper montane	old growth	0.24	362	24	14.54	19.43	13.05	this study
49	S2350	SUL	Lore Lindu NP	120.31	-1.29	2350	2080	acid plut.	upper montane	old growth	0.24	215	26	13.37	19.46	12.14	this study
50	S2400	SUL	Lore Lindu NP	120.31	-1.28	2400	2130	acid plut.	upper montane	old growth	0.24	238	39	22.85	28.11	19.51	this study
51	SUM_BG	SUM	Batang Gadis NP	99.45	0.62	660	4000	sediment	lowland mixed dipt.	undist.	1.00	422	182	109.82	60.37	51.86	(Kartawinata et al. 2004)

[1] Phytogeographic unit according to Brummit et al. (2001). [2 & 3] According to original source; in square brackest, when forest condition was not explicitely mentioned, but could be inferred. Long. = Longitude; Lat. = Latitude; Ind. = Individuals; $^0D_{obs}$ = observed species richness; $^1D_{obs}$ = observed effective number of species; $^0D_{90}$ = species richness rarefied/extrapolated per base sample size 90 individuals; $^1D_{90}$ = effective number of species rarefied/extrapolated per 90 individuals; dipt. = dipterocarp; FR = Forest Reserve; l. = lower; mont. = montane; NP = National Park; plut. = plutonic; undist. = undisturbed

Appendix 4.4 Environmental parameters

Table 1 Soil parameters characterising 13 inventory plots in Lore Lindu National Park, Sulawesi, Indonesia. Values are means ± 1SD of four samples per plot (3 in S1200). Different superscript letters indicate significant differences between values within one column based on ANOVA with post-hoc Tukey's HSD test at significance level $p < 0.05$.

Plot	Thick$_O$	BCo	CNo	pHo	BSa	CNa	pHa
S0700	3	76.95 ± 40.05^{b}	16.3 ± 1.05^{c}	3.20 ± 0.30^{bcd}	4.25 ± 1.36^{c}	9.11 ± 0.89^{d}	3.60 ± 0.07^{de}
S0850	5	41.13 ± 9.45^{b}	17.65 ± 2.05^{bc}	3.06 ± 0.13^{bcde}	2.72 ± 0.09^{c}	10.14 ± 0.63^{d}	3.58 ± 0.08^{e}
S1050	3	122.00 ± 35.94^{b}	15.87 ± 1.92^{c}	3.48 ± 0.09^{bc}	11.31 ± 4.23^{c}	11.49 ± 0.30^{cd}	3.85 ± 0.08^{cde}
S1200	7	1061.25 ± 305.10^{a}	17.10 ± 0.62^{bc}	5.06 ± 0.60^{a}	48.76 ± 22.74^{a}	9.52 ± 0.77^{d}	4.07 ± 0.22^{bcd}
S1400	2	85.30 ± 16.82^{b}	19.50 ± 5.44^{bc}	3.45 ± 0.89^{bc}	12.14 ± 2.30^{c}	9.10 ± 5.21^{d}	4.13 ± 0.09^{abc}
S1450	9	132.62 ± 21.53^{b}	17.08 ± 0.64^{bc}	3.18 ± 0.19^{bcd}	8.21 ± 3.75^{c}	13.57 ± 1.50^{bcd}	3.94 ± 0.06^{bcde}
S1650	8	222.22 ± 49.53^{b}	18.23 ± 2.05^{bc}	3.24 ± 0.69^{bc}	11.94 ± 7.29^{c}	13.82 ± 0.77^{bcd}	4.08 ± 0.09^{bc}
S1850	5	162.72 ± 87.31^{b}	17.74 ± 2.07^{bc}	2.98 ± 0.31^{bcde}	17.09 ± 3.89^{bc}	13.43 ± 1.41^{bcd}	4.15 ± 0.11^{abc}
S1900	5	176.71 ± 103.56^{b}	18.18 ± 2.02^{bc}	3.74 ± 0.38^{b}	32.53 ± 14.47^{ab}	13.40 ± 0.37^{bcd}	4.30 ± 0.07^{ab}
S1950	6	80.19 ± 35.86^{b}	23.06 ± 2.17^{ab}	2.49 ± 0.35^{cde}	7.12 ± 2.71^{c}	23.46 ± 2.99^{a}	4.09 ± 0.26^{bc}
S2150	30	38.59 ± 2.10^{b}	28.38 ± 3.36^{a}	2.07 ± 0.14^{e}	4.07 ± 2.34^{c}	19.81 ± 5.97^{abc}	3.62 ± 0.38^{de}
S2350	45	101.83 ± 25.83^{b}	22.87 ± 1.13^{ab}	2.20 ± 0.12^{de}	14.60 ± 2.53^{bc}	26.20 ± 3.24^{a}	4.54 ± 0.16^{a}
S2400	10	79.66 ± 43.52^{b}	23.60 ± 4.15^{ab}	2.65 ± 0.29^{cde}	6.19 ± 2.91^{c}	21.39 ± 7.91^{ab}	3.54 ± 0.27^{e}

Thick = thickness (cm). BC = Sum of base cations (Ca, Mg, K). BS = base saturation (%). C = total C (g). N = total N (g). C/N = carbon/nitrogen ratio. pH = pH(KCl). Subscript "O" denotes values for organic layer, subscript "A" values for A horizon, measured at 10 cm depth of mineral soil.

Table 2 Correlation among elevation and seven soil parameters on 13 inventory plots in Lore Lindu National Park, Sulawesi, Indonesia. Correlations, calculated by Pearson's r, are shown in upper right triangle matrix, the respective significance values (p) in lower left triangle matrix. Significant correlations ($p < 0.05$) are in bold face.

		Person's r							
		Elev	Thick$_O$	BC$_O$	C/N$_O$	pH$_O$	BS$_A$	C/N$_A$	pH$_A$
p-value	Elev		**0.60**	-0.20	**0.76**	-0.55	-0.02	**0.85**	0.35
	Thick$_O$	**0.031**		-0.13	**0.65**	**-0.56**	-0.10	**0.72**	0.30
	BC$_O$	0.518	0.677		-0.29	**0.81**	**0.87**	-0.31	0.21
	C/N$_O$	**0.003**	**0.015**	0.330		**-0.70**	-0.31	**0.78**	-0.09
	pH$_O$	0.052	**0.045**	**0.001**	**0.008**		**0.79**	**-0.73**	0.13
	BS$_A$	0.958	0.748	**0.000**	0.308	**0.001**		-0.25	0.51
	C/N$_A$	**0.000**	**0.006**	0.306	**0.002**	**0.005**	0.402		0.24
	pH$_A$	0.243	0.323	0.489	0.778	0.681	0.077	0.430	

Appendix 4.5 List of all species and their abundances in inventory plots

See Appendix 4.2 for taxonomic references. Number of individuals of each species per plot are given for big trees (dbh > 10 cm; preceding slash) and small trees (dbh 2–9.9 cm; following slash).

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Adoxaceae															
Viburnum sambucinum Blume (Brambach et al. 1303)			.	.	.	0/1	.	0/1	.	.	.	.	.	.	.
Anacardiaceae															
Dracontomelon dao (Blanco) Merr. & Rolfe (Brambach et al. 0523)			2/0	.	.	.	.	.	.	.	.	.	.	.	.
Koordersiodendron pinnatum Merr. (Brambach et al. 0506)			1/0	.	.	.	.	.	.	.	.	.	.	.	.
Mangifera foetida Lour. (Brambach et al. 0667)			2/1	1/0	.	.	.	.	.	.	.	.	.	.	.
Semecarpus forstenii Blume (Brambach et al. 1299)			.	.	.	2/1	.	.	.	.	.	.	.	.	.
Annonaceae															
Alphonsea javanica Scheff. (Brambach et al. 1312)			0/1	.	0/1	1/1	.	.	.	.	.	.	.	.	.
Cananga odorata (Lam.) Hook.f. & Thomson (Brambach et al. 1258)			.	.	.	1/0	.	.	.	.	.	.	.	.	.
Drepananthus kingii (Boerl. ex Koord.) Survesw. & R.M.K.Saunders (Brambach et al. 0655)	C-Sul	x	1/0	.	1/1	.	.	.	.	.	.	.	.	.	.
Goniothalamus sp. nov. (Brambach et al. 0421)	Sp	x	.	.	1/0	.	.	.	.	.	.	.	.	.	.
Mitrephora macrocarpa (Miq.) Weerasooriya & R.M.K.Saunders (Brambach et al. 1317)	C-Sul	x	.	.	.	2/0	.	1/0	.	.	.	.	.	.	.
Phaeanthus ophthalmicus (Roxb. ex G.Don) J.Sinclair (Brambach et al. 1533)	C-Sul		.	.	.	.	.	1/3	.	.	.	.	.	.	.
Popowia pisocarpa Endl. (Brambach et al. 0415)			.	.	1/18	.	.	.	.	.	.	.	.	.	.
Apocynaceae															
Alstonia spectabilis R.Br. (Brambach et al. 1581)			.	.	.	.	.	1/0	.	.	.	.	.	.	.
Tabernaemontana sphaerocarpa Blume (Brambach et al. 1480)			.	.	.	.	.	1/0	.	2/0	.	.	.	.	.
Aquifoliaceae			.	.	.	.	.	.	.	.	.	.	.	.	.
Ilex celebensis Capit. var. *celebensis* (Brambach et al. 1547)	C-Sul		.	.	.	.	.	4/1	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Ilex odorata Buch.-Ham. ex D.Don var. *teysmannii* Loes. (Brambach et al. 0780)	C-Sul	x	.	.	.	.	.	.	.	.	0/1	0/1	.	.	1/0
Ilex sp. nov. (Brambach et al. 1962)	Sp	x	.	.	.	.	.	.	.	.	.	.	2/0	2/1	.
Araliaceae															
Polyscias diversifolia (Blume) Lowry & G.M.Plunkett (Brambach et al. 1079)	C-Sul		.	.	.	4/0	.	1/1	.	.	.	.	.	.	.
Polyscias nodosa (Blume) Seem. (Brambach et al. 1183)	C-Sul		.	.	.	2/1	.	.	.	.	.	.	.	.	.
Araucariaceae			.	.	.	.	.	.	.	.	.	.	.	.	.
Agathis dammara (Lamb.) Rich. & A.Rich (Culmsee r2182)			.	.	.	.	.	.	.	.	.	2/1	.	.	.
Arecaceae															
Areca vestiaria Giseke (Brambach et al. 0291)			0/1	0/1	.	.	.	.	.	.	.	.	.	.	.
Areca sp. nov. (Brambach et al. 0789)	Sp	x	.	.	.	.	.	.	.	.	.	.	49/9	2/0	.
Caryota rumphiana Zumaidar & Jeanson (Brambach et al. 1081)			.	.	.	1/0	.	.	.	.	.	.	.	.	.
Oncosperma horridum (Griff.) Scheff. (Brambach et al. 0256)	C-Sul		1/0	3/2	.	.	.	.	.	.	.	.	.	.	.
Pinanga caesia Blume (Brambach et al. 0429)		x	.	0/1	1/0	.	.	1/0	.	.	.	.	.	.	.
Asparagaceae															
Dracaena angustifolia (Medik.) Roxb. (Brambach et al. 1119)			1/1	.	.	4/2	.	.	.	.	.	.	.	.	.
Dracaena borneensis (Merr.) Jankalski (Brambach et al. 1124)	Sul		.	.	3/0	5/0	.	.	.	.	.	.	.	.	.
Asteraceae															
Strobocalyx arborea (Buch.-Ham.) Sch.Bip. (Brambach et al. 0384, 0857)			2/0	.	1/0	.	2/1	.	1/0	0/1	2/1	.	.	.	.
Burseraceae															
Canarium balsamiferum Willd. (Brambach et al. 1138)			2/0	.	0/2	6/2	.	1/1	.	.	.	.	.	.	.
Canarium hirsutum Willd. (Brambach et al. 1136)			.	.	.	3/0	.	.	.	.	.	.	.	.	.
Santiria apiculata A.W.Benn. var. *apiculata* (Brambach et al. 0423)			7/6	17/12	6/5	.	7/2	.	.	.	.	.	.	.	.
Calophyllaceae															
Calophyllum soulattri Burm.f. (Brambach et al. 1319)			.	.	1/0	5/1	.	5/10	9/2	.	.	.	.	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Calophyllum sp. nov. (Brambach et al. 0881)	Sp	x	.	.	.	.	2/0	.	.	.	.	.	.	.	.
Calophyllum sp. (Brambach et al. 0642)			1/0	.	.	.	.	.	.	.	.	.	.	.	.
Cannabaceae															
Celtis rubrovenia Elmer (Brambach et al. 1238)	Sul		.	.	.	4/0	.	.	.	.	.	.	.	.	.
Gironniera subaequalis Planch. (Brambach et al. 0224)			3/5	15/4	.	.	.	.	.	.	.	.	.	.	.
Trema orientalis (L.) Blume (Brambach et al. 1053)			.	.	.	1/0	.	.	.	.	.	.	.	.	.
Cardiopteridaceae															
Citronella suaveolens (Blume) Howard (Culmsee r2331)	C-Sul		.	.	.	.	.	0/1	.	.	.	2/0	.	.	.
Celastraceae															
Lophopetalum javanicum (Zoll.) Turcz. (Brambach et al. 1552)	C-Sul		.	.	.	.	.	2/13	.	.	.	.	.	.	.
Siphonodon celastrineus Griff. (Brambach et al. 1277)			.	.	.	0/1	.	.	.	.	.	.	.	.	.
Chloranthaceae															
Ascarina philippinensis C.B.Rob. (Brambach et al. 0688)			.	.	.	.	.	.	.	.	.	.	.	.	4/0
Chrysobalanaceae			.	.	.	.	.	.	.	.	.	.	.	.	.
Maranthes corymbosa Blume (Brambach et al. 0584)			1/0	.	0/1	.	.	.	.	.	.	.	.	.	.
Clethraceae															
Clethra canescens Reinw. ex Blume (Brambach et al. 0687)			.	.	.	.	.	.	.	.	0/1	.	.	.	7/1
Clusiaceae															
Garcinia celebica L. (Brambach et al. 0420)			.	.	1/0	.	.	.	.	.	.	.	.	.	.
Garcinia longipedicellata Kosterm. (Brambach et al. 1487)	C-Sul	x	.	.	.	.	.	1/0	.	.	.	.	.	.	.
Garcinia maluensis Lauterb. (Brambach et al. 1240)	C-Sul		.	.	.	5/0	0/1	.	.	.	.	.	.	.	.
Garcinia sp. (Brambach et al. 1600)			.	.	.	.	.	1/0	.	.	.	.	.	.	.
Cunoniaceae															
Weinmannia aff. *fraxinea* (D.Don) Miq. (Brambach et al. 0761)	Sul	x	.	.	.	.	.	1/0	.	.	.	.	.	.	2/0
Weinmannia furfuracea H.C.Hopkins (Brambach et al. 0949)			.	.	.	.	.	.	.	.	.	.	12/1	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Cyatheaceae															
Alsophila cf. *halconensis* (Christ) R.M.Tryon (Brambach et al. 0653)			0/1	.	.	.	.	.	.	.	.	.	.	.	.
Alsophila roroka (Hovenkamp) Lehnert ined. (*Cyathea roroka* Hovenkamp; Brambach et al. 0740)		x	.	.	.	.	.	.	.	.	.	.	.	.	25/7
Alsophila cf. *saccata* (Christ) R.M.Tryon (Brambach et al. 1361)		x	.	.	.	.	.	1/5	.	.	.	.	.	.	.
Sphaeropteris sarasinorum (Holttum) R.M.Tryon (Brambach et al. 0137)		x	.	.	.	.	.	.	.	.	1/0	1/1	.	.	.
Sphaeropteris tripinnata (Copel.) R.M.Tryon (Brambach et al. 0316)			.	0/1	2/0	.	.	5/5	.	.	.	.	.	.	.
Dicksoniaceae															
Dicksonia blumei (Kunze) T.Moore (Brambach et al. 0944)			.	.	.	.	.	.	.	.	.	.	3/0	1/0	2/0
Ebenaceae															
Diospyros macrophylla Blume (Brambach et al. 0513)			1/0	.	.	.	.	.	.	.	.	.	.	.	.
Diospyros sp. (Brambach et al. 1273)			.	.	.	3/3	.	.	.	.	.	.	.	.	.
Ehretiaceae															
Ehretia javanica Blume (Culmsee r2120)	Sul		.	.	.	.	.	.	1/0	.	.	.	.	.	.
Elaeocarpaceae															
Elaeocarpus angustifolius Blume (Brambach et al. 0658)			3/0	.	.	.	0/1	0/2	.	.	.	.	.	.	.
Elaeocarpus celebicus Koord. (Culmsee y2044)	C-Sul	x	.	.	.	1/0	0/3	.	0/3	.	.	.	.	.	.
Elaeocarpus culminicola Warb. (Brambach et al. 0834)			.	.	.	.	7/2	.	.	.	.	.	.	.	.
Elaeocarpus dolichostylus Schltr. (Brambach et al. 0171)			.	.	.	1/0	.	.	.	.	.	.	.	.	.
Elaeocarpus erdinii Coode (Brambach et al. 1607)			.	.	.	.	8/12	2/1	.	.	.	.	.	.	.
Elaeocarpus firdausii Brambach et al. (Brambach et al. 1953)	Sp	x	.	.	.	.	.	.	.	.	.	.	2/2	3/0	1/0
Elaeocarpus aff. *harunii* Coode (Brambach et al. 1967)	C-Sul	x	.	.	.	.	.	.	.	.	.	.	.	8/0	1/0
Elaeocarpus macropus Warb. ex R.Knuth (Brambach et al. 0490)		x	5/0	.	1/0	2/2	.	0/1	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Elaeocarpus multiflorus (Turcz.) F.Vill. (Brambach et al. 1370)			.	.	.	.	0/2	1/3	.	.	.	.	.	.	.
Elaeocarpus musseri Coode (Brambach et al. 1510)		x	.	.	.	.	0/2	2/2	.	.	.	.	.	.	.
Elaeocarpus octopetalus Merr. (Brambach et al. 0638)		x	7/2	.	0/1	.	.	.	.	.	.	.	.	.	.
Elaeocarpus aff. *octopetalus* Merr. (Brambach et al. 0935)		x	.	.	.	.	.	.	.	.	.	.	9/0	.	.
Elaeocarpus steupii Coode (Brambach et al. 0970)		x	.	.	.	.	.	.	.	.	.	.	11/4	.	.
Elaeocarpus teysmannii Koord. & Valeton ssp. *domatiferus* Coode (Brambach et al. 0744)		x	.	.	.	.	.	.	.	.	.	.	.	.	3/0
Elaeocarpus sp. (Brambach et al. 1329)			.	.	.	.	.	.	.	.	.	1/0	.	.	.
Sloanea celebica Boerl. & Koord. ex Koord. (Brambach et al. 1535)	C-Sul		.	.	.	.	.	7/1	.	.	.	.	.	.	.
Ericaceae															
Rhododendron bloembergenii Sleumer (Brambach et al. 2072)		x	.	.	.	.	.	.	.	.	.	.	.	0/1	.
Vaccinium cuneifolium (Blume) Miq. (Brambach et al. 0421)	C-Sul	x	.	.	.	.	.	.	.	.	.	1/0	3/4	1/0	1/1
Vaccinium dubiosum J.J.Sm. (Brambach et al. 0142)		x	.	.	.	.	.	.	.	.	.	1/0	4/1	.	.
Vaccinium sp. nov. (Brambach et al. 1683)	Sp	x	.	.	.	.	.	.	.	.	.	.	.	0/1	.
Escalloniaceae															
Polyosma celebica Schulze-Menz ined. (Brambach et al. 0766)	Sp	x	.	.	.	.	.	0/2	18/7	7/5	5/7	.	.	.	3/0
Polyosma integrifolia Blume (Brambach et al. 0820)			.	1/0	2/3	.	1/1	2/0	3/3	.	.	.	.	.	.
Euphorbiaceae															
Homalanthus populneus (Geiseler) Pax (Brambach et al. 0887)			.	.	.	.	1/0	.	.	.	.	.	.	.	0/1
Macaranga cf. *celebica* Koord. (Brambach et al. 1416)		x	0/1	.	.	.	.	0/1	.	.	.	.	.	.	.
Macaranga hispida (Blume) Müll.Arg. (Brambach et al. 1057)			.	.	.	4/2	.	.	.	.	.	.	.	.	.
Macaranga rorokae Whitmore (Culmsee r2032)		x	.	.	.	.	.	.	1/0	.	.	.	.	.	.
Macaranga waturandangii Whitmore (Brambach et al. 0113)		x	.	.	.	.	2/3	4/0	1/0	0/2	.	2/0	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Mallotus paniculatus (Lam.) Müll.Arg. var. *paniculatus* (Brambach et al. 1278)			.	.	1/0	2/0	.	.	.	.	.	.	.	.	.
Neoscortechinia nicobarica (Hook.f.) Pax & K.Hoffm. (Brambach et al. 0626)	C-Sul		3/1	.	.	.	.	.	.	.	.	.	.	.	.
Fabaceae															
Archidendron clypearia (Jack) I.C.Nielsen var. *clypearia* (Culmsee y206)			.	.	0/3	.	.	.	.	.	.	.	.	.	.
Archidendron pauciflorum (Benth.) I.C.Nielsen var. *pauciflorum* (Brambach et al. 1309)			.	.	.	0/1	.	1/0	.	.	.	.	.	.	.
Fagaceae															
Castanopsis acuminatissima (Blume) A.DC. (Culmsee r2289)			.	.	.	.	6/2	.	8/1	.	.	35/6	.	.	.
Castanopsis buruana Miq. (Brambach et al. 0358)			5/1	21/1	11/0	.	.	.	.	.	.	.	.	.	.
Lithocarpus cf. *bicoloratus* (Elmer) A.Camus (Brambach et al. 0208)			.	1/1	.	.	.	.	.	.	.	.	.	.	.
Lithocarpus celebicus (Miq.) Rehder (Brambach et al. 0460)			1/0	3/2	3/1	1/0	1/3	4/1	6/1	6/3	14/3	1/0	.	.	6/2
Lithocarpus glutinosus (Blume) Soepadmo (Brambach et al. 0170)			1/0	1/0	.	2/1	1/0	4/0	2/8	1/1	5/0	.	.	.	.
Lithocarpus havilandii (Stapf) Barnett (Brambach et al. 1814)			.	.	.	.	.	0/1	2/2	7/1	13/5	1/0	8/3	21/14	16/9
Lithocarpus indutus (Blume) Rehder (Brambach et al. 0382)			.	.	.	.	1/0	2/0	1/0	3/2	4/1	.	.	.	.
Lithocarpus menadoensis (Koord.) Soepadmo (Culmsee 3223)		x	.	.	.	.	.	.	7/6	40/19	5/1	.	.	.	.
Lithocarpus pusillus Soepadmo (Brambach et al. 1332)	Sul		.	.	.	.	1/0	.	.	.	.	18/11	.	.	.
Trigonobalanus verticillata Forman (Brambach et al. 0343)	Sul		.	3/0	.	.	.	.	.	.	.	.	.	.	.
Gentianaceae															
Fagraea blumei G.Don (Brambach et al. 2006)			.	.	.	.	.	.	.	.	.	.	.	3/0	.
Utania morindifolia (Blume) G.Don (Brambach et al. 0326)	C-Sul		.	1/0	.	.	.	.	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Gesneriaceae															
Cyrtandra sp. nov.1 (Culmsee y2077)	Sp	x	.	.	.	.	.	.	0/1	.	.	.	.	.	.
Cyrtandra sp. nov.2 (Culmsee y2033)	Sp	x	.	.	.	.	.	.	0/1	.	.	.	.	.	.
Cyrtandra sp. nov.3 (Brambach et al. 0485)	Sp	x	0/3	.	0/1	.	.	.	.	.	.	.	.	.	.
Gnetaceae															
Gnetum gnemon L. (Brambach et al. 0189)			0/1	11/7	.	.	.	.	.	.	.	.	.	.	.
Hamamelidaceae															
Distyliopsis dunnii (Hemsl.) P.K.Endress (Culmsee r2302)			.	.	.	.	.	.	0/6	.	3/2	6/5	.	.	.
Himantandraceae															
Galbulimima belgraveana (F.Muell.) Sprague (Brambach et al. 0825)			.	.	.	.	2/0	.	.	.	.	.	.	.	.
Hydrangeaceae															
Dichroa sp. (Culmsee y2031)			.	.	.	.	.	.	0/1	.	.	.	.	.	.
Ixonanthaceae			.	.	.	.	.	.	.	.	.	.	.	.	.
Ixonanthes petiolaris Blume (Brambach et al. 0335)	C-Sul		1/0	6/0	.	.	.	.	.	.	.	.	.	.	.
Juglandaceae															
Engelhardtia apoensis Elmer ex Nagel (Brambach et al. 0856)	C-Sul		.	.	.	.	1/0	.	.	.	.	.	.	.	.
Engelhardtia rigida Blume (Culmsee r2297)			.	.	.	.	.	.	.	.	11/3	1/0	.	.	.
Engelhardtia serrata Blume (Culmsee r2008)			.	.	.	.	.	.	4/2	.	.	.	.	.	.
Engelhardtia spicata Lechen ex Blume (Culmsee 990)	Sul		.	.	1/0	.	2/3	.	.	.	.	.	.	.	.
Lamiaceae															
Callicarpa pentandra Roxb. (Brambach et al. 0654)			1/0	.	.	.	.	.	.	.	.	.	.	.	.
Vitex quinata (Lour.) F.N.Williams (Brambach et al. 1118)			2/0	.	.	3/5	.	.	.	.	.	.	.	.	.
Lauraceae															
Actinodaphne cf. *glomerata* (Blume) Nees (Culmsee 3077)			.	.	.	.	.	.	.	0/1	.	.	.	.	.
Cinnamomum cf. *polderi* Kosterm. (Brambach et al. 1244)		x	.	.	.	2/2	0/2	1/1	.	.	.	.	.	.	.
Cryptocarya cf. *albida* Kosterm. (Brambach et al. 0091)			.	.	.	.	.	.	.	.	.	1/0	.	.	5/0
Cryptocarya cf. *ampla* Merr. (Brambach et al. 0530)			4/1	.	.	.	.	.	1/2	.	.	.	.	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Cryptocarya crassinerviopsis Kosterm. (Brambach et al. 1193)		x	.	.	.	8/3	.	0/2	.	.	.	.	.	.	.
Cryptocarya densiflora Blume (Brambach et al. 0647)	Sul		3/0	5/1	6/0	.	.	1/0	.	.	.	2/3	.	.	.
Cryptocarya ferrea Blume (Brambach et al. 0625)			4/1	.	.	.	0/2	.	.	.	.	.	.	.	.
Cryptocarya griffithiana Wight var. *crassinervia* (Miq.) Ng (Brambach et al. 1107)	C-Sul		.	.	.	5/4	.	.	.	.	.	.	.	.	.
Cryptocarya cf. *microcos* Kosterm. (Brambach et al. 0425)		x	.	2/0	1/1	.	.	0/2	.	.	.	.	.	.	.
Endiandra macrophylla (Blume) Boerl. (Brambach et al. 1106)	Sul		.	.	4/8	3/3	.	.	.	.	.	.	.	.	.
Endiandra scrobiculata Kosterm. ex Kochummen (Brambach et al. 0665)	C-Sul		2/1	.	.	.	2/0	.	.	.	.	.	.	.	.
Endiandra sulavesiana Kosterm. (Culmsee r2025)		x	.	.	.	.	.	1/0	3/0	.	.	.	.	.	.
Lindera apoensis Elmer (Culmsee r2015)			.	.	.	.	.	.	4/0	.	.	.	.	.	.
Lindera novoguineensis Kosterm. (Brambach et al. 0290)	Sul		.	0/3	1/2	.	.	.	.	.	.	.	.	.	.
Litsea angulata Blume (Brambach et al. 0159)	Sul		5/0	6/0	2/1	.	1/0	.	0/1	.	.	.	.	.	.
Litsea elliptica Blume (Brambach et al. 0842)			.	.	.	.	2/0	.	.	.	.	.	.	.	.
Litsea aff. *elongata* (Nees) Hook.f. (Culmsee 2580)		x	.	.	.	.	.	.	.	.	1/0	.	.	.	.
Litsea ferruginea Blume (Brambach et al. 0392)			.	.	.	.	.	.	.	.	0/1	.	.	.	.
Litsea firma (Blume) Hook.f (Brambach et al. 0281)			.	2/0	.	.	.	.	.	.	.	.	.	.	.
Litsea grandis (Wall. ex Nees) Hook.f. (Brambach et al. 1578)			.	1/0	.	.	.	1/0	.	.	.	.	.	.	.
Litsea lancifolia (Roxb. ex Nees.) Benth. & Hook.f. ex Villar var. *grandifolia* (Stapf) Ng (Culmsee y2133)	Sul		.	.	.	1/2	.	.	0/1	.	.	.	.	.	.
Litsea pallida (Blume) Boerl. (Culmsee r2016)	C-Sul		.	.	.	.	.	2/2	4/5	.	.	0/1	.	.	.
Litsea timoriana Span. (Brambach et al. 1293)			.	.	0/1	5/3	.	.	.	.	.	.	.	.	.
Litsea sp.1 (Brambach et al. 1706)			.	.	.	.	.	.	.	.	0/1	.	.	0/1	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Litsea sp.2 (Brambach et al. 1339)			.	.	.	.	.	0/1	.	.	.	.	.	.	.
Machilus rimosa (Blume) Blume (Brambach et al. 0832)			.	.	.	.	1/0	2/1	.	.	.	1/0	.	.	.
Neolitsea cassia (L.) Kosterm. (Brambach et al. 1576, 1957)	C-Sul		.	.	.	.	.	1/2	.	.	.	.	.	12/9	3/6
Nothaphoebe albipes Kostermans ined. (Brambach et al. 0123)	Sp	x	.	.	.	.	1/0	.	.	.	.	1/0	.	.	.
Nothaphoebe sp. nov. (Brambach et al. 1072)	Sp	x	.	.	.	1/0	.	.	.	.	.	.	.	.	.
Phoebe cf. *grandis* (Nees) Merr. (Brambach et al. 0437)			2/0	.	2/0	.	.	.	.	.	.	.	.	.	.
Phoebe cf. *sterculioides* (Elmer) Merr. (Brambach et al. 1162)			.	.	.	7/10	.	.	.	.	.	.	.	.	.
Loganiaceae															
Geniostoma rupestre J.R.Forst & G.Forst (Brambach et al.1284)	C-Sul		.	.	.	1/0	.	.	.	.	1/0	.	.	.	.
Magnoliaceae															
Magnolia carsonii Dandy ex Noot. var. *carsonii* (Brambach et al. 1589)			.	.	.	.	.	4/0	.	.	.	3/1	.	.	.
Magnolia liliifera (L.) Baill. var. *liliifera* (Brambach et al. 0145)			.	.	0/3	.	1/0	2/0	.	.	.	3/0	.	.	.
Magnolia sulawesiana Brambach et al. (Brambach et al. 1334)	Sp	x	.	.	.	.	.	.	.	.	4/0	1/0	.	.	.
Magnolia tsiampacca (L.) Figlar & Noot. var. tsiampacca (Brambach et al. 1113)			.	.	.	1/0	.	.	.	.	.	.	.	.	.
Magnolia vrieseana (Miq.) Baill. ex Pierre (Brambach et al. 0444)			2/0	.	.	.	.	.	.	.	.	.	.	.	.
Malvaceae															
Sterculia insularis R.Br. (Brambach et al. 1056)			.	.	.	1/1	.	1/0	.	.	.	.	.	.	.
Melastomataceae															
Astronia atroviridis Mansf. (Brambach et al. 0381)	Sul		.	.	.	.	.	.	0/1	1/8	6/15	.	.	.	.
Astronia macrophylla Blume (Brambach et al. 0543)	C-Sul		1/0	.	.	.	.	.	.	.	.	.	.	.	.
Memecylon paniculatum Jack (Brambach et al. 0302)			.	0/1	.	0/1	0/1	.	.	.	.	.	.	.	.
Meliaceae															
Aglaia korthalsii Miq. (Brambach et al. 1305)			.	.	.	0/3	.	0/1	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Aglaia lancilimba Merr. (Brambach et al. 0349)			.	1/0	.	.	.	.	.	.	.	.	.	.	.
Aglaia silvestris (M. Roem.) Merr. (Culmsee r2011)	C-Sul		.	.	.	.	.	.	1/0	.	.	.	.	.	.
Aglaia spectabilis (Miq.) S.S.Jain & Bennet (Brambach et al. 1149)	C-Sul		1/0	.	0/1	2/0	.	.	.	.	.	.	.	.	.
Aglaia tomentosa Teijsm. & Binn. (Brambach et al. 0438)			.	.	1/2	.	.	.	.	.	.	.	.	.	.
Chisocheton patens Blume (Culmsee 213)			.	.	2/1	.	.	.	.	.	.	.	.	.	.
Chisocheton pentandrus (Blanco) Merr. ssp. *pentandrus* (Brambach et al. 1219)			.	.	.	5/3	.	.	.	.	.	.	.	.	.
Dysoxylum acutangulum Miq. ssp. *foveolatum* (Radlk.) Mabb. (Culmsee 222)			.	.	1/0	.	.	.	.	.	.	.	.	.	.
Dysoxylum alliaceum (Blume) Blume (Brambach et al. 1103)			.	.	.	1/0	.	1/0	.	.	.	.	.	.	.
Dysoxylum cf. *cyrtobotryum* Miq. (Culmsee y2236)			.	.	.	.	.	.	.	.	.	0/1	.	.	.
Dysoxylum densiflorum (Blume) Miq. (Brambach et al. 1208)			2/0	.	0/2	10/4	.	1/1	.	.	.	.	.	.	.
Dysoxylum excelsum Blume (Culmsee r2106)			.	1/0	.	.	.	.	1/10	.	.	.	.	.	.
Dysoxylum nutans (Blume) Miq. (Brambach et al. 0527)			0/1	.	.	.	.	.	.	.	.	.	.	.	.
Lansium domesticum Correa (Brambach et al. 0462)	C-Sul		0/1	.	.	.	.	.	.	.	.	.	.	.	.
Reinwardtiodendron sp. (Brambach et al. 1509)			.	.	.	.	1/2	1/1	.	.	.	.	.	.	.
Metteniusaceae															
Platea excelsa Blume var. *borneensis* (Heine) Sleumer (Brambach et al. 1575)			.	.	6/4	.	.	22/6	1/0	.	.	.	.	.	.
Platea latifolia Blume (Brambach et al. 1493)			.	.	.	.	12/11	5/0	1/1	0/2	.	.	.	.	.
Monimiaceae															
Kibara coriacea (Blume) Tul. (Brambach et al. 0532)			1/2	.	.	.	.	.	0/2	.	.	.	.	.	.
Levieria montana Becc. (Brambach et al. 0903)			.	.	1/1	.	2/3	.	2/2	.	.	.	.	.	.
Matthaea sancta Blume (Culmsee r536)			.	.	1/3	.	.	.	.	.	.	.	.	.	.
Steganthera hirsuta (Worb.) Perkins (Brambach et al. 0509)			1/0	.	.	0/2	0/1	.	0/1	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Moraceae															
Antiaris toxicaria Lesch. ssp. *toxicaria* (Brambach et al. 0505)	C-Sul		1/0	.	.	.	.	.	.	.	.	.	.	.	.
Artocarpus lacucha Roxb. ex Buch.-Ham. (Brambach et al. 1105)			.	.	.	1/1	.	.	.	.	.	.	.	.	.
Artocarpus teysmannii Miq. ssp. *teysmannii* (Brambach et al. 0366)			.	3/0	.	.	.	.	.	.	.	.	.	.	.
Ficus buntaensis C.C.Berg (Brambach et al. 1113)		x	.	.	.	1/4	.	.	.	.	.	.	.	.	.
Ficus crassiramea (Miq.) Miq. ssp. *crassiramea* (Brambach et al. 1573)			.	.	1/0	.	.	2/0	1/0	.	.	1/0	.	.	.
Ficus lumutana C.C.Berg (Brambach et al. 0295)	C-Sul		2/1	1/0	.	.	.	.	.	.	.	.	.	.	.
Ficus oleifolia King ssp. *oleifolia* (Brambach et al. 1696)			.	.	.	.	.	.	.	.	.	0/1	0/1	0/1	.
Ficus sulawesiana C.C.Berg & Culmsee (Brambach et al. 0357)		x	.	.	.	.	.	.	.	0/1	0/1	.	.	.	.
Ficus tinctoria G.Forst. ssp. *gibbosa* (Blume) Corner (Brambach et al. 1488)			.	.	.	.	.	1/0	.	.	.	.	.	.	.
Ficus variegata Blume (Brambach et al. 1241)			.	.	.	2/0	.	.	.	.	.	.	.	.	.
Ficus cf. *variegata* Blume (Faber et al. y1415)			.	.	.	.	.	.	.	0/1	.	.	.	.	.
Ficus sp. (Brambach et al. 1408)			.	.	.	.	.	0/1	.	.	.	.	.	.	.
Streblus glaber (Merr.) Corner ssp. *glaber* (Brambach et al. 0905)			.	.	.	.	6/3	.	.	.	.	.	.	.	.
Trophis philippinensis (Bureau) Corner (Brambach et al. 1070)			1/0	.	.	1/0	.	.	.	.	.	.	.	.	.
Myricaceae															
Morella javanica (Blume) I.M.Turner (Brambach et al. 0737)			.	.	.	.	.	.	.	.	.	.	.	.	2/0
Myristicaceae															
Gymnacranthera farquhariana (Wall. ex Hook.f. & Thomson) Warb. var. *zippeliana* (Miq.) R.T.A.Schouten (Brambach et al. 0641)			1/0	.	1/1	.	.	.	.	.	.	.	.	.	.
Horsfieldia costulata (Miq.) Warb. (Brambach et al. 0333)			11/6	3/5	2/0	11/8	2/0	.	.	.	.	.	.	.	.
Horsfieldia parviflora (Roxb.) J.Sinclair (Brambach et al. 0504)	C-Sul		2/2	.	.	.	.	.	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Horsfieldia sp. (Brambach et al. 1605)			.	.	.	.	.	1/0	.	.	.	.	.	.	.
Knema stellata Merr. ssp. *minahassae* (Warb.) W.J.de Wilde (Brambach et al. 0588)			0/1	.	2/0	.	.	.	.	.	.	.	.	.	.
Myristica simiarum A.DC. ssp. *celebica* (Miq.) W.J.de Wilde (Brambach et al. 0453)			1/1	.	.	.	.	.	.	.	.	.	.	.	.
Myrtaceae															
Leptospermum javanicum Blume (Brambach et al. 1885)			.	.	.	.	.	.	.	.	.	.	.	1/0	.
Syzygium acuminatissimum (Blume) DC. (Brambach et al. 0160, 0761)			1/0	1/0	1/1	0/1	9/4	.	11/7	31/42	14/13	17/3	0/1	1/1	16/12
Syzygium acutangulum Nied. (Culmsee r2034)	C-Sul		.	.	.	.	.	.	2/3	.	.	.	.	.	.
Syzygium aff. *baeuerlenii* (F.Muell.) Craven & Biffin (Brambach et al. 0161b)		x	.	.	.	.	0/1	.	0/1	1/0	.	.	.	.	.
Syzygium balgooyi ined. (Brambach et al. 1564)	Sp	x	2/2	5/3	1/4	.	3/29	3/2	.	3/3	12/6	6/5	.	.	.
Syzygium benjaminum Diels (Brambach et al. 0775)			.	.	.	.	.	.	.	.	0/1	.	.	0/1	10/9
Syzygium celebicum (Blume) Widodo (Brambach et al. 0631)	C-Sul	x	4/0	.	.	.	.	.	.	.	.	.	.	.	.
Syzygium contiguum ined. (Culmsee 535)	Sp	x	.	.	0/2	.	.	.	.	.	.	.	.	.	.
Syzygium devogelii ined. (Culmsee 1564)	Sp	x	.	.	.	.	0/9	.	.	.	.	.	.	.	.
Syzygium effusum (A.Gray) Müll.Berol. in W.G.Walpers (Brambach et al. 1466)	Sul		.	.	.	.	.	4/3	.	.	.	.	.	.	.
Syzygium fastigiatum (Blume) Merr. & L.M.Perry (Culmsee r2012)	Sul		.	.	.	.	.	.	2/5	.	1/2	2/1	.	.	.
Syzygium galanthum ined. (Brambach et al. 1316)	Sp	x	1/0	.	.	0/3	.	.	.	.	.	.	.	.	.
Syzygium kinabaluense (Stapf) Merr. & L.M.Perry (Brambach et al. 0062)	Sul		.	.	.	.	.	.	.	.	.	5/5	29/19	.	.
Syzygium cf. *leptopodium* Merr. & L.M.Perry (Brambach et al. 0130)			.	.	.	.	.	.	.	6/5	0/2	5/2	.	.	.
Syzygium lineatum (DC.) Merr. & L.M.Perry (Culmsee r2043)	Sul		.	.	.	.	0/6	4/0	2/1	.	.	.	.	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Syzygium nigricans (King) Merr. & L.M.Perry (Brambach et al. 0409)	C-Sul		.	.	.	.	.	.	.	1/4	3/0	.	.	.	.
Syzygium phaeostictum Merr. & L.M.Perry (Brambach et al. 0590)	Sul		1/1	.	.	.	.	.	.	.	.	.	.	.	.
Syzygium aff. *rosenbluthii* (C.B.Rob.) Merr. (Brambach et al. 0985)		x	.	.	.	.	.	.	.	1/0	.	6/2	16/5	.	.
Syzygium tripinnatum (Blanco) Merr. (Brambach et al. 0075)	Sul		.	.	.	.	.	.	.	0/3	24/5	9/7	.	.	.
Syzygium zeylanicum (L.) DC. (Brambach et al. 0915)	C-Sul		.	.	.	.	1/2	.	.	.	.	.	.	.	.
Syzygium sp.1 (Brambach et al. 0768)			.	.	.	.	.	.	.	.	.	.	.	.	6/3
Syzygium sp.2 (Brambach et al. 1805)			.	.	.	.	.	.	.	.	.	.	15/5	12/5	.
Syzygium sp.3 (Brambach et al. 0902)			.	.	.	.	1/1	.	0/1	.	.	.	.	.	.
Syzygium sp.4 (Culmsee r2129)			.	.	.	.	.	.	.	3/2	11/4	4/5	.	.	.
Syzygium sp.5 (Culmsee r2049)			.	.	.	.	1/3	.	5/9	.	0/1	4/2	0/1	.	.
Syzygium sp.6 (Culmsee 1853)			.	.	.	.	.	.	.	.	.	.	.	.	0/2
Xanthomyrtus angustifolia A.J.Scott (Brambach et al. 1907)			.	.	.	.	.	.	.	.	1/0	1/1	22/11	11/7	0/3
Nyssaceae															
Mastixia pentandra Blume ssp. *scortechinii* (King) K.M.Matthew (Culmsee r2321)			.	.	.	.	.	.	0/1	1/0	1/1	5/8	.	.	.
Mastixia rostrata Blume ssp. *caudatifolia* (Merr.) K.M.Matthew (Brambach et al. 0660)	C-Sul		1/0	.	.	.	.	.	.	.	.	.	.	.	.
Mastixia trichotoma Blume (Culmsee D-260211-01)	C-Sul		.	.	.	.	.	.	2/1	.	.	.	.	.	.
Oleaceae															
Chionanthus celebicus Koord. (Brambach et al. 1502)		x	.	0/1	.	.	.	1/0	.	0/2	3/1	.	.	.	.
Chionanthus polygamus (Roxb.) Kiew (Brambach et al. 0317)			2/0	1/0	.	.	17/6	2/0	.	.	.	1/0	.	.	.
Chionanthus ramiflorus Roxb. (Brambach et al. 1184)			.	.	.	1/0	.	.	.	.	.	.	.	.	.
Chionanthus sulawesicus Kiew (Culmsee y2052)		x	.	.	.	.	.	.	1/6	.	.	.	.	.	.
Ligustrum glomeratum Blume (Brambach et al. 1246)	C-Sul		.	.	.	1/0	.	.	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Pandanaceae															
Pandanus cf. *brachyspathus* Martelli (Brambach et al. 0596)		x	0/1	.	1/0	.	.	.	.	.	.	.	.	.	.
Pandanus sulawesicus B.C.Stone (Brambach et al. 0111)		x	.	.	.	.	.	6/0	.	.	.	1/0	.	.	.
Paracryphiaceae															
Quintinia apoensis (Elmer) Schltr. (Brambach et al. 1964)			.	.	.	.	.	.	.	.	.	.	17/9	18/14	29/5
Sphenostemon papuanus (Lauterb.) Steenis & Erdtman (Brambach et al. 0943)			.	.	.	.	.	.	.	0/1	1/3	.	2/1	.	1/0
Pentaphylacaceae															
Adinandra celebica Koord. (Brambach et al. 0079)		x	.	.	.	.	.	.	.	0/1	.	3/3	.	.	.
Adinandra eymae Kobuski (Brambach et al. 0767)	C-Sul	x	.	.	.	.	.	.	.	.	.	1/3	.	5/3	2/1
Adinandra masambensis Kobuski (Culmsee 2589)		x	.	.	.	.	.	.	.	0/2	4/1	.	.	.	.
Adinandra sp. (Brambach et al. 0741)			.	.	.	.	.	.	.	.	.	1/0	.	1/0	1/0
Eurya acuminata DC. (Brambach et al. 0373)			.	.	.	.	1/1	.	.	1/6	2/1	.	.	.	.
Eurya chinensis R.Br. ssp. *flava* (Merr. ex. Melch.) de Wit (Brambach et al. 0784)			.	.	.	.	.	.	.	0/5	1/2	0/1	.	.	1/3
Ternstroemia philippinensis Merr. (Brambach et al. 0163)	Sul		.	.	.	.	.	2/1	0/2	.	.	6/5	.	.	.
Ternstroemia urdanetensis (Elmer) Kobuski var. *crassifolia* Kobuski (Brambach et al. 1938)	C-Sul		.	.	.	.	.	.	.	.	.	.	.	1/1	1/0
Peraceae															
Trigonopleura malayana Hook.f. (Brambach et al. 0234)			.	10/0	1/1	.	.	.	.	.	.	.	.	.	.
Phyllanthaceae			.	.	.	.	.	.	.	.	.	.	.	.	.
Antidesma excavatum Miq. var. *excavatum* (Brambach et al. 1282)			.	.	3/1	4/1	.	0/2	.	.	.	.	.	.	.
Antidesma riparium Airy Shaw ssp. *riparium* (Brambach et al. 0491)			0/2	0/2	0/5	.	.	.	.	.	.	.	.	.	.
Aporosa frutescens Blume (Brambach et al. 0474)			0/1	.	1/1	.	.	.	.	.	.	.	.	.	.
Baccaurea nanihua Merr. (Brambach et al. 0642)	C-Sul		1/1	.	.	.	.	.	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Baccaurea tetrandra (Baill.) Müll.Arg. (Brambach et al. 1301)			.	.	.	1/1	.	.	.	.	.	.	.	.	.
Baccaurea sp. (Brambach et al. 0459)			2/1	.	.	.	.	.	.	.	.	.	.	.	.
Breynia cernua (Poir.) Müll.Arg. in A.P.de Candolle (Brambach et al. 1102)			.	.	.	0/1	.	.	.	.	.	.	.	.	.
Bridelia glauca Blume var. *glauca* (Brambach et al. 1269)			.	.	.	4/0	.	.	.	.	.	.	.	.	.
Glochidion cf. *glabrum* J.J.Sm. (Culmsee y801)			.	.	.	.	0/1	.	.	.	.	.	.	.	.
Glochidion insectum Airy Shaw (Brambach et al. 0390)			.	.	.	.	.	.	.	1/0	0/1	.	.	.	.
Glochidion lucidum Blume (Brambach et al. 0885)			1/0	.	1/6	.	2/1	.	.	.	.	.	.	.	.
Glochidion moluccanum Blume var. *glabrescens* Airy Shaw (Brambach et al. 0383)		x	.	.	.	.	.	.	.	0/1	1/0	.	.	.	.
Podocarpaceae															
Dacrycarpus cinctus (Pilg.) de Laub. (Brambach et al. 0680)			.	.	.	.	.	.	.	.	.	.	.	.	8/3
Dacrycarpus imbricatus (Blume) de Laub. (Brambach et al. 0044, 1951)			.	.	.	.	.	.	.	.	0/1	2/0	.	30/3	18/5
Phyllocladus hypophyllus Hook.f. (Brambach et al. 0164, 0990)			.	.	.	.	.	.	.	.	.	5/0	72/12	51/12	24/4
Podocarpus neriifolius D.Don (Brambach et al. 1569)			.	0/1	.	.	0/3	4/0	1/0	.	.	.	.	.	.
Podocarpus pilgeri Foxw. (Brambach et al. 0675)			.	.	.	.	.	.	.	.	.	.	.	.	2/3
Podocarpus rumphii Blume (Brambach et al. 0157b)			.	.	.	.	.	.	.	.	.	1/0	.	.	.
Primulaceae															
Ardisia anaclasta B.C.Stone (Brambach et al. 0161)		x	.	.	.	.	.	.	.	.	0/1	0/1	.	.	.
Ardisia forbesii S.Moore (Brambach et al. 1409)			0/2	.	.	.	0/1	0/10	.	.	.	0/3	.	.	.
Ardisia leptalea B.C.Stone (Culmsee y2210)		x	.	.	.	.	.	.	.	.	.	0/2	.	.	.
Ardisia ternatensis Scheff. (Brambach et al. 1129)	C-Sul		.	.	.	1/0	.	.	1/0	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Myrsine involucrata (Mez) Pipoly (Brambach et al. 0731)			.	.	.	.	0/1	.	1/0	.	.	0/1	.	0/14	1/11
Myrsine leucantha (K.Schum.) Pipoly (Culmsee y2058)	Sul		.	.	.	.	.	0/2	0/2	.	.	.	.	.	.
Myrsine minutifolia (Knoester et al.) Pipoly (Brambach et al. 1939)			.	.	.	.	.	.	.	.	.	.	4/21	1/11	0/4
Myrsine cf. *rawacensis* A.DC. (Culmsee r2150)			.	.	.	.	.	.	.	.	.	1/0	9/13	.	.
Myrsine sp. (Culmsee y2164)			.	.	.	.	.	.	.	0/1	.	0/10	.	.	.
Proteaceae															
Helicia celebica Sleumer (Culmsee 1820)		x	.	.	.	.	.	1/1	.	.	.	.	.	.	3/1
Lasjia hildebrandii (Steenis) P.H.Weston & A.R.Mast (Brambach et al. 1614)		x	.	.	.	.	3/2	2/3	.	1/0	.	.	.	.	.
Putranjivaceae															
Drypetes cf. *sibuyanensis* (Elmer) Pax & K.Hoffm. (Culmsee y2083)			.	.	.	.	.	.	1/11	.	.	.	.	.	.
Drypetes minahassae (Boerl. & Koord.) Pax & K.Hoffm. (Brambach et al. 0419)			.	.	3/4	.	.	.	.	.	.	.	.	.	.
Rosaceae															
Prunus arborea (Blume) Kalkman (Brambach et al. 0187)			6/4	2/1	0/1	1/1	.	4/2	.	.	.	.	.	.	3/1
Prunus grisea (Blume) Kalkman (Brambach et al. 0764)			.	.	.	1/2	.	.	.	1/0	.	.	6/1	3/0	2/0
Prunus javanica (Teijsm. & Binn.) Miq. (Brambach et al. 0568)	C-Sul		0/1	.	.	.	.	.	.	.	.	.	.	.	.
Rubiaceae															
Diplospora cf. *tinagoensis* (Elmer) Ali & Robbr. (Brambach et al. 0426)			.	.	2/5	.	.	.	.	.	.	.	.	.	.
Diplospora sp. (Faber et al. y1446)			.	.	.	.	.	.	.	0/1	.	.	.	.	.
Gardenia (Culmsee 71)			.	.	1/0	.	.	.	.	.	.	.	.	.	.
Ixora macrothyrsa (Teijsm. & Binn.) T.Moore (Culmsee 910)	C-Sul	x	.	.	0/1	.	.	.	.	.	.	.	.	.	.
Mussaendopsis longipedunculata Ridsdale ined. (Brambach et al. 0476)		x	0/1	.	.	.	.	.	.	.	.	.	.	.	.
Neonauclea lanceolata (Blume) Merr. var. *gracilis* (Vidal) Ridsdale (Brambach et al. 1069)			.	.	.	2/0	.	.	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Porterandia celebica M.S.Zahid (Brambach et al. 0822)		x	.	.	2/0	.	5/1	.	2/0	.	.	.	.	.	.
Praravinia loconensis Bremek. (Culmsee y2049)		x	.	.	.	.	.	.	0/4	.	.	.	.	.	.
Praravinia sp. nov.1 (Culmsee 2704)	Sp	x	.	.	.	.	.	.	.	0/2	.	.	.	.	.
Psychotria viridiflora Reinw. ex Blume (Brambach et al. 0416)	C-Sul		0/1	0/1	0/4	.	.	.	.	.	.	.	.	.	.
Psychotria sp. nov.1 (Culmsee 2601)	Sp	x	.	.	.	.	.	.	.	0/2	0/11	.	.	.	.
Psychotria sp. nov.2 (Brambach et al. 0756)	Sp	x	.	.	.	.	.	.	.	.	.	.	.	1/5	3/4
Timonius minahassae Koord. (Brambach et al. 1074)			.	.	.	2/2	.	.	.	.	.	.	.	.	.
Timonius teysmanii Valeton (Culmsee r2023)	C-Sul	x	.	.	.	.	.	.	2/0	1/1	.	.	.	.	.
Urophyllum strigosum (Blume) Korth. (Brambach et al. 0173, 0330)	C-Sul		.	0/14	.	.	.	.	.	.	.	.	.	.	.
Urophyllum sp. (Brambach et al. 1342)			.	.	.	.	0/2	0/7	.	.	.	.	.	.	.
Rutaceae															
Acronychia pedunculata (L.) Miq. (Brambach et al. 1503)			.	0/1	1/2	.	1/0	1/1	.	.	.	.	.	.	.
Melicope denhamii (Seem.) T.G.Hartley (Brambach et al. 0890)	C-Sul		.	.	.	.	1/0	.	.	.	.	.	.	.	.
Melicope frutescens (Blanco) Appelhans & J.Wen (Brambach et al. 0424)			1/0	1/1	1/0	.	1/0	.	2/0	.	.	.	.	.	.
Melicope maxii T.G.Hartley (Brambach et al. 1816)		x	.	.	.	.	.	.	.	0/1	.	1/0	.	7/1	2/1
Tetractomia tetrandra (Roxb.) Merr. (Brambach et al. 0950, 1492)			.	.	.	.	.	7/4	.	.	.	.	13/6	.	.
Tetradium celebicum (Koord.) T.G.Hartley ined. (Brambach et al. 1158)	C-Sul	x	.	.	.	1/0	.	.	.	.	.	.	.	.	.
Sabiaceae															
Meliosma pinnata (Roxb.) Maxim. ssp. *sylvatica* (Elmer) Beus. (Culmsee r2170)			.	.	.	.	.	.	.	0/1	.	1/1	.	.	.
Meliosma sumatrana (Jack) Walp. (Brambach et al. 0440)			1/0	.	1/2	1/4	.	0/1	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End [3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Salicaceae															
Flacourtia rukam Zoll. & Moritzi (Brambach et al. 1209)	C-Sul		.	.	.	1/1	.	.	.	.	.	.	.	.	.
Sapindaceae															
Acer laurinum Hassk. ex Miq. (Brambach et al. 0301)			.	0/1	0/1	1/0	3/0	1/0	.	.	.	.	.	.	.
Arytera littoralis Blume (Brambach et al. 1152)			.	.	.	1/1	.	.	.	.	.	.	.	.	.
Guioa diplopetala (Hassk.) Radlk. (Brambach et al. 0919)	C-Sul		.	.	.	.	.	.	.	.	.	19/9	1/0	.	.
Guioa hirsuta Welzen (Brambach et al. 0433)		x	.	1/1	1/0	.	0/1	.	0/2	.	.	.	.	.	.
Harpullia cupanioides Roxb. (Brambach et al. 1052)			.	.	.	3/1	.	.	.	.	.	.	.	.	.
Mischocarpus sundaicus Blume (Brambach et al. 0394)	C-Sul		.	.	.	.	.	.	.	.	0/1	.	.	.	.
Pometia pinnata J.R.Forst. & G.Forst. (Brambach et al. 0449)			4/2	.	0/2	.	.	.	.	.	.	.	.	.	.
Sapotaceae															
Palaquium obovatum (Griff.) Engl. var. *orientale* H.J.Lam (Brambach et al. 1055)			7/1	2/0	4/1	7/0	.	.	.	.	.	.	.	.	.
Planchonella chartacea (F.Muell. Ex Benth.) H.J.Lam (Brambach et al. 0519)	C-Sul		2/2	1/0	.	.	.	.	.	.	.	.	.	.	.
Pleioluma firma (Miq.) Swenson (Brambach et al. 0854)			.	.	8/2	2/0	6/9	6/0	7/1	.	.	2/0	.	.	.
Sarcosperma paniculatum (King) Stapf & King (Brambach et al. 0497)			2/0	.	.	.	.	.	.	.	.	.	.	.	.
Simaroubaceae															
Ailanthus integrifolia Lam. ssp. *integrifolia* (Brambach et al. 0458)	C-Sul		1/0	.	.	.	.	1/0	.	.	.	.	.	.	.
Staphyleaceae															
Turpinia sphaerocarpa Hassk. (Brambach et al. 0656)			1/0	.	.	.	.	0/1	1/0	.	0/1	.	.	.	.
Stemonuraceae			.	.	.	.	.	.	.	.	.	.	.	.	.
Gomphandra mappioides Valeton (Brambach et al. 0422)			.	.	1/0	.	.	.	1/0	.	.	.	.	.	.
Medusanthera laxiflora (Miers) R.A. Howard (Brambach et al. 0659)			4/1	.	.	.	.	.	.	.	.	.	.	.	.

Species[1]	New rec.[2]	End[3]	Number of individuals per plot[4]												
			S0700	S0850	S1050	S1200	S1400	S1450	S1650	S1850	S1900	S1950	S2150	S2350	S2400
Styracaceae															
Bruinsmia styracoides Boerl. & Koord. (Brambach et al. 0405)			.	.	.	.	.	.	.	5/0	.	.	.	.	.
Symplocaceae															
Symplocos cochinchinensis (Lour.) S.Moore ssp. *leptophylla* (Brand) Noot. (Brambach et al. 0679)			.	.	.	.	.	.	.	.	.	.	.	2/0	5/3
Symplocos cf. *cochinchinensis* (Lour.) S.Moore (Culmsee 2694)			.	.	.	.	.	.	0/1	0/1	0/2	0/2	.	.	1/2
Symplocos fasciculata Zoll. (Brambach et al. 0150)			.	.	.	.	.	.	0/1	3/2	1/2	0/1	.	.	.
Symplocos odoratissima (Blume) Choisy (Culmsee r2038)			.	.	.	.	.	.	2/1	1/1	0/2	.	.	.	.
Symplocos ophirensis Clarke ssp. *cumingiana* (Brand) Noot. (Brambach et al. 0057)			.	.	.	.	.	.	0/1	1/5	1/6	2/0	.	.	.
Theaceae															
Camellia lanceolata (Blume) Seem. (Brambach et al. 1399)			.	.	.	.	.	0/1	.	.	.	0/5	.	.	.
Polyspora amboinensis (Miq.) Orel et al. (Culmsee r2256, Brambach et al. 1174)			.	.	.	1/1	.	.	.	.	15/6	4/5	.	.	10/3
Thymelaeaceae															
Wikstroemia androsaemifolia Decne. (Culmsee y2073)			.	.	.	.	.	.	0/1	.	0/1	.	.	.	.
Trimeniaceae															
Trimenia papuana Ridl. (Brambach et al. 1866)			.	.	.	.	.	.	.	.	.	.	45/9	14/28	7/7
Winteraceae															
Tasmannia piperita (Hook.f.) Miers (Brambach et al. 0920)			.	.	.	.	.	.	.	0/2	0/2	.	8/4	0/31	0/6
Total		74	146/67	133/69	105/114	170/98	131/147	155/118	129/132	129/144	171/123	200/125	362/143	215/165	238/123

[1] Voucher specimens in parentheses. [2] Species recorded for the first time in Sulawesi (Sul) or the province of Central Sulawesi (C-Sul). New species found during this study marked as 'Sp'. [3] Species endemic to Sulawesi. [4] Plot acronyms contain elevation (m a.s.l.).

Appendix 4.6 Tree diversity measures

Table 1 Diversity measures for all trees: big trees (dbh ≥ 10 cm, recorded on 0.24 ha) plus small trees (dbh 2–9.9 cm, recorded on 0.06 ha).

Plot	Ind.	Families				Genera				Species			
		$^{0}D_{obs}$	$^{1}D_{obs}$	$^{0}D_{210}$	$^{1}D_{210}$	$^{0}D_{obs}$	$^{1}D_{obs}$	$^{0}D_{210}$	$^{1}D_{210}$	$^{0}D_{obs}$	$^{1}D_{obs}$	$^{0}D_{210}$	$^{1}D_{210}$
S0700	213	40	24.1	39.8	24.0	65	38.8	64.6	38.7	78	53.5	77.5	53.3
S0850	202	25	14.8	25.2	14.8	37	20.5	37.6	20.6	44	23.1	44.8	23.2
S1050	219	35	20.9	34.5	20.8	59	40.5	58.2	40.1	67	45.9	66.0	45.4
S1200	268	38	21.2	35.8	20.7	59	39.9	54.7	38.3	72	50.5	66.5	48.0
S1400	278	29	15.0	27.8	14.7	41	17.6	37.6	17.1	60	33.2	54.0	31.7
S1450	273	42	26.0	38.9	25.3	56	35.3	51.5	33.9	78	50.2	70.3	47.3
S1650	261	32	15.9	30.0	15.6	42	20.6	39.3	20.1	63	38.6	57.4	37.0
S1850	273	24	6.7	21.6	6.5	28	7.1	25.2	6.9	46	16.4	41.3	15.8
S1900	294	28	10.5	24.8	10.2	30	10.9	26.5	10.7	49	27.1	43.3	26.0
S1950	325	27	10.6	23.6	10.3	38	15.1	32.6	14.5	61	31.4	50.7	29.3
S2150	505	17	9.9	15.3	9.6	19	11.6	17.1	11.3	27	16.2	23.7	15.6
S2350	380	20	11.1	18.3	10.8	26	14.7	22.7	14.2	32	16.3	26.8	15.6
S2400	361	26	14.4	24.2	13.9	33	18.7	30.2	18.0	44	26.8	39.4	25.5

Plot numbers indicate elevation in m a.s.l. Ind. = number of individuals. $^{0}D_{obs}$ = Observed taxon richness. $^{1}D_{obs}$ = Observed effective number of taxa (Jost 2006). $^{1}D_{210}$ = Taxon richness standardized per 210 individuals. $^{1}D_{210}$ = Effective number of taxa standardized per 210 individuals.

Table 2 Diversity measures for big trees (dbh ≥ 10 cm, recorded on 0.24 ha).

Plot	Ind.	Families				Genera				Species			
		$^{0}D_{obs}$	$^{1}D_{obs}$	$^{0}D_{210}$	$^{1}D_{210}$	$^{0}D_{obs}$	$^{1}D_{obs}$	$^{0}D_{210}$	$^{1}D_{210}$	$^{0}D_{obs}$	$^{1}D_{obs}$	$^{0}D_{210}$	$^{1}D_{210}$
S0700	146	34	21.4	39.0	22.5	51	33.6	58.8	37.9	62	47.1	72.0	54.4
S0850	133	20	12.0	22.9	12.5	26	16.1	31.2	16.7	32	18.6	38.9	19.9
S1050	105	30	19.1	39.0	21.8	48	34.7	67.0	44.6	50	36.1	72.5	46.7
S1200	170	33	20.4	34.0	20.8	53	37.2	56.2	39.1	63	47.0	68.9	50.1
S1400	131	25	17.5	26.1	19.1	31	20.3	33.6	22.6	42	27.3	50.4	31.0
S1450	155	34	22.5	36.5	23.8	46	28.3	52.6	30.1	59	39.8	67.9	43.8
S1650	129	24	12.4	26.8	13.5	31	16.5	36.7	18.3	42	27.5	49.8	31.6
S1850	171	13	4.3	17.0	4.4	13	4.3	17.0	4.4	25	10.4	32.8	10.7
S1900	171	18	7.1	19.3	7.2	20	7.6	21.5	7.7	31	19.5	33.4	19.8
S1950	200	25	9.3	25.4	9.3	32	12.6	32.6	12.6	48	25.3	49.0	25.6
S2150	362	16	9.6	15.3	9.4	18	11.1	17.1	10.9	24	14.5	22.8	14.2
S2350	215	18	8.4	17.9	8.4	22	12.2	21.9	12.1	25	12.9	24.8	12.9
S2400	238	24	13.1	23.6	13.0	30	16.7	29.2	16.5	39	22.9	37.7	22.5

Plot numbers indicate elevation in m a.s.l. Ind. = number of individuals. $^{0}D_{obs}$ = Observed taxon richness. $^{1}D_{obs}$ = Observed effective number of taxa (Jost 2006). $^{1}D_{210}$ = Taxon richness standardized per 210 individuals. $^{1}D_{210}$ = Effective number of taxa standardized per 210 individuals.

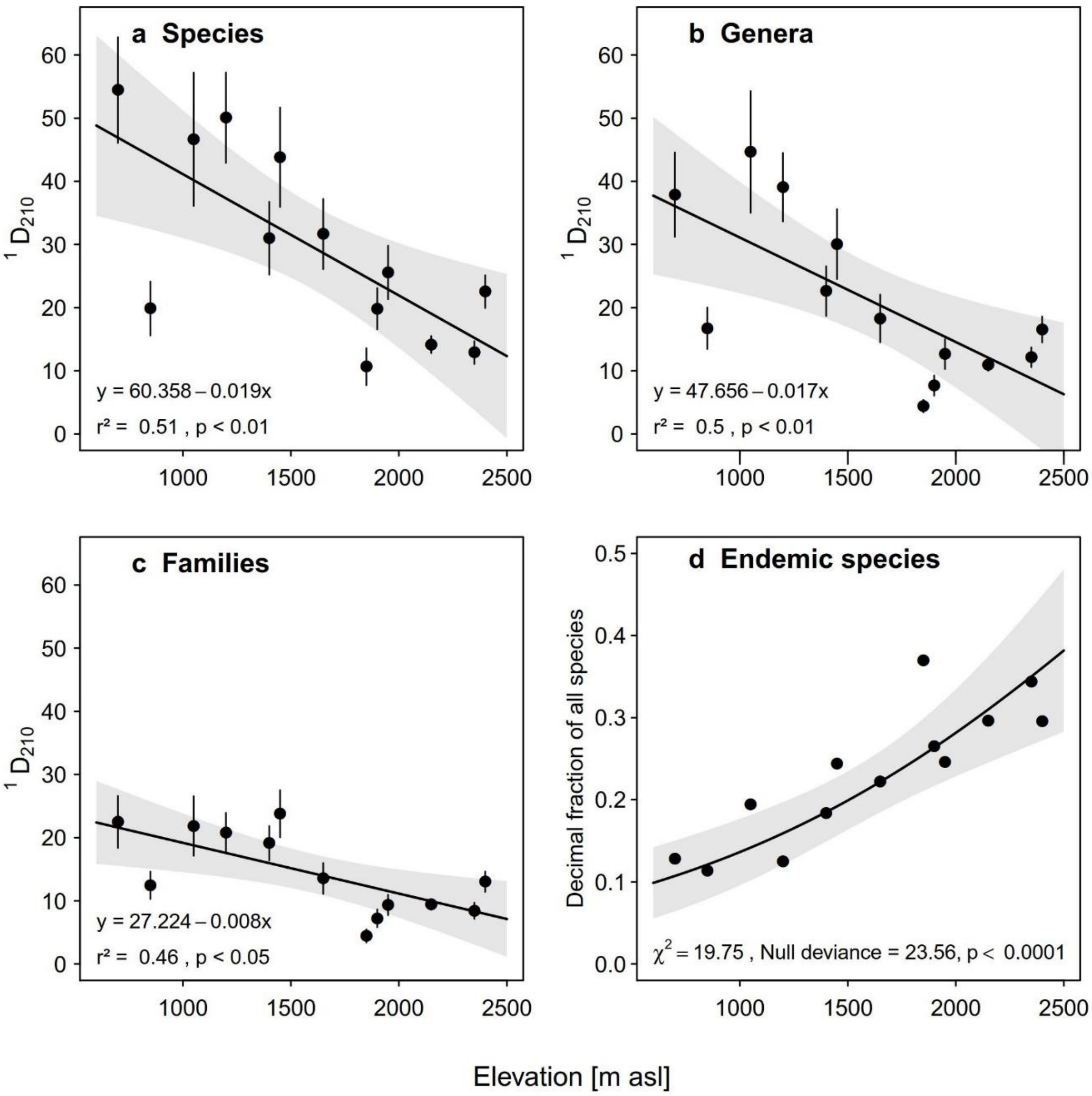

Figure 1 Changes in tree diversity at different taxonomic levels **(a-c)** and endemism **(d)** of big trees (dbh ≥ 10 cm) along the elevational gradient in Lore Lindu National Park. Tree diversity per plot (0.24 ha) is standardised number of taxa per 210 individuals ($^1D_{210}$). Black lines are regression curves of linear regression models (a-c) and a logistic regression model with binomial error structure and logit link function (d). Grey areas represent the 95% confidence intervals of the models. Error bars show 95% confidence intervals of a rarefaction/extrapolation procedure using a bootstrap method with 500 replications; n = 13. See Appendix 4.1, Table 1 for plot details.

Appendix 4.7 Environmental factors influencing community composition

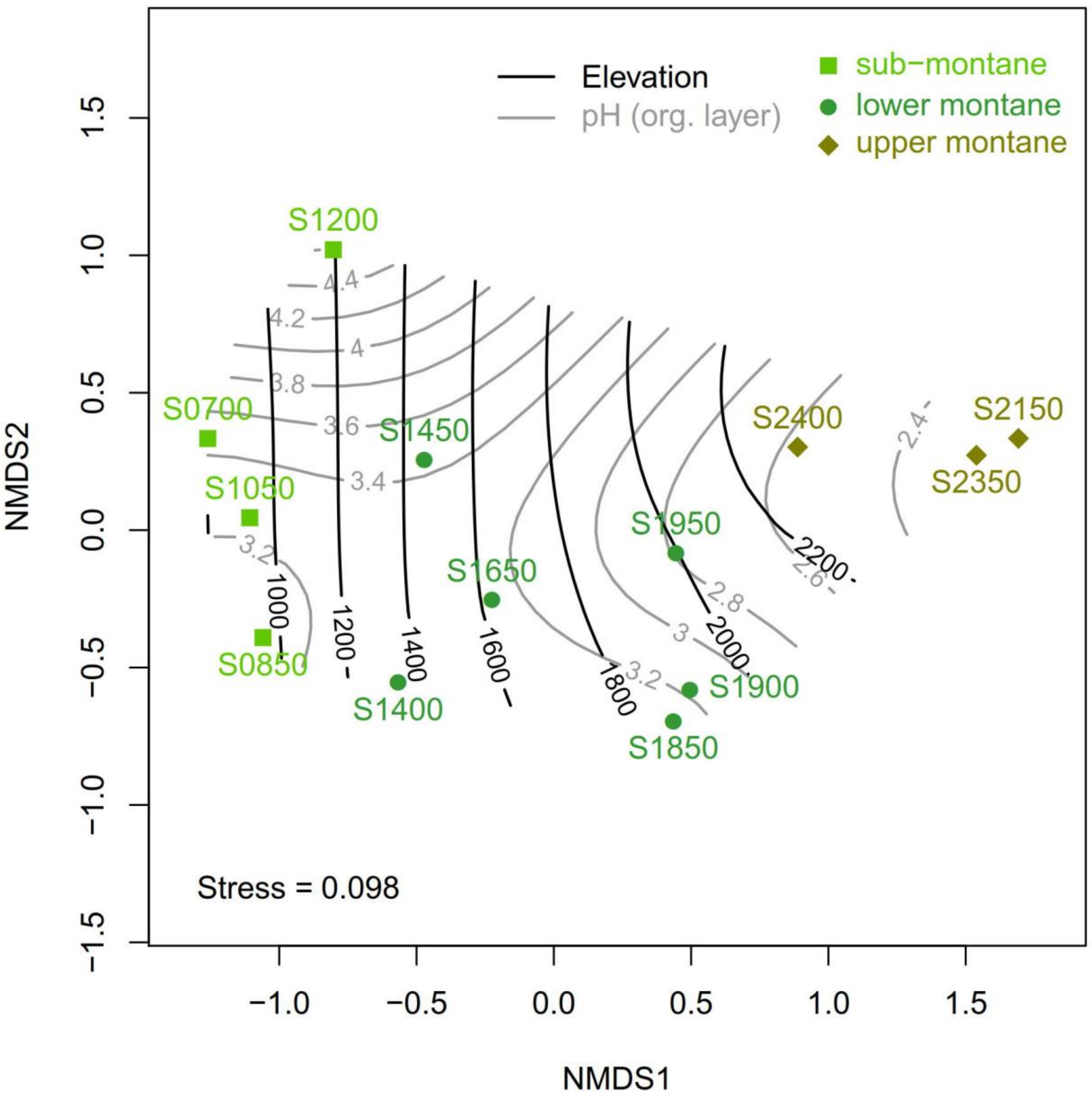

Figure 1 Elevation and the pH values of the organic layer influence the tree community composition in 13 inventory plots in Lore Lindu National Park. Non-metric multidimensional scaling (NMDS) with Bray-Curtis dissimilarity as distance measure showing differences in floristic composition. Based on abundances of all trees with dbh ≥ 10 cm. Plots were grouped beforehand by elevation as given in plot labels.

Appendix 4.8 Family Importance Values for 13 inventory plots

	S0700		S0850		S1050		S1200		S1400		S1450	
Rank	Families	FIV	Families	FIV	Families	FIV	Families	FIV	Families	FIV	Families	FIV
1	Laurac.	32.4	Fagac.	72.1	Fagac.	42.6	Laurac.	43.1	Fagac.	43.7	Metteniusac.	36.6
2	Myristicac.	26.5	Laurac.	41.0	Laurac.	38.6	Meliac.	23.6	Myrtac.	28.9	Elaeocarpac.	26.6
3	Fagac.	25.4	Ixonanthac.	24.3	Sapotac.	32.7	Sapotac.	20.4	Burserac.	24.3	Myrtac.	23.9
4	Sapotac.	21.9	Cannabac.	20.6	Morac.	15.2	Morac.	14.0	Laurac.	24.0	Laurac.	20.5
5	Elaeocarpac.	20.2	Burserac.	20.4	Rubiac.	13.6	Phyllanthac.	13.8	Elaeocarpac.	22.3	Magnoliac.	19.2
6	Myrtac.	16.7	Perac.	16.4	Burserac.	13.3	Sapindac.	12.9	Metteniusac.	19.2	Morac.	16.6
7	Sapindac.	15.5	Morac.	15.5	Meliac.	12.8	Cannabac.	11.5	Oleac.	18.6	Fagac.	14.4
8	Burserac.	13.9	Myrtac.	13.9	Myristicac.	12.6	Magnoliac.	11.4	Sapotac.	17.1	Sapotac.	10.9
9	Morac.	13.1	Gnetac.	13.3	Phyllanthac.	12.3	Burserac.	11.3	Rutac.	12.4	Rutac.	10.8
10	Anacardiac.	11.8	Sapotac.	10.7	Metteniusac.	11.7	Myristicac.	10.9	Morac.	10.1	Proteac.	10.3
11	Phyllanthac.	9.4	Meliac.	8.1	Annonac.	9.5	Fagac.	10.8	Juglandac.	9.0	Calophyllac.	8.8
12	Rosac.	7.3	Rosac.	6.7	Putranjivac.	8.7	Asparagac.	10.0	Rubiac.	7.8	Cyatheac.	8.3
13	Magnoliac.	7.1	Arecac.	5.9	Myrtac.	6.8	Annonac.	9.9	Euphorbiac.	7.5	Meliac.	7.7
14	Meliac.	6.5	Myristicac.	5.9	Rutac.	6.3	Euphorbiac.	9.5	Proteac.	6.7	Pandanac.	6.5
15	Euphorbiac.	6.3	Oleac.	4.9	Monimiac.	6.1	Araliac.	8.7	Myristicac.	6.5	Oleac.	6.3
16	Lamiac.	5.9	Anacardiac.	4.3	Asparagac.	5.7	Elaeocarpac.	8.6	Himantandrac.	5.5	Podocarpac.	6.2
17	Cannabac.	5.3	Rutac.	4.2	Juglandac.	5.7	Ebenac.	7.3	Sapindac.	5.2	Clusiac.	5.9
18	Stemonurac.	5.3	Gentianac.	4.1	Asterac.	4.5	Lamiac.	6.8	Asterac.	4.8	Rosac.	5.8
19	Monimiac.	4.8	Escalloniac.	4.0	Escalloniac.	4.3	Rubiac.	6.0	Phyllanthac.	4.4	Annonac.	5.5
20	Ebenac.	4.5	Sapindac.	4.0	Cyatheac.	4.3	Rutac.	5.7	Calophyllac.	4.4	Aquifoliac.	5.2
21	Simaroubac.	3.9			Euphorbiac.	3.8	Clusiac.	5.5	Monimiac.	4.2	Apocynac.	5.1
22	Oleac.	3.6			Perac.	3.4	Oleac.	5.2	Pentaphylac.	3.4	Euphorbiac.	5.0
23	Asterac.	3.5			Sapindac.	3.4	Calophyllac.	5.1	Meliac.	3.4	Escalloniac.	3.5
24	Chrysobalan.	3.0			Stemonurac.	3.3	Rosac.	4.9	Escalloniac.	3.3	Pentaphylac.	3.3
25	Calophyllac.	3.0			Clusiac.	3.3	Theac.	4.1	Magnoliac.	3.2	Celastrac.	3.3
26	Ixonanthac.	2.7			Calophyllac.	3.1	Anacardiac.	3.8			Cunoniac.	3.2
27	Staphyleac.	2.6			Arecac.	3.1	Malvac.	3.7			Burserac.	2.9
28	Asparagac.	2.6			Elaeocarpac.	3.1	Salicac.	2.4			Malvac.	2.7
29	Sabiac.	2.6			Sabiac.	3.1	Arecac.	2.3			Simaroubac.	2.6
30	Melastomatac.	2.6			Pandanac.	3.1	Primulac.	2.3			Fabac.	2.6
31	Annonac.	2.5					Sabiac.	2.3			Myristicac.	2.5
32	Rutac.	2.5					Loganiac.	2.3			Sapindac.	2.5
33	Arecac.	2.5									Arecac.	2.4
34	Cornac.	2.4									Araliac.	2.4
Top10		197.4		248.1		205.3		172.9		220.6		190.0
Rest		102.6		51.9		94.7		127.1		79.4		110.1

	S1650		S1850		S1900		S1950		S2150		S2350		S2400	
Rank	Families	FIV	Families	FIV	Families	FIV	Families	FIV	Families	FIV	Families	FIV	Families	FIV
1	Fagac.	54.1	Fagac.	127.7	Myrtac.	90.8	Myrtac.	70.9	Podocarpac.	58.7	Podocarpac.	102.2	Podocarpac.	56.9
2	Myrtac.	38.8	Myrtac.	80.8	Fagac.	76.6	Fagac.	70.3	Myrtac.	55.3	Myrtac.	38.8	Fagac.	36.1
3	Morac.	29.5	Symplocac.	17.4	Magnoliac.	18.7	Podocarpac.	19.8	Elaeocarpac.	25.6	Fagac.	27.6	Myrtac.	34.7
4	Escalloniac.	27.3	Styracac.	16.6	Theac.	17.4	Magnoliac.	18.9	Trimeniac.	25.0	Elaeocarpac.	17.3	Paracryphiac.	24.0
5	Laurac.	23.5	Escalloniac.	11.7	Pentaphylac.	15.8	Pentaphylac.	16.5	Arecac.	22.6	Paracryphiac.	16.8	Cyatheac.	19.4
6	Calophyllac.	22.5	Apocynac.	6.7	Juglandac.	13.2	Sapindac.	14.4	Paracryphiac.	19.9	Pentaphylac.	16.1	Elaeocarpac.	14.7
7	Sapotac.	12.3	Rosac.	6.5	Symplocac.	8.0	Laurac.	13.0	Cunoniac.	14.0	Trimeniac.	12.8	Pentaphylac.	14.1
8	Rubiac.	8.9	Proteac.	5.9	Hamamelidac.	7.9	Araucariac.	9.4	Primulac.	13.6	Laurac.	11.0	Laurac.	12.8
9	Metteniusac.	7.1	Rubiac.	5.7	Melastomat.	7.6	Cornac.	8.3	Rutac.	11.8	Rutac.	8.7	Symplocac.	9.2
10	Juglandac.	7.1	Cornac.	5.5	Escalloniac.	7.2	Hamamelidac.	6.6	Ericac.	11.7	Rosac.	6.2	Theac.	8.9
11	Primulac.	6.8	Pentaphylac.	5.4	Oleac.	5.6	Ericac.	5.4	Fagac.	11.0	Gentianac.	5.7	Rosac.	8.5
12	Euphorbiac.	6.7	Phyllanthac.	5.1	Asterac.	5.4	Theac.	4.9	Winterac.	7.5	Aquifoliac.	5.7	Myricac.	7.5
13	Meliac.	6.6	Melastomat.	5.1	Phyllanthac.	5.1	Cardiopterid.	4.6	Rosac.	7.1	Symplocac.	5.1	Clethrac.	7.3
14	Podocarpac.	6.1			Laurac.	4.5	Sapotac.	3.8	Aquifoliac.	6.3	Arecac.	5.0	Trimeniac.	6.8
15	Cornac.	6.1			Paracryphiac.	4.3	Juglandac.	3.5	Dicksoniac.	5.4	Dicksoniac.	4.5	Chloranthac.	4.6
16	Ehretiac.	4.8			Cornac.	4.2	Euphorbiac.	3.5		4.6	Ericac.	4.4	Escalloniac.	4.5
17	Symplocac.	4.7			Loganiac.	4.0	Symplocac.	3.4			Primulac.	4.4	Proteac.	4.4
18	Rutac.	4.6			Cyatheac.	3.9	Elaeocarpac.	3.3			Rubiac.	4.4	Cunoniac.	4.3
19	Staphyleac.	4.5					Primulac.	3.1					Rubiac.	4.1
20	Monimiac.	4.2					Morac.	3.0					Rutac.	4.1
21	Putranjivac.	3.9					Cyatheac.	2.8					Dicksoniac.	3.7
22	Asterac.	3.7					Rutac.	2.7					Aquifoliac.	3.2
23	Stemonurac.	3.3					Sabiac.	2.7					Primulac.	3.1
24	Oleac.	3.2					Oleac.	2.7					Ericac.	3.1
25							Pandanac.	2.7						
Top10		230.9		284.4		263.2		248.1		258.3		257.6		30.7
Rest		69.1		15.6		36.8		51.9		41.8		42.4		69.3

Sum of Family Importance Value (FIV; Mori et al. 1983) per plot is always 300. Sum of FIV of 10 highest ranking families (Top 10) and remaining families (Rest) are shown.

Appendix 5.1 Data sources of tree inventory plots

Aiba S-I, Kitayama K, Repin R (2002) Species composition and species-area relationships of trees in nine permanent plots in altitudinal sequences on different geological substrates of Mount Kinabalu. Sabah Parks Nature Journal 5: 7–69.

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Appendix 5.2 Supplementary methods

The bulk of the phylogeographic, phylogenetic, and floristic studies for the assignation of geographic ancestry of species was compiled over the last years by FB. In addition, we conducted Google Scholar searches using the names of families and infrafamilial groups including subfamilies, tribes, genera and informal clades in combination with the terms “phylogeograph*”, “biogeograph*”, “phylogen*”, “revision”, “monograph”, and “fossil”. Of the original 16 131 individuals in our dataset, only for 245 (1.5%) the geographic ancestry remained ambiguous. The percentages of individuals with ambiguous ancestry per plot ranged from 0% to 11.7% (median 0%, mean 1.3%). We used simple logistic regression models with a quasibinomial error structure to test for significant relationships between environmental parameters and the proportion of individuals with unknown geographic origin per plot. Plots on ultramafic parent material contained a significantly higher portion of those individuals than plots on other substrates ($D^2 = 0.16$, $p < 0.0001$), possibly highlighting the high number of insufficiently known endemics know to occur there; the other variables did not have any significant effects (Figure 1)

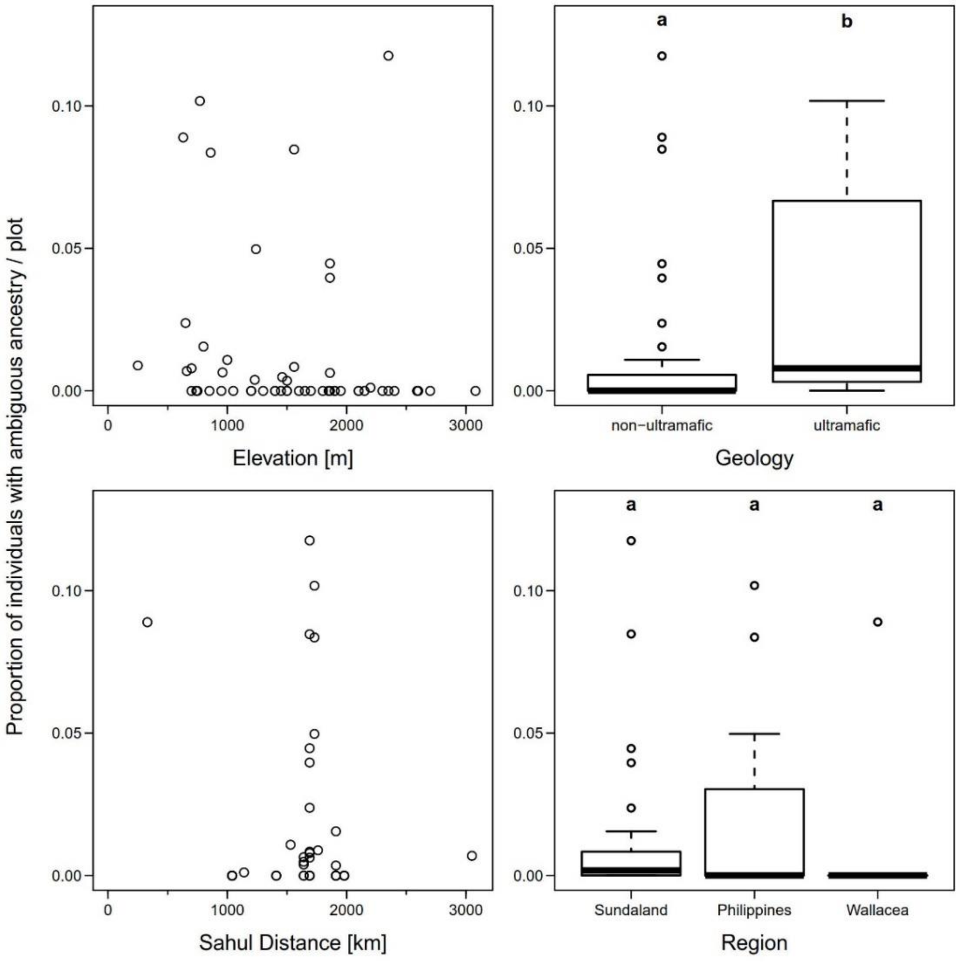

Figure 1. Decimal proportions of tree individuals with ambiguous geographic ancestry per plot and their relation to environmental parameters. Relationships were tested with logistic regression models with quasibinomial error structure. Significant differences were retrieved between ultramafic and non-ultramafic substrates but not between geographic regions. Elevation and Sahul Distance did not show any significant linear or quadratic relationships; regression lines are therefore omitted.

The families are sorted and numbered according to published linear sequences for gymnosperms (Christenhusz et al. 2011), and angiosperms (The Angiosperm Phylogeny Group 2016). Assignment to biogeographic ancestry in parenthesis following the family names only refers to the taxa in our dataset.

Gymnosperms

5 Gnetaceae (Asian)

Gnetum dispersed from Asia into Malesia during the last 20 My in at least two separate events, as inferred by phylogeographic analysis (Won et al. 2006).

8 Araucariaceae (Australian)

The only genus in our dataset, *Agathis*, is sister to the Australian endemic *Wollemia*; together these two are sister to the Gondwanan-distributed *Araucaria*. *Agathis* started to diversify at the Paleogene-Neogene boundary (Kershaw and Wagstaff 2001) and within the genus, *Australian* and *New Caledonian* clades are basal with Malesian species in a derived position (Escapa and Catalano 2013). There are no known *Agathis* fossils from Asia (Fossilworks 2016).

9 Podocarpaceae (Australian)

The genera *Phyllocladus*, *Dacrycarpus*, *Dacrydium*, *Falcatifolium*, and *Podocarpus* are present in our dataset. Although *Phyllocladus* diverged from other Podocarpaceae as early as 200 Ma, extant species of the genus only began to diversify in the late Miocene (ca 6 Ma) in Australasia and only *P. hypophyllus* dispersed into Malesia (Wagstaff 2004).

Dacrycarpus, *Dacrydium*, and *Falcatifolium* are part of the *Dacrydioid* clade for which an Australasian origin (Knopf, Schulz, Little, Stützel, & Stevenson, 2012) with recent diversification in the Neogene was resolved (Biffin et al. 2011).

Podocarpus is represented in Malesia by species of subgenus *Foliolatus*. The subgenus is rooted in Australia and New Caledonia (Knopf et al. 2012) and diversified during the Neogene with several lineages spreading northwards to Malesia and beyond to Southeast Asia (Biffin et al. 2011, Quiroga et al. 2016).

12 Taxaceae (Asian)

Taxus is widespread in the Northern Hemisphere and practically absent south of the Equator (Farjon 2010). The genus started to diversify at the Oligocene-Miocene boundary, probably in North America, where the early diverging species occur (Leslie et al. 2012). The only Malesian species, *Taxus sumatrana*, ist most closely related to the *T. marei* and *T. chinensis* from East Asia and diverged from the latter in the late Miocene (Liu et al. 2011, Leslie et al. 2012).

Angiosperms

6 Trimeniaceae (Australian)

Trimeniaceae originated ca 100 Ma as indicated by macrofossils from Japan (Yamada et al. 2008). Relationships within Trimeniaceae have never been analysed with molecular methods, but the present distribution in East Australia (1 sp.), New Caledonia (1) Central and East Malesia (2) and western Pacific islands (2) points to an Australian origin with recent dispersal into Malesia (Philipson 1986).

9 Winteraceae (Australian)

The predominantly Australian genus *Tasmannia* started to diversify in the early Oligocene(ca 30 Ma; Thomas et al. 2014). The Malesian species are poorly sampled in published phylogenies. They belong to a clade in state of active speciation in mountain habitats, most pronounced in New Guinea, but reaching westward to Borneo and the Philippines, indicating young age and recent dispersal (Vink 1970).

13 Myristicaceae (Asian)

While the evolutionary history, including crown age, of Myristicaceae is unclear (Doyle et al. 2004), the pre-Neogene fossil record of the family involves only Eurasia and the Americas, with no fossils known from Australia (Fossilworks 2016). The presence of these fossils, together with the low dispersal capability of the large seeds of Myristicaceae is here used to indicate recent dispersal into Malesia from Asia (Doyle et al. 2008).

14 Magnoliaceae (Asian)

Magnolia was widespread in Laurasia in the early Eocene and the tropical Asian lineages migrated south in the Neogene, due to climatic cooling, eventually reaching Malesia (Nie et al. 2008, Nooteboom 2011).

16 Himantandraceae (Australian)

Extant distribution of the only genus *Galbulimima* from Sulawesi to N Australia (Endress 1993b) and the sister group relationship with the Fiji endemic Degeneriaceae (Massoni et al. 2014) clearly point to an Australian ancestry of Himantandraceae.

18 Annonaceae (Asian)

Annonaceae probably originated in W Gondwana; their present distribution is the result of the complex interplay of vicariance and dispersal events (Thomas et al. 2015). All Malesian taxa belong to clades that diversified in the Neogene. In these clades, splits between Africa and (SE) Asia are common and Australasian taxa are all nested among SE Asian taxa or diverge from them after the onset of the FMI (ca 23 Ma), indicating recent dispersal into Malesia from SE Asia (Thomas et al. 2015).

24 Monimiaceae (Australian)

All Malesian genera have their origin in Australasia and probably started to migrate no earlier than in the middle Miocene as indicated by the phylogeographic analysis of Renner et al. (2010).

25 Lauraceae (mixed)

Tribe Cryptocaryeae, represented in our dataset by *Eusideroxylon*, *Beilschmiedia*, *Cryptocarya*, and *Endiandra*, is predominantly distributed in the Southern Hemisphere and was inferred to have evolved on Gondwana (Chanderbali et al. 2001). *Eusideroxylon*, endemic to Sundaland, probably separated from the remaining Cryptocaryeae about 120 Ma so despite its Gondwanan origin, we assume early migration to Asia for the genus. The remaining genera, *Cryptocarya* and the *Beilschmiedia* / *Endiandra* clade, have Australasian taxa in basal positions of their phylogenies indicating Australian ancestry (Rohwer et al. 2014).

Perseeae originated from an Eocene radiation in Laurasia and later moved southward due to global cooling during the Oligocene and Miocene, eventually colonising Malesia. *Machilus* diversified ca 20 Ma, the clade containing the intermingled *Alseodaphne*, *Dehaasia*, and *Nothaphoebe*, 20–30 Ma, and *Phoebe* ca 25 Ma; all consistent with Neogene migration into Malesia from Asia (Li et al. 2011).

The *Cinnamomum* group probably originated in early Eocene Laurasia, and all clades containing Malesian and Australian species started to radiate in the early Miocene or later, indicating Neogene dispersal into and beyond Malesia from Asia (Huang et al. 2016). Records of pre-Miocene fossils from Australia attributed to *Cinnamomum* are doubtful (Vadala and Greenwood 2001).

Likewise, *Laureeae*, sister to the *Cinnamomum* group and represented by *Actinodaphne*, *Lindera*, *Litsea*, and *Neolitsea* in our data, originated in the early Eocene of Laurasia and later moved to lower latitudes due to climatic cooling (Chanderbali et al. 2001, Huang et al. 2016). The exact timing of the arrival in Malesia is not known; *Litsea*-type macrofossils from the Eocene have been reported from Australia (Vadala and Greenwood 2001), so possibly some long-distance dispersal from Asia to Australia took place before that. Nevertheless, assignation of many Lauraceae fossils is doubtful and the center of diversity in the Litsea group is clearly in E and SE Asia (Li et al. 2004, 2008), so that we infer an Asian ancestry of this clade with (mostly) recent dispersal into Malesia and to Australia.

26 Chloranthaceae (Australian)

Ascarina diverged from its Asian sister group (*Sarcandra* and *Chloranthus*) in the mid-Createaceous, ca 95 Ma. However, the extant members of the genus only started to diversify in the Pacific Ocean around 30 Ma, forming two clades: one containing Malesian and Pacific Ocean species, which further split up in the Neogene; the other one containing species from Madagascar, New Zealand, and the Pacific Ocean (Zhang et al. 2015). Because of the absence of *Ascarina* fossils from the Tertiary in Asia, and the presence of Eocene *Ascarina* pollen in

Australia (Fossilworks 2016), we consider the most likely explanation to be that *Ascarina* reached Australia / the Pacific Ocean via long-distance dispersal before the Eocene and spread into Malesia from the southeast in the Neogene.

50 Pandanaceae (Asian)

The species in our dataset both belong to *Pandanus* subgenus *Kurzia* (Stone 1974), which belonged to the *Pandanus* subclade I of Gallaher et al. (2015). That study suggests that Pandanaceae originated in Laurasia and *Pandanus* subclade I originated in SE Asia very recently (ca 11 Ma) from where it spread eastward to Malesia and the W Pacific.

74 Asparagaceae (Asian)

Dracaena originated in E or SE Asia and from there repeatedly dispersed to Africa and the Pacific (Lu and Morden 2014). Although the dating of the dispersal events is not clear, we infer an Asian origin of the genus.

76 Arecaceae (Asian)

Oncosperma (stem age ca 20 Ma), *Areca* (14 Ma, and *Pinanga* (12 Ma) belong to a clade in Areceae with SE Asian origin which dispersed into Malesia during the Neogene (Baker and Couvreur 2013). *Caryota* (Caryoteae) displays the same biogeographic pattern but has a stem age of ca 25 My (Baker and Couvreur 2013).

112 Sabiaceae (Asian)

Meliosma has an ample fossil record in Laurasia throughout the Tertiary (van Beusekom 1971). All Old-World species of the genus form one clade (Zúñiga 2015), which has its greatest diversity in E and SE Asia, only one species reaches E Malesia (van Beusekom 1971).

115 Proteaceae (Australian)

Lasjia arrived to Central Malesia due to a dispersal event from Australia less than 12 Ma (Mast et al. 2008). *Helicia* separated from the Australian genus *Hollandaea* at the beginning of the Pliocene (Barker et al. 2007). The exact divergence time of the remaining genus present in our data, *Heliciopsis*, is not clear, but it belongs to a clade otherwise consisting of Australian and New Caledonian taxa (Weston and Barker 2006), so we assume Australian ancestry for *Heliciopsis* as well.

120 Dilleniaceae (Asian)

No dated phylogenetic studies have been conducted for Dilleniaceae so far. *Dillenia*, the only genus in our dataset, is distributed from India to New Guinea and N Australia (Horn 2007). The Malesian species of *Dillenia* are sister to the Bornean endemic *Acrotrema* and *Dillenia* species distributed around the Indian Ocean (Madagascar, Seychelles, Sri Lanka), so we interpret *Dillenia* as having Asian origin (Horn 2009).

123 Altingiaceae (Asian)

The only species in our dataset belongs to the large E Asian clade of *Liquidambar*, which is distributed from India to China and Java and can be considered relictual after the widespread occurrence of *Liquidambar* in Laurasia during the Eocene (Ickert-Bond and Wen 2006).

124 Hamamelidaceae (Asian)

Hamamelidaceae have a rich Tertiary fossil record in Laurasia (Endress 1993a) and their centre of diversity in E to SE Asia. Of the *Sycopsis-Distylium-Distyliopsis*-clade (Li 2008), most diverse in E and SE Asia, only *D. dunnii*, the species in our dataset, reaches E Malesia.

126 Daphniphyllaceae (Asian)

Daphniphyllaceae split from its sister family, the E Asian Cercidiphyllaceae in the late Cretaceous (Jian et al. 2008). Their extant distribution is from E Asia to New Guinea, with the centre of diversity in SW China and a secondary centre in W Malesia (Kubitzki 2007a).

127 Iteaceae (Asian)

Itea, centred in E Asia, has a relic distribution due to climatic cooling, having been widespread in Laurasia during the Tertiary (Hermsen 2013). It barely reaches W Malesia with one species (Kubitzki 2007b).

136 Vitaceae (Asian)

Leea originated in SE Asia in the late Cretaceous and underwent a rapid radiation in Malesia in the Miocene (Molina et al. 2013).

140 Fabaceae (mixed)

Detarioideae: *Crudia*, distributed in the tropics of America, Africa, and Indo-Malesia, is nested within African taxa and diverged from its African sister group in the Eocene (Bruneau et al. 2008, 2014). Within Malesia, it is strongly centred in Sundaland, with only a few species occurring further east. Eocene fossils attributed to *Crudia* have been found in North America (Fossilworks 2016). Taken together, this information points to an African origin of *Crudia*, wide Laurasian distribution during the Eocene and subsequent southward migration due to Neogene cooling, eventually moving into Malesia. *Cynometra*, another pantropical genus, shows a similar pattern, having diverged from its mainly African relatives in the Eocene (Bruneau et al. 2008, 2014). *Sindora* is most diverse in SE Asia and Sundaland, only one species crosses Wallace's line. The genus is sister to a clade composed of African taxa and the Bornean endemic *Pseudosindora* (Fougère-Danezan et al. 2010); the two groups separated at the Oligocene-Miocene boundary (Bruneau et al. 2008) clearly indicating an Asian origin of the Malesian species.

Dialioideae: The widely distributed *Dialium* is nested in an equally widely distributed clade (Neotropics, Africa, Asia). The clade started to diversify in the early Miocene, with all genera except *Dialium* becoming restricted to one continental region, possibly as a result of southward movement due to Neogene cooling or long-distance dispersal (Bruneau et al. 2008). The absence of *Dialium* from C and E Malesia and Australia further supports its Asian origin. *Koompassia* is sister to *Mendoravia* from Madagscar, the two genera having separated ca 18 Ma, presumably as a result of long-distance dispersal. While the direction of the dispersal event is not clear, the general geographical distribution of the Dialiinae rules out Australia as ancestral area (Bruneau et al. 2008).

Caesalpinioideae: *Parkia* is pantropical, originated in the Eocene in America and diversified during the Neogene (Bouchenak-Khelladi et al. 2010). The genus is absent from Australia and within Malesia most diverse in Sundaland, indicating Asian ancestry. Ingeae (*Archidendron*, *Albizia*) evolved in the early Miocene of America and reached Asia and/or Australia via long-distance dispersal only in the Miocene (Bouchenak-Khelladi et al. 2010). Since *Archidendron* was resolved as sister to the E Malesian *Pararchidendron* (Brown et al. 2011) and has its centre of diversity in New Guinea (Nielsen et al. 1984), we assume an Australian origin. *Albizia* is polyphyletic and with the information currently available, we were not able to assign a geographic ancestry to the species represented in our dataset.

Papilionoideae: The pantropical genus *Ormosia* is sister to a clade of Amazonian genera (Cardoso et al. 2017); it is most diverse in the Neotropics and in mainland E and SE Asia, with most Malesian species occurring in Sundaland, indicating a probable origin in Asia. *Millettia* is a polyphyletic genus and the species included in our dataset (*M. sericea*) has not been included in any molecular phylogenetic analyses so far. However, Adema (2001) suggested a close relationship between that species and mainland Asian taxa. We therefore assume Asian ancestry of *Millettia*.

142 Polygalaceae (Australian)

Xanthophyllum diverged from the rest of Polygalaceae in the Paleocene. In the rest, southern hemisphere clades are successively sister to the more widespread Polygaleae (Forest et al. 2007, Bello et al. 2012), indicating a southern hemisphere origin of the family. While most species of *Xanthophyllum* occur west of Wallace's line, the greatest diversity at subgeneric level occurs east of that line (van der Meijden 1988) and W Malesian species of *Xanthophyllum* are nested within their Australian congeners (Persson 2001), so we infer an Australian ancestry for *Xanthophyllum*. Notably, macrofossils of the genus appear in the Mio-Pliocene fossil record of India (Mehrotra et al. 2014), which is consistent with a scenario of recent immigration from Australia through Malesia to India.

143 Rosaceae (Asian)

Prunus appeared ca 60 Ma in E Asia. The tropical species of Malesia belong to different clades which all originated in E Asia and diversified since the late Oligocene (Chin et al. 2014). There was one species of Rosaceae from the Philippines in our dataset with unclear generic identity. The only tree genera occurring in the Philippines besides *Prunus* are *Photinia* and *Raphiolepis* and both have Asian origins (Campbell et al. 2007, Guo et al. 2011).

147 Rhamnaceae (mixed)

Alphitonia separated from the SW Australian endemic *Granitites* in the early Neogene and started to diversify in Australasia ca 10 Ma. From there, some species, including the one in our dataset, entered Malesia in the last 5 My. *Ziziphus* originated in Asia or Africa in the late Cretaceous but diversified in Asia much later, in the Neogene, when some lineages also spread to Malesia (Hauenschild et al. 2018).

149 Cannabaceae (Asian)

Asian species of *Celtis* group together with African species (Sattarian 2006) and have an extensive fossil record in Laurasia from at least the Eocene (Soepadmo 1977). Asian species of *Trema* group together with their African congeners, but without good-enough resolution to infer exact patterns of historical biogeography (Yesson et al. 2004). Nevertheless, fossils of *Trema* appear in the Eocene of Europe, as do those of *Gironniera* (Yesson et al. 2004). The available information suggests wide Laurasian distribution of Cannabaceae during the Paleogene and later southward migration because of Neogene cooling, eventually reaching the tropical regions of Malesia.

150 Moraceae (Asian)

Moraceae probably originated in Gondwana and started to diversify around 90 Ma. Phylogeographic patterns of the family are consistent with a wide Laurasian distribution during the Paleo-Eocene and subsequent southward migration since the Miocene (Zerega et al. 2005). All Malesian species of *Ficus* (except sect. *Malvanthera* which is not present in our dataset) are nested within Asian clades and diverged from their Asian relatives in the Neogene, consistent with immigration to Malesia from Asia in that period. The Paleogene fossils of *Ficus* in Australia belong to sect. *Malvanthera* (Cruaud et al. 2012).

151 Urticaceae (Asian)

Leucosyke, together with the morphologically similar Indo-Malesian-Pacific genus *Maoutia*, is sister to a clade containing taxa formerly included in Cecropiaceae from tropical S America and Africa (Wu et al. 2013). *Dendrocnide* is sister to the Central American genus *Discocnide*; their next closest relative is *Girardinia* from Africa and SE Asia (Wu et al. 2013, Kim et al. 2015). *Pipturus* (Malesia to Pacific) is sister to the Hawaiian *Neraudia*; their closest relative is the pantropical and polyphyletic *Pouzolzia*. *Oreocnide* (Sri Lanka to Japan) is sister to the rest of Boehmerieae, and *Debregeasia* is sister to a widespread clade within Boehmeriae. No dated phylogenetic studies for Urticaceae have been published so far and the exact biogeographic relationships are therefore unclear. However, the great diversity at different taxonomic levels in E and SE Asia, the relative scarcity and terminal position of Australian taxa (Wu et al. 2013), and the presence of several Tertiary fossils from Laurasia (Fossilworks 2016) point to an Asian origin of the Malesian members of the family.

153 Fagaceae (Asian)

Fagaceae have a complex biogeographical history centred in Laurasia. While die diversification of *Quercus* occurred at temperate latitudes, the genera *Lithocarpus* and *Castanopsis* have their evolutionary centre in SE Asia. Regardless of the original region of diversification, all Malesian species have a Laurasian, i.e. Asian origin and invaded Malesia E of Sundaland since the Miocene (Manos and Stanford 2001, Cannon and Manos 2003).

154 Myricaceae (Asian)

Morella diverged from its sister genus, *Myrica* in the mid Eocene in Laurasia and diversified in the Neogene. *Morella javanica*, the species in our dataset, diverged from its Asian relatives ca 16 Ma (Herbert 2005).

155 Juglandaceae (Asian)

Juglandaceae subfamily Engelhardtioideae was widespreaed in Laurasia during the Eocene, as indicated by an abundant fossil record (Manchester 1989). There are no phylogenetic studies with adequate taxon sampling to infer details about the evolutionary history of *Engelhardtia*, but its distribution in Asia and W Malesia together with the fossil record (Manchester 1989) point to an Asian origin of the Malesian species.

160 Anisophylleaceae (Asian)

The Asian species of *Anisophyllea* split from their African sister clade at the beginning of the Miocene. The Sri Langkan *A. cinnamomoides* is then sister to the Southeast Asian species, suggesting an origin in Africa or Asia (Zhang et al. 2007). Since the genus is neither present in East Malesia nor in Australia or the Pacific Ocean, we assume an Asian origin of the Malesian species.

164 Tetramelaceae (Asian)

Tetramelaceae split from Begoniaceae in the Paleocene, probably in Asia (Schaefer et al. 2009) (Schaefer, Heibl, & Renner, 2009). The only two genera, *Octomeles* and *Tetrameles,* split in the Oligocene and *Octomeles* likely reached its present widespread-Malesian distribution (Swensen and Kubitzki 2010) via eastward dispersal afterward

168 Celastraceae (mixed)

Microtropis and two Neotropical genera form a clade that was inferred to have diverged from its large sister clade in the late Cretaceous of Asia (Bacon et al. 2016). The genus is most diverse in E and SE Asia and does not cross Wallace's line (Hou 1962), so we assume an Asian origin.

Siphonodon belongs to another early-diverging (Late Cretaceous) clade of Celastraceae including taxa on former Gondwanan continental areas for which an Australian origin was inferred; the genus diverged from its closest relative, the New Caledonian endemic and monotypic *Peripterigya*, in the Paleocene (Bacon et al. 2016). *S. celastrineaus* was resolved as sister to three Australian endemic species of *Siphonodon* (Simmons et al. 2012a), while the other non-Australian species where not sampled. Given the origin of the clade, we assume recent immigration of *Siphonodon* into Malesia from Australia, although the crown age of the genus is not known.

Euonymus is sister to a clade containing the N American *Acanthothamnus* and *Canotia.* The genus is most diverse in Asia with less species occurring in N America, Europe, Malesia, and Australia (Simmons et al. 2012b, Simmons and Cappa 2013) and has a fossil record spanning the Paleocene to Miocene in N America and the Miocene of Eurasia (Bacon et al. 2016) so we infer an Asian origin for the Malesian species.

Kokoona and *Lophopetalum* are sister to a large Malagasy clade, from which they separated in the Paleocene. An unambiguous ancestral area could be inferred for the common ancestor of these two clades, but it certainly included former fragments of E Gondwana (Bacon et al. 2016). *Kokoona* has an Indo-W Malesian distribution and *Lophopetalum* ranges from India to New Guinea, but both are most diverse in Sundaland (Hou 1962). Given the available information, we assume that the genera or their common ancestor rafted on the Indian plate and dispersed into SE Asia and Malesia after contact with the Asian continent.

170 Connaraceae (Asian)

No molecular phylogenetic studies with adequate generic sampling exist for Connaraceae. *Ellipanthus* occurs in E Africa, Madagascar, India, and from SE Asia to Wallacea but not futher east (Lemmens et al. 2004), so we assume an Asian ancestry.

172 Cunoniaceae (Australian)

Cunoniaceae have an extensive fossil record in Gondwana dating back to the late Paleocene (Bradford et al. 2004). Many extant clades are disjunct between former Gondwanan landmasses: *Schizomeria* belongs to tribe Schizomerieae, distributed mainly in Australasia with one species in South Africa. The tribe Caldcluvieae, containing our E Malesian genus *Spiraeopsis*, has a similar distribution: mostly in Australasia with one species in S America. Cunonieae is distributed in Malesia, Australasia, New Caldedonia, the Indian Ocean, and S Africa, mostly owing to the widespread genus *Weinmannia*, which is in our dataset (Bradford et al. 2004). The morphological diversity of the genera within tribes combined with the ample Gondwanan fossil record led Bradford and Barnes (Bradford and Barnes 2001) to the obvious conclusion of a Gondwanan vicariant origin for these taxa.

173 Elaeocarpaceae (mixed)

Although relatively few Malesian species of *Elaeocarpus* have been sampled in molecular phylogenies so far, all Malesian, Asian, and Pacific species grouped together in specific clades nested within Australian taxa (Baba 2013) suggesting an Australian origin of the genus. Crayn et al. (2006) retrieved a crown age of 30 My for *Elaeocarpus* in their dated phylogeny, but the only Malesian species included in their study split from its Australian congeners much later (ca 14 Ma).

No phylogenetic studies have been carried out for *Sloanea*, but fossil evidence suggests that the genus was a component of Paleo-Oligocene boreotropical forest in N America and Europe (Manchester and Kvaček 2009). The genus is most species-rich the Neotropics. In the Old World, the highest diversity occurs in continental Asia from the Himalayas to the SE Asian peninsula with secondary centres in New Guinea and New Caledonia, while Australia harbours only one species (Coode 1983). Fossil record and species distribution thus suggest an Asian origin of Malesian *Sloanea*.

177 Irvingiaceae (Asian)

Irvingia malayana was retrieved as sister to African species of *Irvingia* (including the monotypic *Desbordesia*) with the African *Klainedoxia* and the Bornean *Allantospermam* successively sister to that clade (Byng et al. 2016). The split between *Klainedoxia* and *Irvingia* occurred in the middle to late Miocene (Xi et al. 2012), suggesting recent long distance dispersal from Africa to SE Asia and Sundaland, where the species occurs at present (Nooteboom 1962).

178 Ctenolophonaceae (Asian)

Pollen attributed to the *Ctenolophus* has been recorded from Africa, where *C. englerianus* exists today, and India since the Paleocene. The appearance of Eocene pollen from SE Asia and W Malesia (Kubitzki 2014a), and Malesian distribution of the only other species of the genus, *C. parvifolius* indicate an Asian origin of the later.

179 Rhizophoraceae (Asian)

The two genera from our dataset, *Pellacalyx* and montypic *Gynotroches,* belong to tribe Gynotrocheae, which diverged from the mangrove clade Rhizophoreae at the Paleocene-Eocene boundary (ca 55 Ma; Xu et al. 2017). All genera of Rhizophoreae have a reliable Eocene fossil record in different areas of Laurasia (Graham 2006). Within Gynotrocheae, *Carallia*, most diverse in continental Asia and Sundaland (Hou 1958, Kostermans 1982, Qin and Boufford 2007), and *Crossostylis* from the western Pacific are successively sister to *Pellacalyx* and *Gynotroches* (Sun et al. 2016). *Pellacalyx* is also most diverse in Sundaland, with six of its eight species occurring there (Hou 1958, Qin and Boufford 2007), and the monotypic *Gynotroches* is widespread from Southeast Asia to Melanesia (Hou 1958). Together, the phylogenetic relationships, fossil record, and diversity patterns of extant species strongly suggest an Asian origin of Gynotrocheae, presumably with long-distance dispersal to and diversification in the western Pacific Ocean by *Crossostylis* (not present in our dataset).

181 Ochnaceae (Asian)

Brackenridgea diverged from the African genus *Idertia* in the middle Miocene and further split into an African and an Asian clade in the Pliocene (Bissiengou 2014).

183 Clusiaceae (Asian)

Garcinia likely originated in Africa and diversified in the Neogene spreading over India to SE Asia and further to Malesia and Australia (Ruhfel et al. 2016).

184 Calophyllaceae (Asian)

Calophyllaceae were present in boreotropical forests of the Holarctic during the Eocene and migrated south to tropical latitudes in response to global climatic cooling starting at the Eocene-Oligocene boundary (Meseguer et al. 2018). The clade containing the genera in our dataset (*Calophyllum*, *Kayea*, and *Mesua*) contains pantropical genera as well as those with a more restricted Old-World distribution. It started to diversify in the early Oligocene; an Indian origin with subsequent eastward migration was inferred for *Kayea*, while the ancestral areas for *Mesua* and *Calophyllum* were ambiguous (Ruhfel et al. 2016). *Mesua* is distributed from India, where most species occur, to West Malesia (Stevens 2007). *Calophyllum* is pantropical, but has its centre of diversity in the Paleotropics and fossils indicate it was present and diversified in South Asia during the Miocene (Khan et al. 2017). These distribution patterns as well as the recent time of divergence of the two genera in the middle Miocene and presence in South Asia at that time strongly suggest an Asian origin for both and later dispersal into Malesia.

186 Hypericacae (Asian)

Cratoxylon separated from the Malagasy genus *Eliea* in the middle Eocene and dispersed from India into SE Asia, Sundaland, and Wallacea afterwards (Ruhfel et al. 2016).

189 Putranjivaceae (Asian)

The pantropical *Drypetes* is sister to *Putranjiva*, which has an Indo-Chinese-Malesian distribution. The former is most diverse in Africa and Indo-Malesia, but diversity declines sharply east of Wallace’s line (Levin 2014). The crown age of Putranjivaceae is not known but the family diverged from the African monotypic Lophopyxidaceae in the late Eocene to early Pliocene (Xi et al. 2012) and pollen associated with *Drypetes* has been found in the late Eocene in Europe (Davis et al. 2005), suggesting an African or Eurasian origin. Together with the patterns of extant diversity of *Drypetes*, we consider the information most compatible with a Neogene migration from SE Asia to Malesia and further to the Pacific and Australia.

190 Centroplacaceae (Asian)

Bhesa diverged from the African *Centroplacum*, the only other genus of the family, in the late Cretaceous (ca 69 Ma), but it is not sure whether this split was due to vicariance involving Africa and Indo-Madagascar or Australia, or whether a dispersal event best explained the split (Cai et al. 2016). *Bhesa* is absent from Australia but most species rich in the region spanning from India to W Malesia (Hou 1962), which makes rafting on the Indian plate and later dispersal onto Asia and further into Malesia the most likely scenario.

194 Trigoniaceae (Asian)

Trigoniaceae separated from their closest relative, the Dichapetalaceae, in the Eocene but the extant members of the family started to diversify only in the late Oligocene (Xi et al. 2012). While generic sampling of the family in molecular phylogenetic studies has been sparse, *Trigoniastrum* is morphologically most similar to the Malagasy genus *Humbertiodendron*, with the Neotropical taxa of the family more distant (Bittrich 2014). With the limited information available, the relatively young crown age and extant distribution pattern of the family seem to suggest a wider past distribution in boreotropical forests and southward migration due to climatic cooling in the Neogene. *Humbertiodendron* could have arrived in Madagascar by wind-facilitated long-distance dispersal. Furthermore, since *Trigoniastrum* only occurs in Sundaland, an origin in Australia is less likely than one in Asia.

195 Dichapetalaceae (Asian)

Dichapetalaceae separated from Trigoniaceae ca 60 Ma and diversified in the early Miocene (Xi et al. 2012). The evolutionary history of *Dichapetalum* has not been tested with molecular methods, but the Malesian members of the genus are centred in Sundaland (Leenhouts 1957), so we consider an Asian origin more likely.

197 Chrysobalanaceae (mixed)

Kostermanthus was retrieved as sister to the rest of Chrysobalanaceae (Bardon et al. 2016) with an ancestral area in SE Asia / Oceania (the study did not discriminate between the two). Since the genus is centred in W Malesia, reaching the Philippines and Sulawesi, and one species is endemic to the Malay peninsula (Prance 1989) and the rest of the family originated in Africa (Bardon et al., 2016), we consider an Asian origin of *Kostermanthus* far more likely than one in Australia.

Parinari originated in Africa in the early Miocene; all sampled Indo-Malesian species formed a monophyletic clade together with Neotropical species in derived positions. Hence, in the early to middle Miocene this clade originated in SE Asia or W Malesia, subsequently diversified in Malesia, and reached the Neotropics via long-distance dispersal (Bardon et al. 2016).

The clade containing the genera *Atuna*, *Maranthes*, and *Parastemon*, originated in Africa in the late Oligocene and involved repeated dispersal to SE Asia / Oceania (Bardon et al. 2016). *Atuna* and *Parastemon* are most diverse in Sundaland and/or continental SE Asia with few species occurring there and the only species of *Maranthes* in the region is widespread all over Malesia (Prance 1989). We consider that original dispersal from Africa to SE Asia / Sundaland and subsequent further eastward expansion, partly coupled with diversification is the most likely scenario for these groups.

The lineage of *Angelesia* and *Hunga* reached SE Asia / Oceania via long-distance dispersal in the middle Miocene and the two genera later separated at the Miocene-Pliocene boundary (Bardon et al. 2016). *Hunga* is now confined to New Caledonia and New Guinea while *Angelesia* has a wider distribution from SE Asia to New Guinea (Sothers and Prance 2014), suggesting that the common ancestor of the two genera arrived in Australasia from S America and then spread westward into Malesia.

199 Achariaceae (Asian)

Trichadenia and *Ryparosa* belong to a clade including the Sundaland-centred genera *Pangium* and *Gynocardia*, as well as several nested S African genera. Likewise, *Hydnocarpus* is sister to a clade containing the widespread *Erythrospermum* and several African taxa. The exact phylogenetic relationships in both clades are unclear (Chase et al. 2002, Groppo et al. 2013), but the complete absence of Achariaceae in Australia and the fact that all three genera included in our dataset are limited to Sundaland or most diverse there (Sleumer 1954), make an Australian origin very unlikely.

204 Salicaceae (mixed)

Casearia belongs to the sister clade to the rest of Salicaceae, sometimes treated as a separate family, Samydaceae. The genus is polyphyletic, but its paleotropical species apparently form a monophyletic lineage, which diverged from Neotropical species of *Samyda* in the early Miocene and subsequently diversified and spread in the Paleotropics (Samarakoon 2015). Although taxon sampling of Paleotropical species was sparse, the basal position of species from New Guinea and Malesia and more nested clades of African and Malagasy taxa together with the recent divergence time suggests initial long-distance dispersal from the Neotropics to Australasia and subsequent further spread westward, including the colonisation of Malesia.

Ahernia is closely related to three small Neotropical genera (Alford 2005) but the crown age of that clade is not known. Since the genus only occurs in the N Philippines and Hainan, we assume a Laurasian, i.e. Asian origin. *Homalium* is most closely related to the Malagasy endemic *Bembicia*, pointing to a likely African origin of the genus (Alford 2005). It has a pantropical distribution, but in the Asian-Australian tropics its diversity is highest in Sundaland and the Philippines with a sharp decline further east (Sleumer 1954), so we also assume an Asian origin of Malesian *Homalium*. The widespread Paleotropical *Flacourtia* and the pantropical *Xylosma* together are sister to *Hemiscolopia* (Alford, 2005), which is distributed in continental SE Asia and Sundaland (Sleumer 1954), indicating an SE Asian origin of all three genera.

205 Peraceae (Asian)

Peraceae started to diversify in the Eocene (Xi et al. 2012) and their present distribution in the tropics of America, Africa, and Asia can probably be seen as a relict due to Neogene climatic cooling. *Trigonopleura* is distributed in Sundaland with one species reaching Sulawesi (van Welzen and Esser 2013), so an Asian origin is assumed.

207 Euphorbiaceae (mixed)

Neoscortechinia is sister to the monotypic *Cheilosa*, distributed in Sundaland and the Philippines (Tokuoka 2007). The morphological phylogenetic study by van Welzen (1994) found a Sundaland (i.e. Asian) origin of the genus, with the only E Malesian species nested among others distributed in W and C Malesia.

Moultonianthus is sister to *Erismanthus* and *Syndiophyllum*; the combined clade is mainly distributed in SE Asia and Sundaland, with only one nested species of *Syndiophyllum* occurring in New Guinea (van Welzen 1995, Wurdack et al. 2005), suggesting an Asian origin.

Elateriospermum is the only Paleotropical genus in the 'articulated crotonoids' subclade of Crotonoideae (Wurdack et al. 2005). Its restricted distribution in Sundaland (Webster, 2014) suggests an origin in that area.

Ostodes is placed in a clade with other genera that are centred in SE Asia (Tokuoka 2007). The genus contains only two species: one from China and SE Asia and another from India to Sundaland (van Welzen and Winkel 2015), making an Australian origin unlikely.

The widespread genus *Acalypha* originated in Africa in the Paleocene and started to diversify in the early Miocene (Cervantes et al. 2016). The sister relationship of a Malesian / Pacific clade with a clade from Africa and Asia (Sagun et al. 2010, 201) suggests recent colonisation of the former areas since the Miocene, possible as a result of climate-driven southward movement.

The clade containing *Blumeodendron*, *Hancea*, *Mallotus*, and *Macaranga* originated in Asia in the middle Paleocene (Cervantes et al. 2016). *Blumeodendron* diverged from the other genera in the early Eocene and today is most diverse in Sundaland, with only two species occurring in E Malesia, presumably due to recent invasion from Sundaland (Ottens-Treurniet and van Welzen 2016). *Hancea* split off the *Macaranga*-*Mallotus*-clade in Sundaland in the late Eocene (Cervantes et al. 2016) and the only species in our dataset, widespread *H. penangiana*, is nested in species which occur in SE Asia and Sundaland (Kulju et al. 2007). Finally, *Macaranga* and *Mallotus* both originated in Sundaland in the Oligocene and single lineages of both genera reached Australasia via long-distance dispersal soon afterwards, *before* the onset of the MFI (van Welzen et al. 2014). All species of *Mallotus* in our dataset belong to clades that spread eastwards through Malesia more recently in the Mio-Pliocene and the genus is therefore scored as having an Asian origin. The situation in *Macaranga* is more complex, with one clade having reached Australasia at the Oligocene-Miocene boundary, diversified there, and later dispersed westward reaching Sundaland again. Two other clades diversified in SE Asia / Sundaland and later, in the Mio-Pliocene several species migrated eastwards (van Welzen et al. 2014). We therefore placed our species of *Macaranga* in one of these three clades according to the phylogeny of Welzen et al. (2014) where possible, otherwise based on the morphologically defined species groups of Whitmore (2008), and assigned them to Asian or Australian ancestry accordingly.

Ptychopyxis presumably also belongs to the clade of the preceding paragraph, but to date has not been included in any molecular phylogenetic study. The genus is most diverse in Sundaland with single species occurring in SE Asia and New Guinea, indicating an Asian origin (Stoops and van Welzen 2013).

Claoxylon belongs to a clade with the African *Erythrococca* and *Micrococca*, distributed from Africa to Malesia, which separated from the African *Discoclaoxylon* in the middle Eocene (Cervantes et al. 2016). Later, in the Oligocene, *Claoxlon* separated from its nearest relatives (*Erythrococca* and *Micrococca*) and diversified reaching its present wide distribution from Madagascar through Asia to Australasia. The genus is most diverse in Sundaland, with secondary centres of diversity in the Malagasy region, Papuasia, and the Pacific Ocean (WCSP 2019). Taken together, the phylogeny and the distribution pattern, suggest an African origin and later dispersal to Asia and further east into and through Malesia.

Melanolepis belongs to the Chrozophorinae, a mainly Asian clade, with single taxa spreading into Africa, Europe, and (our species *Melanolepis multiglandulosus*) throughout Malesia to the Pacific (Webster 2014). Not all genera of the Chrozophorinae have been included in molecular phylogenetic studies, but *Sumbaviopsis* (SE Asia and Sundaland) has repeatedly been resolved as the sister genus of *Melanolepis* (Wurdack et al. 2005, Tokuoka 2007) and the two probably split in the early Miocene (Cervantes et al. 2016). As the whole clade is centred in Asia, despite the lack of resolution in the published phylogenies, we assume an Asian origin.

Koilodepas belongs to the tribe Epiprineae (Webster 2014) which, albeit with rather sparse taxon sampling, was resolved as monophyletic when *Cephalomappa* was included (Wurdack et al. 2005). *Cephalomappa*, the closest of all sampled genera, and *Koilodepas* separated in the early Miocene (Cervantes et al. 2016). Both genera are strongly centred in Sundaland and all other genera of the tribe have their greatest diversity in Asia or Africa (*Cephalocroton*; Webster 2014), making an Australian origin of *Koilodepas* very unlikely.

Pimelodendron belongs to the pantropical tribe Stomatocalyceae, a monophyletic clade sister to the rest of Euphorbioideae (Wurdack et al., 2005) which probably originated in the late Cretaceous (Xi et al. 2012). *Pimelodendron* is most diverse in Sundaland with only one species crossing Wallace's line (Djarwaningsih 2004). Taken together, we consider a scenario of wide Laurasian distribution in the Paleogene and subsequent migration to SE Asia and Malesia most likely.

Balakata, a member of tribe Hippomaneae, has not been included in molecular phylogenetic studies so far, but morphology suggests a close relationship with *Anomostachys* from Africa and Madagascar (Webster 2014). The genus only includes two species, one from India to the Philippines, the other in C and E Malesia (Esser 1999); it is absent from Australia and the Pacific Ocean. Based on the limited information, we consider an origin of the genus in Africa or Asia most likely.

Homalanthus is sister to a pantropical (predominantly S American) clade of several genera (Wurdack et al. 2005), but the timing of the divergence is not known, although it must have occurred less than 40 Ma (Xi et al. 2012). Long-distance dispersal from S America to SE Asia / Australia or a former Laurasian distribution and subsequent southward migration are two possible scenarios consistent with the temporal information available. Because *Homalanthus* is most species- and endemism-rich in New Guinea and the W Pacific Ocean, we here assume a recent long-distance dispersal event from S America to New Guinea and subsequent colonisation of Malesia from there.

209 Ixonanthaceae (Asian)

Ixonanthes diverged from the rest of Ixonanthaceae, distributed in tropical Africa and northern S America near the Paleocene-Eocene boundary (Xi et al. 2012, Byng et al. 2016). The phylogeny and divergence times, together with the present distribution of *Ixonanthes* (SE Asia to the Maluku Islands), suggest a former Laurasian distribution of the family and southward migration to the present relic areas due to Neogene cooling, meaning an Asian origin for our purpose.

211 Phyllanthaceae (Asian)

Breynia originated in the late Oligocene to early Miocene in continental SE Asia and subsequently spread in various directions, including eastward into Malesia and Australia (van Welzen et al. 2015). *Glochidion* diverged from *Breynia* and *Synostemon* in the Oligocene (Li et al. 2009). Although the question of the genus' origin was not specifically addressed in the study of Hembry et al. (2013), their results showed all Malesian, Australian, and Pacific species of *Glochidion* to be derived from continental Asian clades.

Bridelia originated in SE Asia and started to diversify ca 10 Ma. The genus reached Australia at least twice independently ca 2 Ma (Li et al. 2009). The non-African species of *Cleistanthus* form the sister group of *Bridelia*. Most species occur in Southeast Asia and Sundaland, and the only Australian species tested so far diverged from its Malesian counterparts ca 13 Ma (Li et al. 2009) suggesting recent (Miocene) dispersal from Asia into Malesia and further to Australia and the Pacific Ocean.

Bischofia, together with the African *Spondianthus*, is sister to the rest of subfamily Antidesmatoideae; the two genera already diverged in the Late Cretaceous (Li et al. 2009). *Bischofia* contains one species endemic to China and another widespread from India to the Pacific Ocean (van Welzen 2016). Given the relationship with African *Spondianthus* and the endemic Chinese species, we consider an Australian origin of the genus to be unlikely.

Antidesma has a wide paleotropical distribution, with half of its ca 100 species occurring in continental Southeast Asia and Sundaland but also spreading to tropical Africa, India, and China as well as eastward to Papuasia, Australia and the Pacific Ocean (WCSP 2019). The genus diverged from its closest relative, *Thecacoris* from tropical Africa and Madagascar, in the early Miocene (Li et al. 2009). Given the high species diversity in Southeast Asia and Sundaland and the sister relationship to the African genus, we consider an Asian, or at least Laurasian origin of *Antidesma* to be most likely.

Aporosa and *Baccaurea* belong to a pantropical clade that started to diversify in the early Eocene (Li et al. 2009). Eocene leaf fossils of *Aporosa* have been found in India (Shukla et al. 2016) and the genus colonised the rest of Malesia from Sundaland (Schot 1998). *Baccaurea* has its centre of diversity in Sundaland and phylogeographic analysis using morphological characters inferred that it originated in Southeast Asia (Haegens 2000).

214 Combretaceae (Asian)

The pantropical genus *Terminalia* started to diversify in South America in the early Miocene. Most of the Old-World species, including the two species in our dataset, belong to a clade that originated in Africa in the Mid-Miocene and spread through Asia to Australia from there (Berger et al. 2016).

215 Lythraceae (Asian)

Duabanga and *Lagerstroemia* are sister taxa which separated at the beginning of the Tertiary. Although their origin was inferred to be Australian in the phylogeographic analysis of Berger et al. (2016), this is unlikely considering the fossil record: Both genera have an extensive record in Eurasia, especially in India and Sundaland, from at least the Miocene onwards while there are no known fossils from Australia (Graham 2013). Lythraceae originated in South America in the Late Cretaceous and shortly afterwards spread through North America to Eurasia and Africa (Berger et al. 2016). In light of that information, we believe that an Asian origin of the species in our dataset is most likely.

218 Myrtaceae (Australian)

All species in our dataset (including genus indets) belong to subfamily Myrtoideae, which originated at the Cretaceous-Paleogene boundary in Australia. All relevant lineages in Myrtoideae diversified in Australasia and only recently, since the Miocene, spread to other regions, including the expansion to Central- and West-Malesia and into Asia (Sytsma et al. 2004, Thornhill et al. 2015, Berger et al. 2016).

219 Melastomataceae (mixed)

Melastomataceae likely started to diversify in South America in the early Paleocene and LDD by volant animals has played a prominent role in the family's evolutionary history (Berger et al. 2016). *Pternandra* was the earliest diverging lineage of the Melastomataceae crown. The genus is now distributed from Thailand throughout Malesia and likely diversified from the Mid-Miocene onwards (Renner 2004). While from the available data, it cannot be unambiguously concluded whether the ancestors of extant *Pternandra* came from Asia or Australia, the genus' centre of diversity in Sundaland and absence of Australian species points to Asia.

Memecylon, another early diverging lineage split from its Neotropical sister genus *Mouriri* in the early Miocene, probably through LDD (Berger et al. 2016). Most extant species as well as the basal groups occur in Africa, from which the genus diversified and spread several times to Asia and Malesia among other areas (Stone 2014).

The tribe Astronieae, containing our genera *Astronia* and *Astrocalyx*, diverged from the Neotropical Henrietteeae in the early Miocene (ca 18 Ma) probably also via LDD (Berger et al.

2016). The basal position of the New-Guinea-centred genera *Astronidium* and *Beccarianthus* within Astronieae (Penneys, 2013) points to New Guinea as the starting point for further dispersal to Malesia and into Southeast Asia.

In the Eocene (ca 38 Ma), the *Medinilla* lineage split from Neotropical ancestors (Berger et al. 2016). The genus diversified much later, in the Miocene and is now widespread from Africa through Madagascar, India, Southeast Asia, and Australia. It has centres of diversity in Madagascar and Malesia, while in Australia only one species occurs (Bodegom and Veldkamp 2001). Therefore, we infer a Southeast Asian origin for the Malesian members of the genus.

The common ancestor of *Melastoma* and its sister genus *Osbeckia* reached SE Asia via LDD from Africa during the Mid-Miocene (ca 16 Ma) and *Melastoma* presumably spread further east into Malesia afterwards (Veranso-Libalah et al. 2018).

220 Crypteroniaceae (Asian)

Crypteroniaceae split from a clade containing the Neotropical Alzateaceae and Pennaeaceae from southern Africa in the early Eocene. The ancestors of extant species likely rafted on the Indian plate and spread into SE Asia and Malesia after the collision of the Indian plate with Asia (Rutschmann et al. 2004, Berger et al. 2016).

226 Staphyleaceae (Asian)

Turpinia as presently described is not monophyletic. However, the Old-World species of *Turpinia* seem to form a monophyletic group and although results of different markers provided contradictory results, the Malesian species always were nested among mainland Asian taxa, so that an Asian origin is most likely (Harris et al. 2017b).

238 Burseraceae (Asian)

Our species all belong to tribe Canarieae, which after evolving in Eurasia partly moved to Southeast Asia due to Oligocene cooling (Federman et al. 2015). Within Canarieae, several large genera are not monophyletic, but the species in our dataset belong to clades of *Santiria, Dacryodes*, and *Canarium* as well as the monophyletic genera *Scutinanthe* and *Triomma* that all originated in Southeast Asia and underwent recent (Miocene) diversification with some species spreading east through Malesia (Weeks et al. 2014, Federman et al. 2015).

Haplolobus has not been included in phylogenetic analyses so far, so its placement is unclear. However, since all Malesian clades of the family present a uniform pattern of recent diversification in Southeast Asia (Federman et al. 2015), we also attribute an Asian origin to *Haplolobus*.

239 Anacardiaceae (Asian)

Anacardiaceae started to diversify in Southeast Asia in the Upper Cretaceous. Members of the family in our dataset belong to three clades, according to the phylogeographic study of Weeks et al. (2014): *Dracontomelon* is part of the ‘Spondioideae 2’, an early branching lineage that originated in the Upper Cretaceous and started to diversify at the Eocene-Oligocene boundary in Southeast Asia. *Dracontomelon* split from its sister genus *Pseudospondias* at the beginning of the Miocene in Southeast Asia and later, probably only during the Pliocene spread into Central and East Malesia (Weeks et al. 2014).

Buchanania separated from the 'Spondioideae 1' in the Mid-Paleocene in Southeast Asia. The genus underwent recent diversification and eastward expansion in the late Miocene and Pliocene (Weeks et al. 2014).

Koordersiodendron has not been sampled in phylogenetic studies. Based on morphology, it belongs to subfamily Spondioideae (Pell et al. 2010, 201), a polyphyletic assemblage of the two clades 'Spondioideae 1' and 'Spondioideae 2'. Since both of them originated in Southeast Asia and all their Malesian genera arrived in the region from Asia (Weeks et al. 2014), we assume that *Koordersiodendron* also has a Southeast Asian origin.

Gluta, *Mangifera*, *Swintonia*, *Melanochyla*, and *Semecarpus* all belong to 'Anacardioideae 4', a clade which originated in Southeast Asia or Oceania at the Cretaceous-Paleogene boundary and started to diversify in Southeast Asia shortly afterwards. All lineages containing Malesian genera in 'Anacardioideae 4' were present in Southeast Asia in the Oligocene and – if occurring there today – only moved to eastern Malesia and Oceania since the Miocene or later (Weeks et al. 2014).

Since all clades of Malesian Anacardiaceae were retrieved to have Southeast Asian origins and recent expansion into (and sometimes) beyond Malesia (Weeks et al. 2014), we also score *Parishia*, which has not been sampled for phylogenetic studies and several genus indets as originally Asian taxa.

240 Sapindaceae (mixed)

Sapindaceae originated in Eurasia in the early Cretaceous but SE Asia has been a centre of diversification and dispersal throughout much of the family's evolutionary history, which involved several LDD events (Buerki et al. 2011).

Acer belongs to an early-diverging clade, the Hippocastanoideae, and originated in Eurasia. The genus has diversified since the early Miocene from there, giving rise to the Malesian species *Acer laurinum*, among others (Buerki et al. 2011, Harris et al. 2017a).

Harpullia is part of another early branching lineage, the Dodonaeoideae. The genus is nested among Australasian taxa (Buerki et al. 2011) and has most extant species occurring in Australia and New Guinea. The only two widespread Indo-Malesian species form a clade nested among the Australasian species (Buerki et al. 2012), so we infer an Australian origin of the genus.

All remaining taxa in our dataset belong to subfamily Sapindoideae. *Dimocarpus*, *Lepisanthes*, *Litchi*, *Nephelium*, *Pometia*, and *Xerospermum* are part of a clade that originated in Southeast Asia in the Eocene and diversified and spread to different areas since then. The mentioned genera started to diversify in the late Oligocene to early Miocene and partly expanded their ranges to Eastern Malesia and further East (Buerki et al. 2011).

Another group of genera (*Arytera*, *Guioa*, and *Mischocarpus*) are part of a recent radiation starting in the Early Miocene from Australasia (Buerki et al. 2011). Although the Philippine endemic *Gloeocarpus patentivalvis* has not been sampled for phylogenetic studies so far, its morphology suggests a placement within this group (van Welzen 1991). It is therefore assumed to have an Australian origin as well.

241 Rutaceae (mixed)

Achronychia, and *Melicope* form part of the *Acronychia-Melicope* clade of Rutaceae which has its origin in Australasia (Appelhans et al. 2014). *Acronychia* was inferred to have its geographic origin in Australia, from where five of its species colonised Malesia (Holzmeyer et al. 2015), probably in the late Miocene to Pliocene (Appelhans et al. 2012). The species of *Melicope* in our dataset belong to the sections *Lepta* and *Pelea* (Hartley 2000), corresponding to the sister clade of *Acronychia* which has its origin in Australasia and started to diversify in the late Miocene as well (Appelhans et al. 2014). *Tetractomia* is sister to the *Acronychia-Melicope* clade and together they are nested among Australasian taxa (Appelhans et al., 2014). Hence, *Tetractomia,* which is widespread in Malesia today, also has an Australian origin.

Tetradium diverged from its closest relative, the East Asian *Phellodendron*, in the Paleocene and started to diversify ca 20 Ma in continental Asia (Appelhans et al. 2018). Most species of *Tetradium* still occur in that region; only three species have reached Sundaland and one Sulawesi (Hartley 1981).

242 Simaroubaceae (Asian)

Ailanthus started to diversify in the Oligocene of Asia (including Southeast Asia) and colonised Malesia from there in the Early to Mid-Miocene (Clayton et al. 2009). *Eurycoma* split from its sister, *Odyendea* from tropical Africa in the Early Miocene and only diversified in the Pliocene of Sundaland (Clayton et al. 2009). Since all tree-genera of Simaroubaceae occurring in Malesia were inferred to have originated in Asia by the phylogeographic study of Clayton et al. (2009), we also scored one genus indet as Asian.

243 Meliaceae (Asian)

Meliaceae originated in Africa in the Upper Cretaceous (Muellner-Riehl et al. 2016) and soon spread to Laurasia where they were present and widespread during the Eocene (Muellner et al. 2006).

Toona and its sister genus *Cedrela* were present and widespread in Laurasian boreotropical forest of the Eocene and presumably moved to lower latitudes due to climatic cooling in the Oligocene (Muellner et al. 2006). While *Cedrela* became confined to the Americas, *Toona* established in Asia including Sundaland and later, in the Early Miocene, crossed Wallace’s line spreading to New Guinea and Australia (Koecke et al. 2013).

Also in the Mid-Eocene (ca 45 Ma), *Sandoricum* split from the African and Malagasy clade *Ekebergia + Quivisianthe* (Muellner-Riehl et al. 2016) presumably from a Laurasian ancestor. *Sandoricum* diversified in the Miocene (Koenen 2011) and is now strongly centred in Sundaland with only one species widespread in Malesia.

The clade containing *Aglaia*, *Dysoxylum*, *Chisocheton*, and *Cabralea* separated from its sister clade containing mostly Neotropical and African species in the Mid Oligocene and started to diversify shortly afterwards, most likely in Sundaland and/or mainland Southeast Asia (Koenen et al. 2015). *Aglaia*, including the nested *Reinwardtiodendron*, originated in Sundaland and started to diversify at the Oligocene-Miocene boundary. The genus repeatedly dispersed into and through Malesia starting from the Mid-Miocene (ca 14 Ma; Grudinski et al. 2014). *Aphanamixis* is sister to Aglaia and originated in Sundaland as well, with subsequent diversification and expansion into eastern Malesia from the late Miocene onwards (Grudinski et al. 2014). The genera *Dysoxylum*, *Chisocheton*, and the Neotrpical *Cabralea* form a grade basal to *Aglaia*. *Dysoxylum* is strongly polyphyletic, with species of the genus spread over at least four clades (Koenen 2011, Koenen et al. 2015). The monophyletic *Chisocheton* is nested within one of these clades.

Since all relevant lineages of Meliaceae have a Laurasian origin and are inferred to have colonised Malesia from Asia (Muellner et al. 2006, Koenen 2011, Koecke et al. 2013, Grudinski et al. 2014, Muellner-Riehl et al. 2016), we also score the Meliaceae records with uncertain generic identity as Asian.

247 Malvaceae (Asian)

Malvaceae have an extensive fossil record in Laurasia from the Cretaceous throughout the Cenozoic (Xie et al. 2014) pointing to a presence in Laurasian boreotropic forest during the Eocene, when all major clades had already evolved (Richardson et al. 2015).

The Sterculioideae evolved in Africa or Asia in the Mid Eocene (ca 40 Ma) and diversified mostly in Asia where the major lineages were present by the Mid-Oligocene (Carter 2011). The genera of our dataset belong to three clades: The *Cola* clade (*Firmiana*, *Pterocymbium*, *Scaphium*), *Sterculia* clade (*Sterculia*), and *Heritiera* clade (*Heritiera*). The exact relationships between these clades are not clear, but all originated in Asia and diversified from the Miocene onwards (Carter 2011, Richardson et al. 2015).

Helicteroideae originated in the Mid Eocene and started do diversify in the Mid-Oligocene, splitting into a clade of mainland Asian taxa and a mostly Malesian clade. The latter diversified in Sundaland – where most species occur today – since the Mid-Miocene (Richardson et al. 2015) and contains the genera *Coelostegia*, *Durio*, and *Neesia* of our dataset.

Brownlowioideae separated from the mostly Laurasian subfamilies Tilioideae and Dombeyoideae in the late Eocene (Richardson et al. 2015), presumably from an ancestor which also occurred in Laurasia. Most species of the subfamily now occur in tropical Asia, especially in

Sundaland. *Diplodiscus* and *Pentace* from our dataset are both strongly centred in Sundaland as well (Bayer and Kubitzki 2003). The latter and another Sunda-centred genus, *Brownlowia*, split only in the Pliocene (Richardson et al. 2015).

Grewioideae also originated in the late Eocene and the *Grewia* clade containing our genera, *Grewia*, and *Microcos* started to diversify in the Mid-Oligocene (Richardson et al. 2015). The paleotropical *Microcos* and *Colona* split from Neotropical ancestors at some point during the Miocene or Pliocene, suggesting recent transoceanic LDD (Brunken and Muellner 2012, Richardson et al. 2015). The current diversity centres in Sundaland and absence from Australia of both genera (Bayer and Kubitzki 2003) point to an initial colonization of Sundaland and later spread into Malesia from there. The pantropical *Grewia* is sister to the tropical African genus *Desplatsia*, indicating an African origin of *Grewia* in the Miocene and later dispersal to Asia and into Malesia (Richardson et al. 2015).

Pterospermum split from other genera occurring in Asia and the western Indian Ocean in the Miocene (Richardson et al. 2015). Together with the genus' extant distribution from India and China to Central Malesia (Bayer and Kubitzki 2003) this suggests recent diversification in Asia and dispersal into Malesia from there.

249 Thymelaeaceae (Asian)

Thymelaeaceae originated in the Eocene, but the area of origin is not known. The earliest diverging clade contains the monotypic *Synandrodaphne* from Africa and Octolepidoideae (Gonystyloideae) with one subclade in Africa and Madagascar as well. The remainder of Octolepidoideae is distributed in Malesia, northern Australia, and the western Pacific Ocean with centres of diversity in Sundaland and New Caledonia (Herber 2003) and split from the African species in the Mid-Miocene (Motsi 2009). The presence of fossils of the Octolepioideae in Eocene India and Oligocene to Miocene of Borneo (Herber 2003) indicates that this clade has its origin in tropical Asia. It diversified in the Mid-Miocene, apparently reaching Africa via LDD first and later (ca 8 Ma) spreading from Sundaland eastwards with a secondary radiation in New Caledonia (Motsi 2009).

Subfamily Aquilarioideae split from Thymelaeoideae in the Eocene (ca 40 Ma). It contains two genera, *Aquilaria* and *Gyrinops*, started to diversify only in the Miocene, and now together encompass ca 25 species distributed from India to New Guinea with most species in Malesia (Motsi 2009). *Aquilaria* and *Gyrinops* are mutually paraphyletic, but the combined lineage has early diverging clades in India and Sundaland with Eastern Malesian members generally nested between more western congeners (Eurlings and Gravendeel 2005), which indicates recent colonisation of Malesia from Southeast Asia.

Thymelaeoideae contain the bulk of the family's species. They started to diversify in the Early Oligocene*.* *Wikstroemia*, widespread from Asia to Hawaii, belongs to a fundamentally Eurasian clade (Herber 2003) and split from other Eurasian genera in the Mid-Miocene (Motsi 2009).

Since all tree-genera of Thymelaeaceae which occur in the Philippines have Asian origins (Herber 2003, Eurlings and Gravendeel 2005, Motsi 2009), we also scored to genus indets from the Philippines as Asian.

253 Dipterocarpaceae (Asian)

Dipterocarpaceae started to diversify in the Paleocene (Heckenhauer et al. 2017). Fossils of the family from the Eocene have been found in India (Dutta et al. 2011, 20) and South China (Feng et al. 2013). Later, in the Oligocene, they also appear in Sundaland, where the overwhelming diversity of extant species occurs. The family is much less diverse east of Wallace's line (Ashton 2003a) and the species there belong to several lineages which all evolved in the Neogene and are nested among clades from mainland Asia and/or Sundaland (Heckenhauer et al. 2017).

273 'Olacaceae' (Asian)

'Olacaceae' as defined by APG IV are a paraphyletic grade at the base of the order Santalales (The Angiosperm Phylogeny Group 2016). They contain three families with species from our dataset (Nickrent et al. 2010), all rather old with origins dating back to the Cretaceous (Vidal-Russell and Nickrent 2008):

Strombosiaceae arose in the Early Cretaceous (ca 105 Ma; Vidal-Russell and Nickrent 2008) and are likely sister to all other Santalales. The small family is pantropical and the earliest diverging clade, monotypic *Scorodocarpus*, is distributed in Sundaland. The rest of the family is composed of *Strombosia*, which contains species from tropical Africa, India, and Sundaland plus an African clade including the nested Neotropical *Tetrastylidium* (Nickrent et al. 2010, Su et al. 2015). Due to the basal position of Sundaland taxa in the family and because none of the clades occurs east of Wallace's line, we assume an Asian origin of *Strombosia* and *Scorodocarpus*.

Aptandraceae originated in the early Cretaceous and started to split into two clades in the Late Cretaceous (ca 82 Ma; Vidal-Russell and Nickrent 2008). One of these clades, the *Anacoloseae*, later split into the South American genus *Cathedra* and a Paleotropical group: *Phanerodiscus* from Madagascar and *Anacolosa*, widely distributed from Africa and Madagascar to Australia and the Pacific Ocean. Most species of *Anacolosa* today occur in continental Southeast Asia, but there are also a number of species in East Malesia and the Western Pacific Ocean (Sleumer 1980). Given the present distribution of the genus, its close relationship to *Phanerodiscus* and the extensive fossil record of Anacoloseae throughout the Tertiary in Laurasia (Malécot and Lobreau-Callen 2005), we assume an Asian origin of *Anacolosa*.

Coulaceae originated in the early Cretaceous (ca 104 Ma; Magallón et al. 2015) and consist of three monotypic genera. *Minquartia* from the Neotropics is sister to the tropical African *Coula* and the Sundaland endemic *Ochanostachys* (Nickrent et al. 2010). The timing of diversification in the family is not known, but the absence of the family from Australasia and the distribution of *Ochanostachys* suggests that the latter originated in Asia.

276 'Santalaceae' (mixed)

Santalaceae, as currently circumscribed are a paraphyletic assemblage including Balanophoraceae (The Angiosperm Phylogeny Group 2016).

Dendrotrophe belongs to the Amphorogynaceae, a family that originated in the late Cretaceous (ca 73 Ma) and started to diversify in the early Eocene (ca 42 Ma; Vidal-Russell and Nickrent 2008). The origin of Amphorogynaceae must be Australasian, since the early diverging lineages of the family have extant members in New Caledonia and Australia, whereas the Malesian genera, including *Dendrotrophe*, belong to one nested clade (Su et al. 2015) which diversified only in the Neogene (Vidal-Russell and Nickrent 2008).

Cervantesiaceae originated in the late Cretaceous (ca 79 Ma) as it split from Thesiaceae (Vidal-Russell and Nickrent 2008). The topology of the family tree, with the South American *Cervantesia*-clade sister to the mainly Paleotropic *Pyrularia*-clade and nested position of the Indo-Malesian *Scleropyrum* within African taxa (Su et al. 2015) suggests that the family originated in Laurasia and split apart because of climate-induced southward.

308 Nyctaginaceae (Australian)

The pantropical genus *Pisonia* originated in the Neotropics, as indicated by its position among the Neotropical genera *Pisoniella*, *Neea*, and *Guapira* (Douglas and Spellenberg 2010). Apparently, the other three genera are nested within a paraphyletic *Pisonia* and the whole clade (Pisonieae) is quite young, having diversified in the Neogene only with several LDD events from the Americas to the Indo-Pacific (Hayward and Horton 2014). Species sampling has been too sparse so far to infer the exact timing and patterns of the genus' biogeographical history. Nevertheless, the relative paucity of species in the Indian Ocean and hence Africa/Asia as compared to the richness in the Pacific Ocean (Stemmerik 1964) indicates predominant dispersal from the Neotropics to the Pacific Ocean and from there into Malesia.

318 Nyssaceae (Asian)

Mastixia split from the small East and Southeast Asian genus *Diplopanax* in the Late Cretaceous to Paleocene and started to diversify in the Late Eocene of Eurasia (Xiang et al. 2011) as indicated by a rich fossil record (Matthew 1976). Today the genus has an Indo-Malesian distribution with most species occurring in Sundaland (Matthew 1976).

320 Hydrangeaceae (Asian)

Dichroa forms a clade with mostly Asian species within the large, overwhelmingly Asian clade *Hydrangea* II of the paraphyletic genus *Hydrangea* (Samain et al. 2010). The clade containing *Dichroa* split from its Asian ancestors in the Miocene (Xiang et al. 2011) and most extant species occur in China, Southeast Asia, and Sundaland (Hufford 2004).

324 Cornaceae (Asian)

Alangium originated in the Late Cretaceous of East to Southeast Asia. The species in our dataset belong to sections *Conostigma*, *Alangium*, and/or *Marlea*, all of which have their origins in Southeast Asia with only recent, if any, dispersal to Central and East Malesia in the Neogene (Feng et al. 2009).

330 Lecythidaceae (Asian)

Lecythidaceae originated in the Cretaceous (ca 100 Ma; Magallón et al. 2015) and started to diversify in the Mid-Eocene (ca 47 Ma; Bell et al. 2010), presumably in Africa, as indicated by the two early-diverging lineages Napoleonaeoideae and Scytopetaloideae which both exclusively or overwhelmingly occur on that continent today (Mori et al. 2007). *Barringtonia* is nested in clades from Africa (*Foetidia*, *Petersianthus*) and Indo-Malesia (*Chydenanthus*, *Petersianthus*) but the timing of that divergence is not known (Mori et al. 2007). *Barringtonia* itself is fundamentally a Malesian genus with centres of diversity in Sundaland and New Guinea, although a few widespread species reach from Madagascar to the Pacific Ocean (Payens 1967). Given the nested position among African and Asian genera, the primary centre of diversity in Sundaland, and the presence of Eocene macrofossils from India, we conclude that the genus has an Asian rather than Australian origin. The relatively high diversity in East Malesia and the Western Pacific is probably due to recent speciation (Payens 1967).

Only three genera (*Barringtonia*, *Chydenanthus*, and *Planchonia*) of Lecythidaceae, all of subfamily Barringtonioideae occur in Borneo. The discussion for *Barringtonia* (see above) applies also to the subfamily. We therefore scored one genus indet from Borneo as Asian as well.

332 Pentaphylacaceae (Asian)

The genera in our dataset (*Ternstroemia*, *Eurya*, and *Adinandra*) belong to three different clades in the family but have in common that they occur – often with many members – in East and Southeast Asia and/or have close relatives there and have started to diversify in the Miocene (Su et al. 2011, Tsou et al. 2016).

Ternstroemia is a pantropical genus most diverse in the Neotropics and Malesia (Weitzman et al. 2004). While no Neotropical species have been included in phylogenetic studies of the family, the Asian and Malesian species are nested among *Anneslea* and *Sladenia*, both from China and Southeast Asia, and started to diversify in the Early Miocene (Su et al. 2011, Tsou et al. 2016).

The closest relative of *Eurya* is the Neotropical *Freziera*. Together, they diverged from another pair with an amphipacific distribution, monotypic *Euryodendron* from China and *Symplococarpon* from the Neotropics in the Early Miocene (Su et al. 2011, Tsou et al. 2016). Disjunctions between temperate East Asia and North America have been found in many families and have been attributed to the split up of arcto-Tertiary forests due to climatic cooling in the Mid-Miocene. Pentaphylacaceae today are most species rich in subtropical areas of East Asia as well as in tropical mountains, so their ecological niche and timing match the disjunction with subsequent southward movement of Eurya into East Asia, where the genus is by far most species-rich today. The dispersal to Malesia – mostly to mountainous areas – occurred then in the course of the diversification of the genus.

Adinandra and *Cleyera* are probably both not monophyletic; together they form a monophyletic lineage sister to the clade mentioned in the preceding paragraph (Tsou et al. 2016). They are distributed from China and India to Malesia and in the Neotropics; most species occur in Sundaland and the diversity sharply declines towards the east with no species in Australia (Kobuski 1947). The diversity pattern suggests an evolutionary origin in arcto-Tertiary forests (see above) with subsequent southward movement in the Miocene (Su et al. 2011), eventually reaching Sundaland, where the genus diversified and then moved further into Central and East Malesia.

333 Sapotaceae (mixed)

Sapotaceae probably originated in Asia as indicated by the two fundamentally Indo-Chinese genera *Sarcosperma* and *Eberhardtia*, which successively split from the rest of the family in the Cretaceous (Richardson et al. 2014). *Sarcosperma paniculatum* is the only member of the genus occurring on both sides of Wallace's line while the remaining ten species are distributed in India, China, and Sundaland (WCSP 2019).

Madhuca, *Palaquium*, and *Payena* belong to a clade of subfamily Sapotoideae, which originated in Sundaland at the Eocene-Oligocene boundary. The genera have diversified during the Neogene in Sundaland with some species dispersing to Papuasia and – in the case of *Palaquium* – undergoing extensive radiation there (Richardson et al. 2014).

In subfamily Chrysophylloideae, *Pleioluma* and *Planchonella* belong to a clade which started to diversify with the split of *Pleioluma* from the rest during the Early Eocene (ca 50 Ma) in the then isolated Australia. The extant members of *Pleioluma* diversified much later, in the Mid-Miocene of New Guinea and/or Australia and from there dispersed to New Caledonia and westward. However, only the two species from our dataset crossed Wallace's line (Swenson et al. 2014). *Planchonella*, including several formerly segregated genera, is much older (Late Eocene). It also originated in Australia and repeatedly spread to New Caledonia and the Western Pacific Ocean. The few species disjunctions between Papuasian and Sundaland-species occurred since the Mid-Miocene, indicating recent dispersal from east to west(Swenson et al. 2014).

Donella, also of subfamily Chrysophylloideae, has a different biogeographic history: The genus split from the monotypic African *Breviea* in the Paleocene and is confined to Africa and Madagascar except for the species in our dataset, *Donella lanceolata*. *D. lanceolata* has a wide Indo-Pacific distribution and diverged from its Madagascan congeners in the Late Miocene (<10 Ma), indicating recent long-distance dispersal from Madagascar to West Malesia and further east from there (Bartish et al. 2011).

334 Ebenaceae (Asian)

Diospyros likely originated in Africa / Eurasia in the Mid-Eocene (41 Ma; Turner et al. 2013). In the Late Eocene one clade reached Australia, while the rest of the genus continued to strive in Africa and Eurasia with later occasional vicariance or dispersal events to other areas. All species occurring in Malesia belong to clades that originated in Eurasia and mostly diversified since the late Oligocene, so the genus probably colonised Malesia from Asia (Duangjai et al. 2009, Turner et al. 2013).

335 Primulaceae (mixed)

The genera in our dataset (*Ardisia*, *Embelia*, and *Myrsine*) all belong to the tropical woody clade sister to the north-temperate Lysimachieae and traditionally circumscribed as Myrsinaceae. The tropical woody clade split from its herbaceous relatives in the Early Oligocene (ca 30 Ma; Yesson et al. 2009), but its internal structure is poorly known due to insufficient taxon sampling in published phylogenies. *Ardisia* is distributed worldwide in the tropics, but best represented in Mesoamerica and Malesia, especially Sundaland (Stone 1989, Ricketson and Pipoly 2003). The genus belongs to a clade which – apart from the pantropical *Ardisia* – is restricted to Indo-Malesia and the Pacific Ocean and split from its Neotropical sister clade, including *Parathesis*, *Stylogyne* and *Geissanthus*, in the Early Miocene (14–17 Ma; Yesson et al. 2009, Strijk et al. 2014) indicating a boreotropical origin. Ardisia has not been sampled sufficiently in phylogenies to infer its phylogeography, but the patterns of species richness of the genus suggest an origin in Asia and/or North America and subsequent southward migration and extensive speciation in Sundaland during the Neogene. The genus is furthermore species-poor in Australia (6 species; Jackes 2009), so we assume an Asian origin.

Embelia and *Myrsine*, together with the paleotropical mangrove genus *Aegiceras* and the Neotropical *Cybianthus*, form another poorly resolved clade within the tropical woody Primulaceae-Myrsinoideae (Yesson et al. 2009, Chen et al. 2016). The clade originated in the Early to Mid-Miocene (15–22 Ma), but it is not known whether the New Zealand endemic *Elingamita*, or the two clades mentioned in the preceding paragraph are its sister group (Yesson et al. 2009, Strijk et al. 2014). *Embelia* is widely distributed from Africa and Madagascar through tropical Asia and Malesia to the Pacific Ocean (Ståhl and Anderberg 2004), but has its center of diversity in Southeast Asia and West Malesia, so we place it as an Asian genus.

Myrsine, on the other hand, has a pantropical distribution with most species occurring in the Pacific Ocean and surrounding areas like Australia, New Guinea, the Philippines, the Andes, and Mesoamerica, while Sundaland and continental Asia harbour relatively few species (Ståhl and Anderberg 2004). The genus has probably only diversified within the last 10 My (Strijk et al. 2014) and we propose an Eastern (Papuasian) origin for the Malesian species based on the distribution pattern.

336 Theaceae (Asian)

Theaceae likely originated in Laurasia in the Late Cretaceous and started to diversify in the Mid-Eocene of the same area. *Schima* is nested in the North American genera *Franklinia* and *Gordonia* and its ancestors probably moved to East Asia via the Bering land bridge in the Late Miocene (Li et al. 2013). Today, most species of *Schima* occur in China and Southeast Asia (Stevens et al. 2004a) and the genus colonised Malesia from there.

The remaining genera in our dataset belong to Tribe Theeae, where *Polyspora* diverged from the remaining lineages in the late Oligocene of Asia (Li et al. 2013) and started to diversify only in the last 10 My (Zhang et al. 2014) with some clades spreading into Malesia, where it shows the highest diversity in Sundaland today (Keng 1984). *Pyrenaria* is nested in the paraphyletic *Camellia*, the lineage started to diversify at the beginning of the Neogene in Asia and spread from there (Li et al. 2013, Zhang et al. 2014).

337 Symplocaceae (Asian)

Symplocos originated in Eurasia ca 52 Ma, from where they dispersed to the Americas, and later moved to lower latitudes on both continents due to climatic cooling since the Oligocene, thus colonising South America and Malesia (Fritsch et al. 2015).

339 Styracaceae (Asian)

Styracaceae originated in Eurasia and formed part of the boreotropical flora before becoming disjunct on both sides of the Pacific Ocean due to climatic deterioration. Both *Styrax* and *Bruinsmia* therefore have Asian origin (Fritsch et al. 2001).

342 Actinidiaceae (Asian)

Actinidiaceae is composed of only three genera, two of which are confined to Asia and most species-rich in China, and the amphipacific *Saurauia*, which is present in our data (Dressler and Bayer 2004). The distribution pattern of *Saurauia* in the Neotropics and Tropical Asia (India and China to Fiji), together with the presence of *Saurauia* fossils from the Tertiary in Europe has been attributed to a former boreotropical distribution and later southward migration due to climatic cooling in the Oligocene (Soejarto 1980), an interpretation we follow here.

343 Clethraceae (Asian)

Most species of *Clethra* belong to a recently evolved Neotropical clade, which is sister to the remainder of the species (Fior et al. 2003). The latter are distributed in Macaronesia (*C. arborea*), North America (two species) and Asia including Malesia (Dressler and Bayer 2004). More specifically, the Malesian species of *Clethra*, including the species in our dataset, are sister to a clade of mainly East Asian (plus *C. acuminata* from North America) species (Fior et al. 2003). Although divergence times have not been assessed for the genus, the phylogenetic topology strongly suggests a former boreotropical distribution and recent colonization of Malesia after the ancestors of extant species had moved towards the equator in the course of Mid-Tertiary climatic cooling.

345 Ericaceae (Asian)

Our dataset only contains one indeterminate record of *Rhododendron* from Mount Banahaw in Luzon. It most likely belongs to section *Vireya*, since all species of *Rhododendron* occurring in the Philippines, with the exception of two species from extreme northern Luzon belong to that section (Sleumer 1966). *Vireya* rhododendrons originated in Asia and later moved into Sundaland, from where since the Late Eocene (ca 40 Ma) they repeatedly crossed Wallace's line, and once also Lydekker's line to New Guinea (Landis et al. 2013). However, there seem to have been no back-dispersals, so we score *Rhododendron* as an Asian genus (although *Rhododendron* apparently belongs to the few taxa that started to disperse from Asia to Australasia before the onset of the Malesian floristic exchange).

Diplycosia, a fundamentally Malesian genus with two outlying species in Assam and SE Asia, is sister to *Gaultheria* series *Gymnobotrys*, a clade which is distributed from the Himalayas to New Guinea. Together, these two are sister to *G.* series *Hispidula* from the East Asia and North America (Fritsch et al. 2011). The topology is thus consistent with a scenario of colonisation of Malesia from Asian ancestors.

Malesian species of *Vaccinium*, although sparsely sampled so far, are apparently sister to the *Agapetes*-clade from continental Asia, and these two are nested among Asian and American taxa (Powell and Kron 2002), so we assume an Asian origin.

349 Metteniusaceae (Asian)

Metteniusaceae are a mostly Neotropical family, with only four genera occurring in the Old World tropics (Potgieter and Duno 2016, Stevens 2017). *Platea*, from our dataset, and the Neotropical *Calatola* are together sister to the remaining Metteniusaceae, which then split into a clade of *Apodytes* from the Paleotropics, *Raphiostylis* from Africa, and *Dendrobangia* from the Neotropics and another clade with mostly Neotropical genera plus the Southeast Asian *Pittosporopsis* (Stull et al. 2015). The Malesian members of the family are thus not closely related, but their placement in the phylogeny suggests a Tertiary boreotropical distribution of the family with later movement to areas near the equator. The presence of *Platea* in Laurasia is also indicated by pollen records from the Paleocene in North America (Manchester et al. 2015).

352 Rubiaceae (mixed)

The ancestor of subfamilies Ixoroideae and Cinchonoideae originated in the Neotropics during the late Cretaceous (Manns et al. 2012). Cinchonoideae today are predominantly Neotropical, but there have been several dispersal events to the Old World in different periods: One clade (tribes Naucleeae and Hymanodictyeae) dispersed to the Old World at the latest in the Eocene, where it had a wide distribution in boreotropical forests. As the boreotropical forest belt disintegrated due to climatic cooling in the Late Eocene to Oligocene, members of Naucleeae (*Nauclea*, *Adina*, and *Neonauclea* in our data) moved south to tropical areas of Asia (Manns et al. 2012). There, the lineages diversified in the Miocene, giving rise among others to the subtribe Naucleinae (*Nauclea* from our data) which later dispersed to Africa and into Malesia and to the

Adidinae (*Adina* and *Neonauclea* in our dataset) which also spread into Malesia (Löfstrand et al. 2014).

Guettardeae, on the other hand, remained in the Neotropics, from where in the Miocene several lineages, among them *Timonius* from our dataset, dispersed westward over the Pacific Ocean to Australia, Malesia and the Indian Ocean (Manns and Bremer 2010, Manns et al. 2012). *Timonius* thus has a different biogeographic history and entered Malesia from the east

In subfamily Ixoroideae, Augusteae diverged from the remainder of the Coffeeae alliance (except the earlier-diverging Airospermeae) during the Oligocene and split into the two genera *Augusta* (two species in Melanesia, two in the Neotropics) and *Wendlandia* (Kainulainen et al. 2017). *Wendlandia* is widely distributed in the Paleotropics from Ethiopia to Australia and most of its species occur in China and continental Southeast Asia, while there are only three species in New Guinea, five in Australia, and none in the Pacific (WCSP 2019). In addition, species occurring in Malesia appear nested between those from continental Asia (Kainulainen et al. 2013), so we assume a Miocene colonisation of Malesia from Southeast Asia.

The remaining genera of our dataset in the Coffeeae alliance belong to different tribes but their ancestors all diversified in Southeast Asia during the Late Miocene to Pliocene after having diverged from African ancestors in the (Mid- to) Late Miocene (Kainulainen et al. 2017). They are *Discospermum* and *Diplospora* in Coffeeae, *Hypobathrum* in Octotropidae, *Tarenna* in Pavetteae, and *Aidia*, *Gardenia*, *Porderandia*, *Randia*, and *Rothmannia* in Gardenieae. The species from Borneo and the Philippines originally determined as *Randia* are also placed here. Asian and Malesian members of '*Randia*' have been transferred to a number of other genera, which, however, all fall into the Coffeeae alliance.

Generic limits in Vanguerieae have been in constant flux over the last decades, with a major trend being the disintegration of large, paraphyletic *Canthium*, and placement of Malesian members of Vanguerieae in *Canthium* subgenus *Canthium* (including Meyna), *Psydrax*, *Cyclophyllum* and *Pyrostria* (WCSP 2019). Specifically, the Bornean specimens originally determined as *Canthium* sp. could belong to *Psydrax* (Bridson 1985), *Cyclophyllum* (Bridson 1987, Razafimandimbison et al. 2009), or *Pyrostria* (Alejandro et al. 2014). *Psydrax* and the dioecious group of Vanguerieae (including *Cyclophyllum* and *Pyrostria*) diverged from an African clade (*Keetia* and *Afrocanthium*) in the Mid- to Late Miocene, and have a mainly African and Malagasy distribution. The Asian taxa all appear in derived positions, indicating recent (Late Miocene or later) dispersal from Africa to Asia and Malesia with subsequent diversification (Verstraete et al. 2017).

Lasiantheae originated in the Neotropics and reached Eurasia by boreotropical migration or transatlantic long-distance dispersal in the Eocene. After the split-off of African and Neotropical species, *Lasianthus* quickly diversified in tropical Asia from the beginning of the Neogene (Smedmark et al. 2014). Likewise, *Urophyllum* split from its African sister group in the early Oligocene, as the Eurasian boreotropical forest belt broke up into an African and East Asian portion. In the early Miocene, the genus diversified and spread into Malesia (Smedmark et al. 2010).

The *Psychotria* species from our dataset belong to the Afro-Asian-WIOR Psychotria lineage, which originated in Africa in the Early Miocene. It is not clear, whether there were two independent colonisations of Asia from Africa in this clade, or only one with later back-dispersal to Africa. Regardless, the ancestral lineage of our *Psychotria* species reached tropical Asia from Africa in the Mid-Miocene and further diversified from there (Razafimandimbison et al. 2017).

353 Gentianaceae (Asian)

The genera in our dataset all belong to a clade (*Fagraea* s.l.) which diverged from its closest relatives, Neotropical *Potalia* and African-Malagasy *Anthocleista* in the Early Miocene and started to diversify in the Mid-Miocene (ca 10 Ma; Merckx et al. 2013). A former boreotropical connection between the genera has been suggested, but long-distance dispersal is also an option (Frasier 2008). In any case, the clade is most species rich in Sundaland and all species occurring east of Wallace’s line are nested among congeners from further west (Sugumaran and Wong 2012), indicating recent colonisation of Malesia from Southeast Asia.

354 Loganiaceae (mixed)

Geniostoma diverged ca 20 Ma from its sister clade, comprising the Australian *Orianthera* and cosmopolitan *Mitreola* (Foster et al. 2014). *Geniostoma* apparently underwent a rapid radiation in the Pacific Ocean, especially in New Caledonia and Melanesia in the last 10 My (Foster et al. 2014) and one species spread further westward into Malesia (Conn 1980).

Norrisia belongs to Antonieae, a small pantropical tribe of four genera that split from the rest of Loganiaceae >40 Ma (Frasier 2008, Foster et al. 2014). The other genera of Antonieae occur in the Neotropics (*Antonia*, *Bonyunia*) and tropical Africa (Tropicos 2015). Relationships within the tribe are not entirely clear, but one or both of the Old World genera (*Norrisia*, *Usteria*) are sister to the Neotropical members (Frasier 2008, Yang et al. 2016). Although there are no age estimates for the internal phylogeny of Antonieae, the distribution pattern suggests a former boreotropical distribution of the clade. Furthermore, *Norrisia* only occurs in Sundaland and the Philippines, so it is reasonable to assume an Asian origin of the genus.

356 Apocynaceae (mixed)

Alstonia and *Dyera* together form the tribe Alstonieae, after the Neotropical Aspidospermateae sister to all remaining Apocynaceae (Simões et al. 2007). *Dyera* is restricted to Sundaland, while *Alstonia* has a wide paleotropical distribution from tropical Africa to the Pacific, with centres of diversity in continental Southeast Asia and Sundaland and on New Caledonia (WCSP 2019). Based on the sister relationship with *Dyera* from Sundaland and the geographic diversity pattern of *Alstonia*, we assume an Asian origin of both genera.

Ochrosia split from the remainder of tribe Vinceae (except *Kopsia*) in the Late Eocene, ca 37 Ma, and started to diversify in the Late Oligocene (ca 25 Ma; Morokawa 2014). The genus is most species rich in Papuasia and the tropical West Pacific, has no endemic species in continental Asia or Sundaland (WCSP 2019), and the species occurring in other regions are nested among those from Papuasia and the West Pacific (Morokawa 2014), clearly indicating an Australasian origin of *Ochrosia*.

Tabernaemontana is a large, pantropical genus that diverged from its mostly African sister clade in the Mid Oligocene (ca 26 Ma) and started to diversify shortly afterwards (Early Miocene, 22 Ma; Morokawa 2014). First, the genus split into a Neotropical and a Paleotropical clade. From the latter, the Malagasy members separated ca 14 Ma followed by a divergence of African and Asian populations (ca 13 Ma). The topology and divergence times suggest an Asian origin of Paleotropical *Tabernaemontana* or an African origin and later dispersal to Malesia via Asia. They rule out an Australian origin and the latter is also unlikely because only one widely distributed member of the genus occurs in Australia (WCSP 2019).

Kibatalia belongs to the pantropical tribe Malouetieae and its successive sister groups are African *Funtumia* and *Malouetia* from tropical Africa and tropical South America (Livshultz et al. 2007). The genus itself is distributed from continental Southeast Asia to Sulawesi and most species occur in Sundaland and the Philippines (WCSP 2019). Since the whole tribe includes no Australian taxa and because of *Kibatalia's* distribution pattern, we assume an Asian origin.

357 Boraginaceae (Ehretiaceae, Asian)

Ehretia javanica, the only Malesian member of the otherwise Asian *Ehretia* III–clade of was inferred to have colonised Malesia from Asia (Gottschling and Hilger 2004).

366 Oleaceae (Asian)

Most species of *Ligustrum* occur in Asia, with only seven spreading into Malesia and one barely reaching North Australia (WCSP 2019). The genus is nested within *Syringa* (Li et al. 2002) and diverged from East Asian lineages of *Syringa* in the middle Miocene, ca 12 Ma (Li et al. 2012).

Neither *Chionanthus* nor *Olea* are monophyletic, but rather intermingled together with several other genera (e.g. *Osmanthus*, *Olea*, *Noronhia*, *Nestegis*, *Notelaea*, *Phillyraea*) in the subtribe Oleinae. The subtribe has a near worldwide distribution (WCSP 2019) but most species occur in Eurasia. The only Australian / Pacific genera, *Nestegis* and *Notelaea,* split from Eurasian sister lineages less than 15 Ma (Wallander and Albert 2000, Hong-Wa and Besnard 2013), so despite the unsettled taxonomy, species of *Chionanthus* and *Olea* are here considered to be of Asian origin. More specifically, the species of *Olea* in our dataset belong to subgen. *Tetrapilus*, a monophyletic group present in Asia to central Malesia (Green 2002) which diverged from other Eurasian taxa ca 25 Ma (Besnard et al. 2009). The Asian and Malesian members of *Chionanthus*, though sparsely sampled, were resolved as sister to a clade of North American congeners, diverging ca 25 Ma (Hong-Wa and Besnard 2013).

378 Bignoniaceae (Asian)

Radermachera belongs to the Paleotropical clade of Bignoniaceae, which diverged from the Neotropical *Tabebuia* alliance. Its closest relatives are the monotypic *Tecomella* from dry areas in India and Pakistan and then a group of African taxa from dry habitats (Olmstead et al. 2009). The genus occurs from India to Wallacea and is most species-rich in continental Southeast Asia, with only two species crossing Wallace’s line (van Steenis 1977). The phylogenetic topology suggests an origin of the clade in Asia or Africa and recent colonisation of Malesia from Southeast Asia.

383 Lamiaceae (Asian)

Callicarpa, together with the Australian endemic subfamily Prosteranthoideae forms the sister clade to all remaining Lamiaceae (Li et al. 2016). However, species from East Malesia and Australia appear in derived positions in the phylogeny of *Callicarpa* (Li et al. 2016) and the genus is most species rich in Sundaland and continental Asia with much fewer species in Papuasia and Australia (WCSP 2019), so we assume an Asian origin.

The Malesian forest species of *Clerodendrum* (subfamily Ajugoideae) belong to the ‘Asian’ clade, which is sister to the rest of the genus from tropical Africa (Yuan et al. 2010). Within the ‘Asian’ clade, most species occur in Sundaland and continental Asia with a sharp decline in species richness towards the east (WCSP 2019) and fossils of Ajugoideae have been found from the Oligocene of Europe (Harley et al. 2004), so we assume an Asian origin of *Clerodendrum*.

Teijsmanniodendron is probably nested within *Vitex* (together with the Caribbean *Petitia* and *Pseudocarpidium*), forming the pantropical subfamily Viticoideae, sister to Symphoremoideae (Li et al. 2016). *Vitex* s.l. is most species rich in tropical Africa, followed by the Neotropics and tropical Asia (WCSP 2019). Within tropical Asia, the genus is most diverse in continental Southeast Asia and Sundaland with only a few species occurring east of Wallace’s line (WCSP 2019) suggesting a boreotropical origin of the genus and colonisation of Malesia by Asian lineages.

388 Stemonuraceae (Australian)

Stemonuraceae, represented in our dataset by *Gomphandra*, *Medusanthera*, and *Stemonurus*, is of Australasian origin and diversified ca 20 Ma (Beaulieu et al. 2013). *Medusanthera* and *Stemonurus*, although not sampled by Beaulieu et al. (2013), must have arisen from Australian ancestors due to the overall young age of the family.

389 Cardiopteridaceae (Australian)

According to the phylogeographic study of Beaulieu et al. (2013), Cardiopteridaceae originated around 55 Ma in Australasia. All genera were resolved to have Australasian descent: *Citronella* diverged first, *Gonocaryum* and *Cardiopteris* split later (ca 40 Ma).

392 Aquifoliaceae (Asian)

Extant species of *Ilex* stem from a Miocene radiation starting in East Asia ca 15 Ma, and all Malesian species, as well as those occurring further east (Australia, New Caledonia), represent derived Asian lineages. *Ilex* pollen records from the Oligocene of Australia (Martin 1977) are doubtful (Manen et al. 2002).

403 Asteraceae (Asian)

Strobocalyx, together with *Tarlmounia*, probably arrived in the region via long-distance dispersal from America less than ca 15 Ma, as indicated by the pair's closest relatives, which are all American (Keeley et al. 2007). Although from the phylogeny it is not clear, where exactly it first established, we take the occurrence of the monotypic sister genus *Tarlmounia*, endemic to continental S and SE Asia, as indication that *Strobocalyx* colonised Malesia from Asia.

404 Escalloniaceae (Australian)

Polyosma, the only genus of Escalloniaceae in our data, is an old genus (ca 70 My stem age) and, as the rest of the family has an Australasian origin (Beaulieu et al. 2013).

407 Paracryphiaceae (Australian)

Paracryphiaceae, present in our dataset with *Quintinia* and *Sphenostemon,* are an old family (ca 95 My) with Australasian origin (Beaulieu et al. 2013) and a present distribution from New Caledonia and Australia to Central Malesia (Sulawesi and the Philippines). Since in Malesia it is only present in mountain habitats, and since Central and East Malesian mountains only started to form recently (≤ 10 Ma; Hall 2012), we consider this family a recent immigrant from Australia.

408 Adoxaceae (Asian)

The family is centred in Laurasia; only *Viburnum* occurs in our dataset. *Viburnum* originated in tropical lowland forests of SE-Asia in the Oligocene and the Malesian species belong to several distinct lineages (Spriggs et al. 2015).

413 Pittosporaceae (Australian)

Pittosporaceae originated in the Mid Miocene of Australasia (Beaulieu et al. 2013), and six of its nine genera are endemic to Australia today (Bakker and van Steenis 1957). Within *Pittosporum*, which is present in our data, many basal lineages are Australian indicating multiple dispersal out of Australia into the adjacent regions Indian Ocean, Malesia, and SW Pacific (Chandler et al. 2007).

414 Araliaceae (mixed)

Araliaceae originated in Australia or Southeast Asia, probably in the Mid Eocene (Beaulieu et al. 2013). The genera of our dataset belong to two different groups, all in subfamily Aralioideae:

Aralia bipinnata belongs to *Aralia* section *Dimorphanthus*, which originated in Laurasia where it was present in Early Tertiary boreotropical forests (Wen 2000). The Asian and North American members of the section split in the Late Eocene to Late Oligocene (Valcárcel et al. 2014, Zuo et al. 2017) probably due to climatic cooling and the Malesian members are derived from continental Asian lineages.

The Asian Palmatae group of Araliaceae, containing the genera *Macropanax*, *Trevesia*, and *Schefflera* (the latter wildly polyphyletic, but the Asian members belong here) from our dataset, originated in Southeast Asia in the Late Cretaceous or Paleocene (Li and Wen 2014, Valcárcel et al. 2014). Temporal estimates for the diversification of the genera vary between studies, but all retrieve Southeast Asia as area of origin and dispersal of single lineages to East Malesia since the Miocene (Li and Wen 2014, Valcárcel et al. 2014, Zuo et al. 2017).

Polyscias is a large genus, which originated in Australasia (Nicolas and Plunkett 2014). All but one of our species belong to subgenus *Arthrophyllum*, distributed from continental Southeast Asia to Australia and Caledonia. Within the subgenus, the Malesian species all appear in derived positions and the basal clades are all Australian (Plunkett and Lowry 2010), indicating that *Polyscias* subgenus *Arthrophyllum* originated in Australia. *P. nodosa*, the sole member of subgenus *Eupteron*, is distributed from Java to the Solomon Islands (Philipson 1979). It diverged from a large clade distributed from Africa to Polynesia in the late Eocene (ca 39 Ma; Plunkett and Lowry 2010, Zuo et al. 2017). Together, they are sister to subgenus *Tieghemopanax*, which is centred in Melanesia, especially New Caledonia (Plunkett and Lowry 2010). The wide distribution of the sister group of *P. nodosa* makes the biogeographic interpretation difficult, but the fact that the large sister group does not include a single species from continental Asia, as well as the nested position among Melanesian taxa points to an Australian origin of *P. nodosa*.

Appendix 5.3 Tree species with assigned geographic origin

Tree species used for the analysis with their geographic origin, applied classification methods, and references (see Appendix 5.1). distr. = geographic distribution, phyl. = phylogenetic analysis, phylogeogr. = phylogeographic analysis.

No	Family	Species	Origin	Classification method	References
Gymnosperms					
11	Gnetaceae	Gnetum cuspidatum Blume	Asian	phylogeogr.	Won et al. 2006
12		Gnetum gnemon L.	Asian	phylogeogr.	Won et al. 2006
13	Araucariaceae	Agathis borneensis Warb.	Austr.	dated phyl., distr./fossils	Escapa & Catalano 2013, Kershaw & Wagstaff 2001
14		Agathis dammara (Lamb.) Rich. & A.Rich.	Austr.	dated phyl., distr./fossils	Escapa & Catalano 2013, Kershaw & Wagstaff 2001
15		Agathis kinabaluensis de Laub.	Austr.	dated phyl., distr./fossils	Escapa & Catalano 2013, Kershaw & Wagstaff 2001
16	Podocarpaceae	Dacrycarpus cinctus (Pilg.) de Laub.	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
17		Dacrycarpus cumingii (Parl.) de Laub.	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
18		Dacrydium gibbsiae Stapf	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
19		Dacrycarpus imbricatus (Blume) de Laub.	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
20		Dacrycarpus kinabaluensis (Wasscher) de Laub.	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
21		Dacrydium pectinatum de Laub.	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
22		Falcatifolium falciforme (Parl.) de Laub.	Austr.	phylogeogr.	Biffin et al. 2011, Knopf et al. 2012
23		Phyllocladus hypophyllus Hook.f.	Austr.	phylogeogr.	Wagstaff 2004
24		Podocarpus gibbsii N.E.Gray	Austr.	phylogeogr.	Knopf et al. 2012, Quiroga et al. 2016
25		Podocarpus neriifolius D.Don	Austr.	phylogeogr.	Knopf et al. 2012, Quiroga et al. 2016
26		Podocarpus pilgeri Foxw.	Austr.	phylogeogr.	Knopf et al. 2012, Quiroga et al. 2016
27		Podocarpus ramosii R.R.Mill	Austr.	phylogeogr.	Knopf et al. 2012, Quiroga et al. 2016
28		Podocarpus rumphii Blume	Austr.	phylogeogr.	Knopf et al. 2012, Quiroga et al. 2016
29		Podocarpus sp.	Austr.	phylogeogr.	Knopf et al. 2012, Quiroga et al. 2016
30	Taxaceae	Taxus sumatrana (Miq.) de Laub.	Asian	dated phyl., distr./fossils	Farjon 2010, Leslie et al. 2012, Liu et al. 2011

No	Family	Species	Origin	Classification method	References
Angiosperms					
31	Achariaceae	Hydnocarpus borneensis Sleumer	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
32		Hydnocarpus pinguis Sleumer	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
33		Hydnocarpus sp.1	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
34		Hydnocarpus sp.2	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
35		Hydnocarpus sp.3	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
36		Hydnocarpus sumatranus (Miq.) Koord.	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
37		Hydnocarpus tenuipetalus Sleumer	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
38		Hydnocarpus woodii Merr.	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
39		Ryparosa baccaureoides Sleumer	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
40		Ryparosa caesia Blume	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
41		Ryparosa kostermansii Sleumer	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
42		Trichadenia philippinensis Merr.	Asian	undated phyl., distr./fossils	Chase et al. 2002, Sleumer 1954
43	Actinidiaceae	Saurauia bracteosa DC.	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
44		Saurauia javanica (Nees) Hoogland	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
45		Saurauia latibractea Choisy	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
46		Saurauia microphylla de Vriese	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
47		Saurauia nudiflora DC.	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
48		Saurauia pendula Blume	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
49		Saurauia polysperma (Blanco) Merr.	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
50		Saurauia sp.	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
51		Saurauia subcordata Korth.	Asian	distr./fossils	Dressler & Bayer 2004, Soejarto 1980
52	Adoxaceae	Viburnum coriaceum Blume	Asian	phylogeogr.	Spriggs et al. 2015
53		Viburnum hispidulum J.Kern	Asian	phylogeogr.	Spriggs et al. 2015

No	Family	Species	Origin	Classification method	References
54		Viburnum lutescens Blume	Asian	phylogeogr.	Spriggs et al. 2015
55		Viburnum sambucinum Blume	Asian	phylogeogr.	Spriggs et al. 2015
56	Altingiaceae	Liquidambar excelsa (Noronha) Oken	Asian	phylogeogr.	Ickert-Bond & Wen 2006
57	Anacardiaceae	Anacardiaceae sp.1	Asian	phylogeogr.	Weeks et al. 2014
58		Anacardiaceae sp.2	Asian	phylogeogr.	Weeks et al. 2014
59		Buchanania arborescens (Blume) Blume	Asian	phylogeogr.	Weeks et al. 2014
60		Buchanania insignis Blume	Asian	phylogeogr.	Weeks et al. 2014
61		Buchanania aff. sessilifolia Blume	Asian	phylogeogr.	Weeks et al. 2014
62		Dracontomelon dao (Blanco) Merr. & Rolfe	Asian	phylogeogr.	Weeks et al. 2014
63		Gluta laxiflora Ridl.	Asian	phylogeogr.	Weeks et al. 2014
64		Gluta oba (Merr.) Ding Hou	Asian	phylogeogr.	Weeks et al. 2014
65		Gluta sabahana Ding Hou	Asian	phylogeogr.	Weeks et al. 2014
66		Gluta sp.1	Asian	phylogeogr.	Weeks et al. 2014
67		Gluta sp.2	Asian	phylogeogr.	Weeks et al. 2014
68		Gluta wallichii (Hook.f.) Ding Hou	Asian	phylogeogr.	Weeks et al. 2014
69		Koordersiodendron pinnatum Merr.	Asian	phylogeogr.	Weeks et al. 2014
70		Mangifera foetida Lour.	Asian	phylogeogr.	Weeks et al. 2014
71		Mangifera laurina Blume	Asian	phylogeogr.	Weeks et al. 2014
72		Mangifera swintoniodes Kosterm.	Asian	phylogeogr.	Weeks et al. 2014
73		Melanochyla beccariana Oliv.	Asian	phylogeogr.	Weeks et al. 2014
74		Melanochyla bracteata King	Asian	phylogeogr.	Weeks et al. 2014
75		Melanochyla caesia (Blume) Ding Hou	Asian	phylogeogr.	Weeks et al. 2014
76		Melanochyla elmeri Merr.	Asian	phylogeogr.	Weeks et al. 2014
77		Parishia maingayi Hook.f.	Asian	phylogeogr.	Weeks et al. 2014
78		Semecarpus forstenii Blume	Asian	phylogeogr.	Weeks et al. 2014
79		Semecarpus glauciphylla Elmer	Asian	phylogeogr.	Weeks et al. 2014
80		Semecarpus heterophylla Blume	Asian	phylogeogr.	Weeks et al. 2014
81		Semecarpus rufovelutina Ridl.	Asian	phylogeogr.	Weeks et al. 2014
82		Semecarpus sp.1	Asian	phylogeogr.	Weeks et al. 2014
83		Semecarpus sp.2	Asian	phylogeogr.	Weeks et al. 2014

No	Family	Species	Origin	Classification method	References
84		Swintonia foxworthyi Elmer	Asian	phylogeogr.	Weeks et al. 2014
85		Swintonia glauca Engl.	Asian	phylogeogr.	Weeks et al. 2014
86		Swintonia sp.	Asian	phylogeogr.	Weeks et al. 2014
87	Anisophylleaceae	Anisophyllea sp.	Asian	phylogeogr.	Zhang et al. 2007
88	Annonaceae	Alphonsea elliptica Hook.f. & Thomson	Asian	phylogeogr.	Thomas et al. 2015
89		Alphonsea javanica Scheff.	Asian	phylogeogr.	Thomas et al. 2015
90		Cananga odorata (Lam.) Hook.f. & Thomson	Asian	phylogeogr.	Thomas et al. 2015
91		Cyathocalyx sp.	Asian	phylogeogr.	Thomas et al. 2015
92		Drepananthus hexagynus (Miq.) Survesw. & R.M.K.Saunders	Asian	phylogeogr.	Thomas et al. 2015
93		Drepananthus kingii (Boerl. ex Koord.) Survesw. & R.M.K.Saunders	Asian	phylogeogr.	Thomas et al. 2015
94		Drepananthus magnificus (Diels) Survesw. & R.M.K.Saunders	Asian	phylogeogr.	Thomas et al. 2015
95		Fissistigma manubriatum (Hook.f. & Thomson) Merr.	Asian	phylogeogr.	Thomas et al. 2015
96		Annonaceae sp.1	Asian	phylogeogr.	Thomas et al. 2015
97		Annonaceae sp.2	Asian	phylogeogr.	Thomas et al. 2015
98		Annonaceae sp.3	Asian	phylogeogr.	Thomas et al. 2015
99		Annonaceae sp.4	Asian	phylogeogr.	Thomas et al. 2015
100		Annonaceae sp.5	Asian	phylogeogr.	Thomas et al. 2015
101		Annonaceae sp.6	Asian	phylogeogr.	Thomas et al. 2015
102		Annonaceae sp.7	Asian	phylogeogr.	Thomas et al. 2015
103		Annonaceae sp.8	Asian	phylogeogr.	Thomas et al. 2015
104		Annonaceae sp.9	Asian	phylogeogr.	Thomas et al. 2015
105		Goniothalamus amuyon (Blanco) Merr.	Asian	phylogeogr.	Thomas et al. 2015
106		Goniothalamus fasciculatus Boerl.	Asian	phylogeogr.	Thomas et al. 2015
107		Goniothalamus macrophyllus (Blume) Hook.f & Thomson	Asian	phylogeogr.	Thomas et al. 2015
108		Goniothalamus ridleyi King	Asian	phylogeogr.	Thomas et al. 2015
109		Goniothalamus sp.1	Asian	phylogeogr.	Thomas et al. 2015
110		Goniothalamus sp.nov.	Asian	phylogeogr.	Thomas et al. 2015
111		Haplostichanthus lanceolata (S. Vidal) Heusden	Asian	phylogeogr.	Thomas et al. 2015

No	Family	Species	Origin	Classification method	References
112		Huberantha rumphii (Blume ex Hensch.) Chaowasku	Asian	phylogeogr.	Thomas et al. 2015
113		Maasia hypoleuca (Hook.f. & Thomson) Mols, Kessler & Rogstad	Asian	phylogeogr.	Thomas et al. 2015
114		Maasia sumatrana (Miq.) Mols, Kessler & Rogstad	Asian	phylogeogr.	Thomas et al. 2015
115		Mezzettia havilandi (Boerl.) Ridl.	Asian	phylogeogr.	Thomas et al. 2015
116		Mezzettia parviflora Becc.	Asian	phylogeogr.	Thomas et al. 2015
117		Mitrella kentii (Blume) Miq.	Asian	phylogeogr.	Thomas et al. 2015
118		Mitrephora macrocarpa (Miq.) Weerasooriya & R.M.K.Saunders	Asian	phylogeogr.	Thomas et al. 2015
119		Monocarpia kalimantanensis Kessler	Asian	phylogeogr.	Thomas et al. 2015
120		Monoon lateriflorum (Blume) Miq.	Asian	phylogeogr.	Thomas et al. 2015
121		Neo-uvaria acuminatissima (Miq.) Airy Shaw	Asian	phylogeogr.	Thomas et al. 2015
122		Orophea hexandra Blume	Asian	phylogeogr.	Thomas et al. 2015
123		Phaeanthus ophthalmicus (Roxb. ex G.Don) J.Sinclair	Asian	phylogeogr.	Thomas et al. 2015
124		Polyalthia cauliflora Hook.f. & Thomson	Asian	phylogeogr.	Thomas et al. 2015
125		Polyalthia sp.1	Asian	phylogeogr.	Thomas et al. 2015
126		Polyalthia sp.2	Asian	phylogeogr.	Thomas et al. 2015
127		Polyalthia sp.3	Asian	phylogeogr.	Thomas et al. 2015
128		Polyalthia sp.4	Asian	phylogeogr.	Thomas et al. 2015
129		Popowia pisocarpa Endl.	Asian	phylogeogr.	Thomas et al. 2015
130		Popowia sp.	Asian	phylogeogr.	Thomas et al. 2015
131		Sageraea lanceolata Miq.	Asian	phylogeogr.	Thomas et al. 2015
132		Xylopia elliptica Maingay ex Hook.f. & Thomson	Asian	phylogeogr.	Thomas et al. 2015
133		Xylopia malayana Hook.f. & Thomson	Asian	phylogeogr.	Thomas et al. 2015
134		Xylopia sp.1	Asian	phylogeogr.	Thomas et al. 2015
135		Xylopia sp.2	Asian	phylogeogr.	Thomas et al. 2015
136	Apocynaceae	Alstonia macrophylla Wall. ex G.Don	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
137		Alstonia parvifolia Merr.	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
138		Alstonia scholaris (L.) R. Br.	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017

No	Family	Species	Origin	Classification method	References
139		Alstonia sp.1	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
140		Alstonia sp.2	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
141		Alstonia sp.3	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
142		Alstonia spectabilis R.Br.	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
143		Dyera costulata (Miq.) Hook.f.	Asian	undated phyl., distr./fossils	Simões et al. 2007, WCSP 2017
144		Kibatalia sp.	Asian	undated phyl., distr./fossils	Livshultz et al. 2007, WCSP 2017
145		Ochrosia apoensis Elmer	Austr.	phylogeogr., distr./fossils	Morokawa 2014, WCSP 2017
146		Tabernaemontana corymbosa Roxb. ex Wall.	Asian	phylogeogr., distr./fossils	Morokawa 2014, WCSP 2017
147		Tabernaemontana macrocarpa Jack	Asian	phylogeogr., distr./fossils	Morokawa 2014, WCSP 2017
148		Tabernaemontana sp.	Asian	phylogeogr., distr./fossils	Morokawa 2014, WCSP 2017
149		Tabernaemontana sphaerocarpa Blume	Asian	phylogeogr., distr./fossils	Morokawa 2014, WCSP 2017
150	Aquifoliaceae	Ilex apoensis Elmer	Asian	phylogeogr.	Manen et al. 2010
151		Ilex celebensis Capit.	Asian	phylogeogr.	Manen et al. 2010
152		Ilex crenata Thunb.	Asian	phylogeogr.	Manen et al. 2010
153		Ilex cymosa Blume	Asian	phylogeogr.	Manen et al. 2010
154		Ilex odorata Buch.-Ham.	Asian	phylogeogr.	Manen et al. 2010
155		Ilex oppositifolia Merr.	Asian	phylogeogr.	Manen et al. 2010
156		Ilex sp.	Asian	phylogeogr.	Manen et al. 2010
157		Ilex sp. nov.	Asian	phylogeogr.	Manen et al. 2010
158		Ilex zygophylla Merr.	Asian	phylogeogr.	Manen et al. 2010
159	Araliaceae	Aralia bipinnata Blanco	Asian	phylogeogr.	Valcárcel et al. 2014, Wen 2000
160		Macropanax concinnus Miq.	Asian	phylogeogr.	Li & Wen 2014, Valcárcel et al. 2014, Zuo et al. 2017
161		Macropanax dispermus (Blume) Kuntze	Asian	phylogeogr.	Li & Wen 2014, Valcárcel et al. 2014, Zuo et al. 2017
162		Polyscias aherniana (Merr.) Lowry & G.M.Plunkett	Austr.	dated phyl., distr./fossils	Lowry & Plunkett 2010, Plunkett & Lowry 2010
163		Polyscias collina (Philipson) Lowry & G.M.Plunkett	Austr.	dated phyl., distr./fossils	Lowry & Plunkett 2010, Plunkett & Lowry 2010
164		Polyscias diversifolia (Blume) Lowry & G.M.Plunkett	Austr.	dated phyl., distr./fossils	Lowry & Plunkett 2010, Plunkett & Lowry 2010

No	Family	Species	Origin	Classification method	References
165		Polyscias nodosa (Blume) Seem.	Austr.	dated phyl., distr./fossils	Philipson 1979, Plunkett & Lowry 2010, Zuo et al. 2017
166		Schefflera divaricata (Blume) Koord.	Asian	phylogeogr.	Li & Wen 2014, Valcárcel et al. 2014, Zuo et al. 2017
167		Schefflera heptaphylla (L.) Frodin	Asian	phylogeogr.	Li & Wen 2014, Valcárcel et al. 2014, Zuo et al. 2017
168		Trevesia sundaica Miq.	Asian	phylogeogr.	Li & Wen 2014, Valcárcel et al. 2014, Zuo et al. 2017
169	Araucariaceae	Agathis borneensis Warb.	Austr.	dated phyl., distr./fossils	Escapa & Catalano 2013, Kershaw & Wagstaff 2001
170		Agathis dammara (Lamb.) Rich. & A.Rich.	Austr.	dated phyl., distr./fossils	Escapa & Catalano 2013, Kershaw & Wagstaff 2001
171		Agathis kinabaluensis de Laub.	Austr.	dated phyl., distr./fossils	Escapa & Catalano 2013, Kershaw & Wagstaff 2001
172	Arecaceae	Areca sp.nov.	Asian	phylogeogr.	Baker & Couvreur 2013
173		Caryota rumphiana Mart.	Asian	phylogeogr.	Baker & Couvreur 2013
174		Oncosperma horridum (Griff.) Scheff.	Asian	phylogeogr.	Baker & Couvreur 2013
175		Pinanga caesia Blume	Asian	phylogeogr.	Baker & Couvreur 2013
176		Pinanga rumphiana (Mart.) J.Dransf. & Govaerts	Asian	phylogeogr.	Baker & Couvreur 2013
177	Asparagaceae	Dracaena angustifolia (Medik.) Roxb.	Asian	phylogeogr.	Lu & Morden 2014
178		Dracaena borneensis (Merr.) Jankalski	Asian	phylogeogr.	Lu & Morden 2014
179	Asteraceae	Strobocalyx arborea (Buch.-Ham.) Sch.Bip.	Asian	dated phyl.	Keeley et al. 2007
180	Bignoniaceae	Radermachera gigantea (Bl.) Miq.	Asian	undated phyl., distr./fossils	Olmstead 2013, van Steenis 1977
181	Burseraceae	Burseraceae sp.1	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
182		Burseraceae sp.2	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
183		Burseraceae sp.3	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
184		Canarium asperum Benth.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
185		Canarium balsamiferum Willd.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
186		Canarium denticulatum Blume	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
187		Canarium hirsutum Willd.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014

No	Family	Species	Origin	Classification method	References
188		Canarium littorale Blume	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
189		Canarium megalanthum Merr.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
190		Canarium merrillii H.J.Lam	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
191		Canarium patentinervium Miq.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
192		Canarium sp.1	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
193		Canarium sp.2	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
194		Canarium sp.3	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
195		Canarium sp.4	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
196		Canarium sp.5	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
197		Canarium vulgare Leenh.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
198		Dacryodes costata (A.W.Benn.) H.J.Lam	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
199		Dacryodes laxa (A.W.Benn.) H.J.Lam	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
200		Dacryodes rostrata (Blume) H.J.Lam	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
201		Dacryodes rugosa (Blume) H.J.Lam	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
202		Dacryodes sp.1	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
203		Dacryodes sp.2	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
204		Dacryodes sp.3	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
205		Dacryodes sp.4	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
206		Dacryodes sp.5	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
207		Dacryodes sp.6	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
208		Dacryodes sp.7	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
209		Dacryodes sp.8	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
210		Dacryodes sp.9	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
211		Haplolobus floribundus (K.Schum.) H.J.Lam	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014

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212		Santiria apiculata A.W.Benn.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
213		Santiria laevigata Blume	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
214		Santiria megaphylla Kalkman	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
215		Santiria mollis Engl.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
216		Santiria oblongifolia Blume	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
217		Santiria sp.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
218		Santiria tomentosa Blume	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
219		Triomma malaccensis Hook.f.	Asian	phylogeogr.	Federman et al. 2015, Weeks et al. 2014
220	Calophyllaceae	Calophyllum blancoi Planch. & Triana	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
221		Calophyllum calaba L.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
222		Calophyllum dasypodium Miq.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
223		Calophyllum depressinervosum M.R.Hend. & Wyatt-Sm.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
224		Calophyllum garcinioides P.F.Stevens	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
225		Calophyllum gracilipes Merr.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
226		Calophyllum macrocarpum Hook.f.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
227		Calophyllum nodosum Vesque	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007

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228		Calophyllum pentapetalum (Blanco) Merr.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
229		Calophyllum rigidum Miq.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
230		Calophyllum soulattri Burm.f.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
231		Calophyllum sp.1	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
232		Calophyllum sp.2	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
233		Calophyllum sp.3	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
234		Calophyllum sp.4	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
235		Calophyllum sp.5	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
236		Calophyllum sp.6	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
237		Calophyllum sp.nov.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
238		Calophyllum tetrapterum Miq.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
239		Calophyllum venulosum Zoll.	Asian	phylogeogr., distr./fossils	Khan et al. 2017, Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007

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240		Kayea beccariana Baill.	Asian	phylogeogr.	Ruhfel et al. 2016
241		Kayea elmeri Merr.	Asian	phylogeogr.	Ruhfel et al. 2016
242		Kayea grandis King	Asian	phylogeogr.	Ruhfel et al. 2016
243		Kayea oblongifolia Ridl.	Asian	phylogeogr.	Ruhfel et al. 2016
244		Kayea sp.1	Asian	phylogeogr.	Ruhfel et al. 2016
245		Kayea sp.2	Asian	phylogeogr.	Ruhfel et al. 2016
246		Kayea sp.3	Asian	phylogeogr.	Ruhfel et al. 2016
247		Mesua ferrea L.	Asian	phylogeogr., distr./fossils	Meseguer et al. 2018, Ruhfel et al. 2016, Stevens 2007
248	Cannabaceae	Celtis luzonica Warb.	Asian	undated phyl., distr./fossils	Sattarian 2006, Soepadmo 1977
249		Celtis rubrovenia Elmer	Asian	undated phyl., distr./fossils	Sattarian 2006, Soepadmo 1977
250		Gironniera celtidifolia Gaudich.	Asian	undated phyl., distr./fossils	Yesson et al. 2004
251		Gironniera nervosa Planch.	Asian	undated phyl., distr./fossils	Yesson et al. 2004
252		Gironniera subaequalis Planch.	Asian	undated phyl., distr./fossils	Yesson et al. 2004
253		Trema orientalis (L.) Blume	Asian	phylogeogr.	Yesson et al. 2004
254	Cardiopteridaceae	Citronella suaveolens (Blume) Howard	Austr.	phylogeogr.	Beaulieu et al. 2013
255		Gonocaryum minus Sleumer	Austr.	phylogeogr.	Beaulieu et al. 2013
256	Celastraceae	Euonymus glandulosus (Merr.) Ding Hou	Asian	dated phyl., distr./fossils	Bacon et al. 2016, Simmons et al. 2012b, Simmons & Cappa 2013
257		Kokoona littoralis M.A.Lawson	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
258		Lophopetalum beccarianum Pierre	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
259		Lophopetalum javanicum (Zoll.) Turcz.	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
260		Lophopetalum sp.1	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
261		Lophopetalum sp.2	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
262		Microtropis rigida Ridl.	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
263		Microtropis wallichiana Wight ex Thwaites	Asian	phylogeogr., distr./fossils	Bacon et al. 2016, Hou 1962
264		Siphonodon celastrineus Griff.	Austr.	phylogeogr.	Bacon et al. 2016, Simmons et al. 2012a
265	Centroplacaceae	Bhesa paniculata Arn.	Asian	phylogeogr.	Cai et al. 2016, Hou 1962
266		Bhesa sp.	Asian	phylogeogr.	Cai et al. 2016, Hou 1962

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267	Chloranthaceae	Ascarina philippinensis C.B.Rob.	Austr.	phylogeogr.	Zhang et al. 2015
268	Chrysobalanaceae	Angelesia splendens Korth.	Austr.	phylogeogr., distr./fossils	Bardon et al. 2016, Sothers & Prance 2014
269		Atuna racemosa Raf.	Asian	phylogeogr., distr./fossils	Bardon et al. 2016, Prance 1989
270		Kostermanthus heteropetalus (Scort. ex King) Prance	Asian	phylogeogr., distr./fossils	Bardon et al. 2016, Prance 1989
271		Maranthes corymbosa Blume	Asian	phylogeogr., distr./fossils	Bardon et al. 2016, Prance 1989
272		Parastemon grandifructus Prance	Asian	phylogeogr., distr./fossils	Bardon et al. 2016, Prance 1989
273		Parinari canarioides Kosterm.	Asian	phylogeogr.	Bardon et al. 2016
274		Parinari costata (Korth.) Blume	Asian	phylogeogr.	Bardon et al. 2016
275		Parinari elmeri Merr.	Asian	phylogeogr.	Bardon et al. 2016
276		Parinari oblongifolia Hook.f.	Asian	phylogeogr.	Bardon et al. 2016
277	Clethraceae	Clethra canescens Reinw. ex Blume	Asian	undated phyl., distr./fossils	Dressler & Bayer 2004, Fior et al. 2003
278		Clethra pachyphylla Merr.	Asian	undated phyl., distr./fossils	Dressler & Bayer 2004, Fior et al. 2003
279	Clusiaceae	Garcinia beccarii Pierre	Asian	phylogeogr.	Ruhfel et al. 2016
280		Garcinia binucao (Blanco) Choisy	Asian	phylogeogr.	Ruhfel et al. 2016
281		Garcinia blumei Pierre	Asian	phylogeogr.	Ruhfel et al. 2016
282		Garcinia brevirostris Scheff.	Asian	phylogeogr.	Ruhfel et al. 2016
283		Garcinia caudiculata Ridl.	Asian	phylogeogr.	Ruhfel et al. 2016
284		Garcinia celebica L.	Asian	phylogeogr.	Ruhfel et al. 2016
285		Garcinia dioica Blume	Asian	phylogeogr.	Ruhfel et al. 2016
286		Garcinia dulcis (Roxb.) Kurz	Asian	phylogeogr.	Ruhfel et al. 2016
287		Garcinia gaudichaudii Planch. & Triana	Asian	phylogeogr.	Ruhfel et al. 2016
288		Garcinia havilandii Stapf	Asian	phylogeogr.	Ruhfel et al. 2016
289		Garcinia lateriflora Blume	Asian	phylogeogr.	Ruhfel et al. 2016
290		Garcinia longipedicellata Kosterm.	Asian	phylogeogr.	Ruhfel et al. 2016
291		Garcinia maingayi Hook.f. ex T.Anderson	Asian	phylogeogr.	Ruhfel et al. 2016
292		Garcinia maluensis Lauterb.	Asian	phylogeogr.	Ruhfel et al. 2016
293		Garcinia merguensis Wight	Asian	phylogeogr.	Ruhfel et al. 2016

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294		Garcinia parvifolia (Miq.) Miq.	Asian	phylogeogr.	Ruhfel et al. 2016
295		Garcinia penangiana Pierre	Asian	phylogeogr.	Ruhfel et al. 2016
296		Garcinia rhizophoroides Elmer	Asian	phylogeogr.	Ruhfel et al. 2016
297		Garcinia rostrata (Hassk.) Miq.	Asian	phylogeogr.	Ruhfel et al. 2016
298		Garcinia sp.01	Asian	phylogeogr.	Ruhfel et al. 2016
299		Garcinia sp.02	Asian	phylogeogr.	Ruhfel et al. 2016
300		Garcinia sp.03	Asian	phylogeogr.	Ruhfel et al. 2016
301		Garcinia sp.04	Asian	phylogeogr.	Ruhfel et al. 2016
302		Garcinia sp.05	Asian	phylogeogr.	Ruhfel et al. 2016
303		Garcinia sp.06	Asian	phylogeogr.	Ruhfel et al. 2016
304		Garcinia sp.07	Asian	phylogeogr.	Ruhfel et al. 2016
305		Garcinia sp.08	Asian	phylogeogr.	Ruhfel et al. 2016
306		Garcinia sp.09	Asian	phylogeogr.	Ruhfel et al. 2016
307		Garcinia sp.10	Asian	phylogeogr.	Ruhfel et al. 2016
308		Garcinia sp.11	Asian	phylogeogr.	Ruhfel et al. 2016
309		Garcinia sp.12	Asian	phylogeogr.	Ruhfel et al. 2016
310		Garcinia sp.13	Asian	phylogeogr.	Ruhfel et al. 2016
311		Garcinia sp.14	Asian	phylogeogr.	Ruhfel et al. 2016
312		Garcinia sp.15	Asian	phylogeogr.	Ruhfel et al. 2016
313		Garcinia sp.16	Asian	phylogeogr.	Ruhfel et al. 2016
314		Garcinia sp.17	Asian	phylogeogr.	Ruhfel et al. 2016
315		Garcinia sp.18	Asian	phylogeogr.	Ruhfel et al. 2016
316		Garcinia sp.19	Asian	phylogeogr.	Ruhfel et al. 2016
317		Garcinia sp.20	Asian	phylogeogr.	Ruhfel et al. 2016
318		Garcinia sp.21	Asian	phylogeogr.	Ruhfel et al. 2016
319		Garcinia sp.22	Asian	phylogeogr.	Ruhfel et al. 2016
320		Garcinia sp.23	Asian	phylogeogr.	Ruhfel et al. 2016
321		Garcinia urophylla Scort. ex King	Asian	phylogeogr.	Ruhfel et al. 2016
322	Combretaceae	Terminalia foetidissima Griff.	Asian	phylogeogr.	Berger et al. 2016
323		Terminalia nitens C.Presl	Asian	phylogeogr.	Berger et al. 2016
324	Connaraceae	Ellipanthus beccarii Pierre	Asian	distr./fossils	Lemmens et al. 2004
325	Cornaceae	Alangium javanicum (Blume) Wangerin	Asian	phylogeogr.	Feng et al. 2009
326		Alangium sp.	Asian	phylogeogr.	Feng et al. 2009
327	Crypteroniaceae	Axinandra coriacea Baill.	Asian	phylogeogr.	Berger et al. 2016, Rutschmann et al. 2004
328		Crypteronia cumingii (Planch.) Endl.	Asian	phylogeogr.	Berger et al. 2016, Rutschmann et al. 2004
329		Crypteronia paniculata Blume	Asian	phylogeogr.	Berger et al. 2016, Rutschmann et al. 2004
330		Crypteronia sp.	Asian	phylogeogr.	Berger et al. 2016, Rutschmann et al. 2004

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331	Ctenolophonaceae	Ctenolophon parvifolius Oliv.	Asian	distr./fossils	Kubitzki 2014
332	Cunoniaceae	Schizomeria serrata (Hochr.) Hochr.	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
333		Spiraeopsis celebica (Blume) Miq.	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
334		Weinmannia clemensiae Steenis	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
335		Weinmannia aff. fraxinea (D.Don) Miq.	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
336		Weinmannia furfuracea H.C.Hopkins	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
337		Weinmannia hutchinsonii Merr.	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
338		Weinmannia negrosensis Elmer	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
339		Weinmannia sp.	Austr.	undated phyl., distr./fossils	Bradford & Barnes 2001, Bradford et al. 2004
340	Daphniphyllaceae	Daphniphyllum borneense Stapf	Asian	dated phyl., distr./fossils	Jian et al. 2008, Kubitzki 2007
341		Daphniphyllum buchananiifolium Hallier f.	Asian	distr./fossils	Jian et al. 2008, Kubitzki 2007
342	Dichapetalaceae	Dichapetalum sp.	Asian	dated phyl., distr./fossils	Leenhouts 1957, Xi et al. 2012
343	Dilleniaceae	Dillenia beccariana Martelli	Asian	undated phyl.	Hoorn 2007, 2009
344		Dillenia indica L.	Asian	undated phyl.	Hoorn 2007, 2009
345		Dillenia ovalifolia Hoogland	Asian	undated phyl.	Hoorn 2007, 2009
346		Dillenia philippinensis Rolfe	Asian	undated phyl.	Hoorn 2007, 2009
347		Dillenia reifferscheidia Fern.-Vill.	Asian	undated phyl.	Hoorn 2007, 2009
348		Dillenia sp.1	Asian	undated phyl.	Hoorn 2007, 2009
349		Dillenia sp.2	Asian	undated phyl.	Hoorn 2007, 2009
350		Dillenia sp.3	Asian	undated phyl.	Hoorn 2007, 2009
351	Dipterocarpaceae	Anisoptera costata Korth.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
352		Anisoptera laevis Ridl.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
353		Anisoptera thurifera (Blanco) Blume	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
354		Dipterocarpus caudatus Foxw.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017

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355		Dipterocarpus palembanicus Slooten	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
356		Dryobalanops beccarii Dyer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
357		Dryobalanops lanceolata Burck	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
358		Hopea beccariana Burck	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
359		Hopea dryobalanoides Miq.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
360		Hopea dyeri F.Heim	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
361		Hopea foxworthyi Elmer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
362		Hopea nigra Burck	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
363		Hopea pentanervia Symington ex G.H.S.Wood	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
364		Hopea sangal Korth.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
365		Hopea sp.1	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
366		Parashorea malaanonan (Blanco) Merr.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
367		Parashorea smythiesii Wyatt-Sm. ex P.S.Ashton	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
368		Shorea acuminata Dyer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
369		Shorea almon Foxw.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
370		Shorea amplexicaulis P.S.Ashton	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017

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371		Shorea argentifolia Symington	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
372		Shorea confusa P.S.Ashton	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
373		Shorea domatiosa P.S.Ashton	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
374		Shorea exelliptica Meijer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
375		Shorea faguetiana F.Heim	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
376		Shorea fallax Meijer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
377		Shorea ferruginea Dyer ex Brandis	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
378		Shorea foxworthyi Symington	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
379		Shorea gibbosa Brandis	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
380		Shorea hypoleuca Meijer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
381		Shorea laevis Ridl.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
382		Shorea leprosula Miq.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
383		Shorea macroptera Dyer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
384		Shorea maxwelliana King	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
385		Shorea monticola P.S.Ashton	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
386		Shorea obscura Meijer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017

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387		Shorea parvifolia Dyer	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
388		Shorea pauciflora King	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
389		Shorea platyclados Slooten ex Endert	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
390		Shorea polysperma (Blanco) Merr.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
391		Shorea scaberrima Burck	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
392		Shorea scrobiculata Burck	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
393		Shorea sp.1	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
394		Shorea sp.2	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
395		Shorea sp.3	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
396		Shorea sp.4	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
397		Shorea sp.5	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
398		Vatica endertii Slooten	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
399		Vatica granulata Slooten	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
400		Vatica mangachapoi Blanco	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
401		Vatica micrantha Slooten	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
402		Vatica odorata (Griff.) Symington	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017

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403		Vatica perakensis King	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
404		Vatica sp.	Asian	dated phyl., distr./fossils	Ashton 2008, Dutta et al. 2011, Feng et al. 2013, Heckenhauer et al. 2017
405	Ebenaceae	Diospyros bangkana Bakh.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
406		Diospyros borneensis Hiern	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
407		Diospyros buxifolia (Blume) Hiern	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
408		Diospyros castanea (Craib) Fletcher	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
409		Diospyros caudisepala Bakh.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
410		Diospyros confertiflora (Hiern) Bakh.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
411		Diospyros curranii Merr.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
412		Diospyros diepenhorstii Miq.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
413		Diospyros discolor Willd.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
414		Diospyros elliptifolia Merr.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
415		Diospyros frutescens Blume	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
416		Diospyros javanica Bakh.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
417		Diospyros macrophylla Blume	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
418		Diospyros piscicapa Ridl.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
419		Diospyros pseudomalabarica Bakh.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
420		Diospyros sp.01	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
421		Diospyros sp.02	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
422		Diospyros sp.03	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
423		Diospyros sp.04	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
424		Diospyros sp.05	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
425		Diospyros sp.06	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013

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426		Diospyros sp.07	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
427		Diospyros sp.08	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
428		Diospyros sp.09	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
429		Diospyros sp.10	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
430		Diospyros sp.11	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
431		Diospyros sp.12	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
432		Diospyros sp.13	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
433		Diospyros sp.14	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
434		Diospyros sp.15	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
435		Diospyros sp.16	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
436		Diospyros sp.17	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
437		Diospyros sumatrana Miq.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
438		Diospyros venosa Wall. ex A.DC.	Asian	phylogeogr.	Duangjai et al. 2009, Turner et al. 2013
439	Ehretiaceae	Ehretia javanica Blume	Asian	phylogeogr.	Gottschling & Hilger 2004
440	Elaeocarpaceae	Elaeocarpus acronodia Mast.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
441		Elaeocarpus angustifolius Blume	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
442		Elaeocarpus calomala (Blanco) Merr.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
443		Elaeocarpus celebicus Koord.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
444		Elaeocarpus corneri Weibel	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
445		Elaeocarpus culminicola Warb.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
446		Elaeocarpus cumingii Turcz.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
447		Elaeocarpus dolichostylus Schltr.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
448		Elaeocarpus erdinii Coode	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
449		Elaeocarpus firdausii Brambach, Coode, Biagioni & Culmsee	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006

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450		Elaeocarpus glaber Blume	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
451		Elaeocarpus gustaviifolius Knuth	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
452		Elaeocarpus aff. harunii Coode	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
453		Elaeocarpus hochreutineri Weibel	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
454		Elaeocarpus knuthii Merr.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
455		Elaeocarpus macrophyllus Blume	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
456		Elaeocarpus mastersii King	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
457		Elaeocarpus multiflorus (Turcz.) Fern.-Vill.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
458		Elaeocarpus musseri Coode	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
459		Elaeocarpus nitidus Jack	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
460		Elaeocarpus aff. octopetalus Merr.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
461		Elaeocarpus palembanicus (Miq.) Corner	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
462		Elaeocarpus pierrei Koord. & Valeton	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
463		Elaeocarpus sarcanthus Schltr.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
464		Elaeocarpus sp.02	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
465		Elaeocarpus sp.03	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
466		Elaeocarpus sp.04	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
467		Elaeocarpus sp.05	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
468		Elaeocarpus sp.06	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
469		Elaeocarpus sp.07	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
470		Elaeocarpus sp.08	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
471		Elaeocarpus sp.09	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
472		Elaeocarpus sp.10	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006

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473		Elaeocarpus sp.11	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
474		Elaeocarpus sp.12	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
475		Elaeocarpus sp.13	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
476		Elaeocarpus steupii Coode	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
477		Elaeocarpus stipularis Blume	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
478		Elaeocarpus submonoceras Miq.	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
479		Elaeocarpus teysmannii Koord. & Valeton	Austr.	phylogeogr.	Baba 2013, Crayn et al. 2006
480		Sloanea celebica Boerl. & Koord. ex Koord.	Asian	distr./fossils	Coode 1983, Manchester & Kvaček 2009
481	Ericaceae	Diplycosia sp.	Asian	undated phyl.	Fritsch et al. 2011
482		Rhododendron sp.	Asian	phylogeogr.	Landis et al. 2013
483		Vaccinium bancanum Miq.	Asian	undated phyl.	Powell & Kron 2002
484		Vaccinium cuneifolium (Blume) Miq.	Asian	undated phyl.	Powell & Kron 2002
485		Vaccinium dubiosum J.J.Sm.	Asian	undated phyl.	Powell & Kron 2002
486		Vaccinium laurifolium (Blume) Miq.	Asian	undated phyl.	Powell & Kron 2002
487		Vaccinium simulans Sleumer	Asian	undated phyl.	Powell & Kron 2002
488		Vaccinium sp.1	Asian	undated phyl.	Powell & Kron 2002
489	Escalloniaceae	Polyosma celebica Schulze-Menz ined.	Austr.	phylogeogr.	Beaulieu et al. 2013
490		Polyosma cyanea Elmer	Austr.	phylogeogr.	Beaulieu et al. 2013
491		Polyosma hookeri Stapf	Austr.	phylogeogr.	Beaulieu et al. 2013
492		Polyosma illicifolia Blume	Austr.	phylogeogr.	Beaulieu et al. 2013
493		Polyosma integrifolia Blume	Austr.	phylogeogr.	Beaulieu et al. 2013
494		Polyosma kingiana Schltr.	Austr.	phylogeogr.	Beaulieu et al. 2013
495		Polyosma sorsogonensis Elmer	Austr.	phylogeogr.	Beaulieu et al. 2013
496		Polyosma sp.1	Austr.	phylogeogr.	Beaulieu et al. 2013
497		Polyosma sp.2	Austr.	phylogeogr.	Beaulieu et al. 2013
498		Polyosma sp.3	Austr.	phylogeogr.	Beaulieu et al. 2013
499		Polyosma verticillata Merr.	Austr.	phylogeogr.	Beaulieu et al. 2013
500	Euphorbiaceae	Acalypha amentacea Roxb.	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Sagun et al. 2010
501		Balakata baccata (Roxb.) Esser	Asian	distr./fossils	Esser 1999, Webster 2014

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502		Blumeodendron kurzii (Hook.f.) J.J.Sm. ex Koord. & Valeton	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Ottens-Treurniet & van Welzen 2016
503		Blumeodendron sp.1	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Ottens-Treurniet & van Welzen 2016
504		Blumeodendron subrotundifolium (Elmer) Merr.	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Ottens-Treurniet & van Welzen 2016
505		Blumeodendron tokbrai (Blume) Kurz	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Ottens-Treurniet & van Welzen 2016
506		Claoxylon brachyandrum Pax & K.Hoffm.	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, WCSP 2017
507		Claoxylon sp.1	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, WCSP 2017
508		Elateriospermum tapos Blume	Asian	undated phyl., distr./fossils	Webster 2014, Wurdack et al. 2005
509		Hancea penangensis (Müll.Arg.) S.E.C.Sierra	Asian	phylogeogr.	Cervantes et al. 2016, Kulju et al. 2007
510		Homalanthus fastuosus (Linden) Fern.-Vill.	Austr.	dated phyl., distr./fossils	Esser 1997, Wurdack et al. 2005, Xi et al. 2012
511		Homalanthus macradenius Pax & K.Hoffm.	Austr.	dated phyl., distr./fossils	Esser 1997, Wurdack et al. 2005, Xi et al. 2012
512		Homalanthus populneus (Geiseler) Pax	Austr.	dated phyl., distr./fossils	Esser 1997, Wurdack et al. 2005, Xi et al. 2012
513		Homalanthus sp.1	Austr.	dated phyl., distr./fossils	Esser 1997, Wurdack et al. 2005, Xi et al. 2012
514		Homalanthus sp.2	Austr.	dated phyl., distr./fossils	Esser 1997, Wurdack et al. 2005, Xi et al. 2012
515		Koilodepas longifolium Hook.f.	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Webster 2014
516		Macaranga bicolor Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
517		Macaranga costulata Pax & K.Hoffm.	Asian	phylogeogr.	van Welzen et al. 2014
518		Macaranga denticulata (Blume) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
519		Macaranga gigantea (Rchb.f. & Zoll.) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
520		Macaranga hispida (Blume) Müll.Arg.	Austr.	phylogeogr.	van Welzen et al. 2014
521		Macaranga hosei King ex Hook.f.	Asian	phylogeogr.	van Welzen et al. 2014
522		Macaranga hypoleuca (Rchb.f. & Zoll.) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014

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523		Macaranga lowii King ex Hook.f.	Asian	phylogeogr.	van Welzen et al. 2014
524		Macaranga pachyphylla Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
525		Macaranga rhizinoides (Blume) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
526		Macaranga rorokae Whitmore	Austr.	phylogeogr.	van Welzen et al. 2014
527		Macaranga sarcocarpa Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
528		Macaranga strigosissima Airy Shaw	Asian	phylogeogr.	van Welzen et al. 2014
529		Macaranga tanarius (L.) Müll.Arg.	Austr.	phylogeogr.	van Welzen et al. 2014
530		Macaranga thomasii Whitmore	Austr.	phylogeogr.	van Welzen et al. 2014
531		Macaranga trachyphylla Airy Shaw	Asian	phylogeogr.	van Welzen et al. 2014
532		Macaranga triloba (Thunb.) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
533		Macaranga umbrosa S.J.Davies	Asian	phylogeogr.	van Welzen et al. 2014
534		Macaranga waturandangii Whitmore	Asian	phylogeogr.	van Welzen et al. 2014
535		Mallotus cumingii Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
536		Mallotus mollissimus (Geiseler) Airy Shaw	Asian	phylogeogr.	van Welzen et al. 2014
537		Mallotus paniculatus (Lam.) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
538		Mallotus philippensis (Lam.) Müll.Arg.	Asian	phylogeogr.	van Welzen et al. 2014
539		Mallotus sp.	Asian	phylogeogr.	van Welzen et al. 2014
540		Melanolepis multiglandulosa (Reinw. ex Blume) Rchb. & Zoll.	Asian	phylogeogr., distr./fossils	Cervantes et al. 2016, Webster 2014
541		Moultonianthus leembruggianus (Boerl. & Koord.) Steenis	Asian	undated phyl., distr./fossils	van Welzen 1995, Wurdack et al. 2005
542		Neoscortechinia kingii (Hook.f.) Pax & K.Hoffm.	Asian	phylogeogr.	Tokuoka 2007, van Welzen 1994
543		Neoscortechinia nicobarica (Hook.f.) Pax & K.Hoffm.	Asian	phylogeogr.	Tokuoka 2007, van Welzen 1994
544		Neoscortechinia philippinensis (Merr.) Welzen	Asian	phylogeogr.	Tokuoka 2007, van Welzen 1994

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545		Ostodes paniculata Blume	Asian	undated phyl., distr./fossils	Tokuoka 2007, van Welzen & Winkel 2015
546		Pimelodendron griffithianum (Müll.Arg.) Benth. ex Hook.f.	Asian	dated phyl., distr./fossils	Djawarningsih 2004, Xi et al. 2012
547		Ptychopyxis javanica (J.J.Sm.) Croizat	Asian	distr./fossils	Stoops & van Welzen 2013
548		Ptychopyxis kingii Ridl.	Asian	distr./fossils	Stoops & van Welzen 2013
549		Ptychopyxis sp.	Asian	distr./fossils	Stoops & van Welzen 2013
550	Fabaceae	Archidendron bubalinum (Jack) I.C.Nielsen	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
551		Archidendron clypearia (Jack) I.C.Nielsen	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
552		Archidendron ellipticum (Blanco) I.C.Nielsen	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
553		Archidendron havilandii (Ridl.) I.C.Nielsen	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
554		Archidendron microcarpum (Benth.) I.C.Nielsen	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
555		Archidendron nervosum de Wit	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
556		Archidendron pauciflorum (Benth.) I.C.Nielsen	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
557		Archidendron sp.	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
558		Archidendron sp.1	Austr.	dated phyl., distr./fossils	Bouchenak-Khelladi et al. 2010, Brown et al. 2011
559		Crudia sp.	Asian	dated phyl., distr./fossils	Bruneau et al. 2008, 2014
560		Crudia tenuipes Merr.	Asian	dated phyl., distr./fossils	Bruneau et al. 2008, 2014
561		Cynometra ramiflora L.	Asian	dated phyl., distr./fossils	Bruneau et al. 2008, 2014
562		Dialium indum L.	Asian	dated phyl., distr./fossils	Bruneau et al. 2008
563		Dialium kunstleri Prain	Asian	dated phyl., distr./fossils	Bruneau et al. 2008
564		Dialium sp.1	Asian	dated phyl., distr./fossils	Bruneau et al. 2008
565		Koompassia excelsa (Becc.) Taub.	Asian	dated phyl., distr./fossils	Bruneau et al. 2008
566		Koompassia malaccensis Benth.	Asian	dated phyl., distr./fossils	Bruneau et al. 2008
567		Millettia sericea (Vent.) Wight & Arn. ex Hassk.	Asian	undated phyl., distr./fossils	Adema 2001, Cardoso et al. 2012

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568		Ormosia sumatrana (Miq.) Prain	Asian	undated phyl., distr./fossils	Cardoso et al. 2012
569		Parkia speciosa Hassk.	Asian	phylogeogr.	Bouchenak-Khelladi et al. 2010
570		Sindora coriacea (Baker) Prain	Asian	dated phyl., distr./fossils	Bruneau et al. 2008, Fougère-Danezan et al. 2010
571	Fagaceae	Castanopsis acuminatissima (Blume) A.DC.	Asian	phylogeogr.	Manos & Stanford 2001
572		Castanopsis argentea (Blume) A.DC.	Asian	phylogeogr.	Manos & Stanford 2001
573		Castanopsis buruana Miq.	Asian	phylogeogr.	Manos & Stanford 2001
574		Castanopsis clemensii Soepadmo	Asian	phylogeogr.	Manos & Stanford 2001
575		Castanopsis costata (Blume) A.DC.	Asian	phylogeogr.	Manos & Stanford 2001
576		Castanopsis javanica (Blume) A.DC.	Asian	phylogeogr.	Manos & Stanford 2001
577		Castanopsis megacarpa Gamble	Asian	phylogeogr.	Manos & Stanford 2001
578		Castanopsis motleyana King	Asian	phylogeogr.	Manos & Stanford 2001
579		Castanopsis paucispina Soepadmo	Asian	phylogeogr.	Manos & Stanford 2001
580		Castanopsis philipensis (Blanco) Vidal	Asian	phylogeogr.	Manos & Stanford 2001
581		Castanopsis sp.01	Asian	phylogeogr.	Manos & Stanford 2001
582		Castanopsis sp.02	Asian	phylogeogr.	Manos & Stanford 2001
583		Castanopsis sp.03	Asian	phylogeogr.	Manos & Stanford 2001
584		Castanopsis sp.04	Asian	phylogeogr.	Manos & Stanford 2001
585		Castanopsis sp.05	Asian	phylogeogr.	Manos & Stanford 2001
586		Castanopsis sp.06	Asian	phylogeogr.	Manos & Stanford 2001
587		Castanopsis sp.07	Asian	phylogeogr.	Manos & Stanford 2001
588		Castanopsis sp.08	Asian	phylogeogr.	Manos & Stanford 2001
589		Castanopsis tungurrut (Blume) A.DC.	Asian	phylogeogr.	Manos & Stanford 2001
590		Fagaceae sp.	Asian	phylogeogr.	Manos & Stanford 2001
591		Lithocarpus beccarianus (Benth.) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
592		Lithocarpus bennettii (Miq.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
593		Lithocarpus cf. bicoloratus (Elmer) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
594		Lithocarpus blumeanus (Korth.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
595		Lithocarpus bullatus Hatus. ex Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001

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596		Lithocarpus caudatifolius (Merr.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
597		Lithocarpus celebicus (Miq.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
598		Lithocarpus clementianus (King ex Hook.f.) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
599		Lithocarpus confertus Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
600		Lithocarpus cyclophorus (Endl.) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
601		Lithocarpus daphnoideus (Blume) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
602		Lithocarpus elegans (Blume) Hatus. ex Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
603		Lithocarpus encleisocarpus (Korth.) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
604		Lithocarpus glutinosus (Blume) Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
605		Lithocarpus hallieri (Seemen) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
606		Lithocarpus hatusimae Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
607		Lithocarpus havilandii (Stapf) Barnett	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
608		Lithocarpus hystrix (Korth.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
609		Lithocarpus cf. indutus (Blume) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
610		Lithocarpus korthalsii (Endl.) Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
611		Lithocarpus lampadarius (Gamble) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
612		Lithocarpus leptogyne (Korth.) Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
613		Lithocarpus lucidus (Roxb.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
614		Lithocarpus luteus Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
615		Lithocarpus maingayi (Benth.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
616		Lithocarpus menadoensis (Koord.) Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
617		Lithocarpus nieuwenhuisii (Seemen) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
618		Lithocarpus nodosus Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001

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619		Lithocarpus papillifer Hatus. ex Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
620		Lithocarpus philippinensis (A.DC.) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
621		Lithocarpus pseudomoluccus (Blume) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
622		Lithocarpus pusillus Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
623		Lithocarpus rigidus Soepadmo	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
624		Lithocarpus rotundatus (Blume) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
625		Lithocarpus sp.01	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
626		Lithocarpus sp.02	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
627		Lithocarpus sp.03	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
628		Lithocarpus sp.04	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
629		Lithocarpus sp.05	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
630		Lithocarpus sp.06	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
631		Lithocarpus sp.07	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
632		Lithocarpus sp.08	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
633		Lithocarpus sp.09	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
634		Lithocarpus sp.10	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
635		Lithocarpus sp.11	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
636		Lithocarpus sp.12	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
637		Lithocarpus sp.13	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
638		Lithocarpus sp.14	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
639		Lithocarpus sp.15	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
640		Lithocarpus sp.16	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
641		Lithocarpus sundaicus (Blume) Rehder	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001

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642		Lithocarpus turbinatus (Stapf) Forman	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
643		Lithocarpus woodii (Hance) A.Camus	Asian	phylogeogr.	Cannon & Manos 2003, Manos & Stanford 2001
644		Quercus argentata Korth.	Asian	phylogeogr.	Manos & Stanford 2001
645		Quercus chrysotricha A.Camus	Asian	phylogeogr.	Manos & Stanford 2001
646		Quercus elmeri Merr.	Asian	phylogeogr.	Manos & Stanford 2001
647		Quercus gemelliflora Blume	Asian	phylogeogr.	Manos & Stanford 2001
648		Quercus lowii King	Asian	phylogeogr.	Manos & Stanford 2001
649		Quercus pseudoverticillata Soepadmo	Asian	phylogeogr.	Manos & Stanford 2001
650		Quercus sp.1	Asian	phylogeogr.	Manos & Stanford 2001
651		Quercus sp.2	Asian	phylogeogr.	Manos & Stanford 2001
652		Quercus subsericea A.Camus	Asian	phylogeogr.	Manos & Stanford 2001
653		Quercus sumatrana Soepadmo	Asian	phylogeogr.	Manos & Stanford 2001
654		Quercus treubiana Seemen	Asian	phylogeogr.	Manos & Stanford 2001
655		Quercus valdinervosa Soepadmo	Asian	phylogeogr.	Manos & Stanford 2001
656		Trigonobalanus verticillata Forman	Asian	phylogeogr.	Manos & Stanford 2001
657	Gentianaceae	Fagraea auriculata Jack	Asian	dated phyl.	Frasier et al. 2008, Merckx et al. 2013, Sugumaran & Wong 2012
658		Fagraea blumei G.Don	Asian	dated phyl.	Frasier et al. 2008, Merckx et al. 2013, Sugumaran & Wong 2012
659		Fagraea ceilanica Thunb.	Asian	dated phyl.	Frasier et al. 2008, Merckx et al. 2013, Sugumaran & Wong 2012
660		Fagraea sp.1	Asian	dated phyl.	Frasier et al. 2008, Merckx et al. 2013, Sugumaran & Wong 2012
661		Picrophloeus collinus (K.M.Wong & Sugau) K.M.Wong	Asian	dated phyl.	Frasier et al. 2008, Merckx et al. 2013, Sugumaran & Wong 2012
662		Utania morindifolia (Blume) G.Don	Asian	dated phyl.	Frasier et al. 2008, Merckx et al. 2013, Sugumaran & Wong 2012
663	Hamamelidaceae	Distyliopsis dunnii (Hemsl.) P.K.Endress	Asian	undated phyl., distr./fossils	Endress 1993, Li 2008
664	Himantandraceae	Galbulimima belgraveana (F.Muell.) Sprague	Austr.	undated phyl., distr./fossils	Endress 1993, Massoni et al. 2014

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665	Hydrangeaceae	Dichroa sylvatica (Reinw. ex Bl.) Merr.	Asian	dated phyl., distr./fossils	Hufford 2004, Samain et al. 2010, Xiang et al. 2011
666	Hypericaceae	Cratoxylum arborescens (Vahl) Blume	Asian	phylogeogr.	Ruhfel et al. 2016
667		Cratoxylum formosum (Jacq.) Benth. & Hook.f. ex Dyer	Asian	phylogeogr.	Ruhfel et al. 2016
668		Cratoxylum sumatranum (Jack) Blume	Asian	phylogeogr.	Ruhfel et al. 2016
669	Irvingiaceae	Irvingia malayana Oliv. ex A.W.Benn.	Asian	phylogeogr., distr./fossils	Byng et al. 2016, Nooteboom 1962, Xi et al. 2012
670	Iteaceae	Itea macrophylla Wall.	Asian	distr./fossils	Hermsen 2013
671	Ixonanthaceae	Ixonanthes petiolaris Blume	Asian	phylogeogr., distr./fossils	Byng et al. 2016, Xi et al. 2012
672		Ixonanthes reticulata Jack	Asian	phylogeogr., distr./fossils	Byng et al. 2016, Xi et al. 2012
673	Juglandaceae	Engelhardtia apoensis Elmer ex Nagel	Asian	distr./fossils	Manchester 1989
674		Engelhardtia rigida Blume	Asian	distr./fossils	Manchester 1989
675		Engelhardtia serrata Blume	Asian	distr./fossils	Manchester 1989
676		Engelhardtia sp.1	Asian	distr./fossils	Manchester 1989
677		Engelhardtia spicata Lechen ex Blume	Asian	distr./fossils	Manchester 1989
678	Lamiaceae	Callicarpa pentandra Roxb.	Asian	undated phyl., distr./fossils	Li et al. 2016, WCSP 2017
679		Clerodendrum brachyanthum Schauer	Asian	undated phyl., distr./fossils	Harley et al. 2004, WCSP 2017, Yuan et al. 2010
680		Clerodendrum phyllomega Steud.	Asian	undated phyl., distr./fossils	Harley et al. 2004, WCSP 2017, Yuan et al. 2010
681		Teijsmanniodendron holophyllum (Baker) Kosterm.	Asian	undated phyl., distr./fossils	Li et al. 2016, WCSP 2017
682		Teijsmanniodendron pteropodum (Miq.) Bakh.	Asian	undated phyl., distr./fossils	Li et al. 2016, WCSP 2017
683		Teijsmanniodendron sarawakanum (H.Pearson) Kosterm.	Asian	undated phyl., distr./fossils	Li et al. 2016, WCSP 2017
684		Teijsmanniodendron sp.	Asian	undated phyl., distr./fossils	Li et al. 2016, WCSP 2017
685		Vitex quinata (Lour.) F.N.Williams	Asian	undated phyl., distr./fossils	Li et al. 2016, WCSP 2017
686	Lauraceae	Actinodaphne angustifolia (Blume) Nees	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
687		Actinodaphne glabra Blume	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008

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688		Actinodaphne glomerata (Blume) Nees	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
689		Actinodaphne sp.1	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
690		Actinodaphne sp.2	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
691		Alseodaphne longipes Quisumb. & Merr.	Asian	phylogeogr.	Li et al. 2011
692		Alseodaphne oblanceolata (Merr.) Kosterm.	Asian	phylogeogr.	Li et al. 2011
693		Alseodaphne peduncularis (Wall. ex Nees) Meisn.	Asian	phylogeogr.	Li et al. 2011
694		Alseodaphne sp.1	Asian	phylogeogr.	Li et al. 2011
695		Alseodaphne sp.2	Asian	phylogeogr.	Li et al. 2011
696		Beilschmiedia dictyoneura Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
697		Beilschmiedia glabra Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
698		Beilschmiedia gynotrochioides Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
699		Beilschmiedia madang Blume	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
700		Beilschmiedia perakensis Gamble	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
701		Beilschmiedia rivularis Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
702		Beilschmiedia sp.1	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
703		Beilschmiedia sp.2	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
704		Beilschmiedia sp.3	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
705		Beilschmiedia sp.4	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
706		Beilschmiedia sp.5	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
707		Beilschmiedia sp.6	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
708		Cinnamomum mercadoi S.Vidal	Asian	phylogeogr.	Huang et al. 2016
709		Cinnamomum polderi Kosterm.	Asian	phylogeogr.	Huang et al. 2016
710		Cinnamomum porrectum (Roxb.) Kosterm	Asian	phylogeogr.	Huang et al. 2016
711		Cinnamomum sintoc Blume	Asian	phylogeogr.	Huang et al. 2016

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712		Cinnamomum sp.1	Asian	phylogeogr.	Huang et al. 2016
713		Cinnamomum sp.2	Asian	phylogeogr.	Huang et al. 2016
714		Cinnamomum sp.3	Asian	phylogeogr.	Huang et al. 2016
715		Cinnamomum sp.4	Asian	phylogeogr.	Huang et al. 2016
716		Cinnamomum subcuneatum Miq.	Asian	phylogeogr.	Huang et al. 2016
717		Cryptocarya acutifolia H.W.Li	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
718		Cryptocarya albida Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
719		Cryptocarya ampla Merr.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
720		Cryptocarya crassinerviopsis Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
721		Cryptocarya densiflora Blume	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
722		Cryptocarya ferrea Blume	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
723		Cryptocarya griffithiana Wight	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
724		Cryptocarya microcos Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
725		Cryptocarya palawanensis Merr.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
726		Cryptocarya sp.1	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
727		Cryptocarya sp.2	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
728		Cryptocarya sp.3	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
729		Dehaasia firma Blume	Asian	phylogeogr.	Li et al. 2011
730		Dehaasia incrassata (Jack) Kosterm.	Asian	phylogeogr.	Li et al. 2011
731		Dehaasia membranacea Kosterm.	Asian	phylogeogr.	Li et al. 2011
732		Dehaasia sp.1	Asian	phylogeogr.	Li et al. 2011
733		Endiandra clavigera Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
734		Endiandra macrophylla (Blume) Boerl.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
735		Endiandra rubescens (Blume) Miq.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
736		Endiandra scrobiculata Kosterm. ex Kochummen	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
737		Endiandra sp.1	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
738		Endiandra sp.2	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014

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739		Endiandra sp.3	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
740		Endiandra sp.4	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
741		Endiandra sulavesiana Kosterm.	Austr.	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
742		Eusideroxylon zwageri Teijsm. & Binn.	Asian	dated phyl.	Chanderbali et al 2001, Rohwer et al. 2014
743		Lindera apoensis Elmer	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
744		Lindera novoguineensis Kosterm.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
745		Lindera polyantha (Blume) Boerl.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
746		Litsea accedens (Blume) Boerl.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
747		Litsea angulata Blume	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
748		Litsea brachystachya Fern.-Vill.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
749		Litsea caulocarpa Merr.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
750		Litsea cordata (Jack) Hook.f.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
751		Litsea costata Boerl.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
752		Litsea cubeba (Lour.) Pers.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
753		Litsea cuprea Merr.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
754		Litsea diversifolia Blume	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
755		Litsea elliptica Blume	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
756		Litsea elongata (Nees) Hook.f.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
757		Litsea erectinervia Kosterm.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
758		Litsea firma (Blume) Hook.f.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
759		Litsea formanii Kosterm.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
760		Litsea grandis (Wall. ex Nees) Hook.f.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
761		Litsea guppyi (F. Muell.) F. Muell. ex Forman	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
762		Litsea lanceolata (Blume) Kosterm.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008

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763		Litsea longipes (Meisn.) Hook. f.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
764		Litsea luzonica (Blume) Fern.-Vill.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
765		Litsea mappacea (Blume) Boerl.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
766		Litsea noronhae (Blume)	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
767		Litsea ochracea (Blume) Boerl.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
768		Litsea pallida (Blume) Boerl.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
769		Litsea perrottetii (Blume) Fern.-Vill.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
770		Litsea quercoides Elmer	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
771		Litsea resinosa Blume	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
772		Litsea sarawacensis Gamble	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
773		Litsea sp.01	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
774		Litsea sp.02	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
775		Litsea sp.03	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
776		Litsea sp.04	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
777		Litsea sp.05	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
778		Litsea sp.06	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
779		Litsea sp.07	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
780		Litsea sp.09	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
781		Litsea sp.10	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
782		Litsea sp.11	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
783		Litsea sp.12	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
784		Litsea sp.13	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
785		Litsea sp.14	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
786		Litsea sp.15	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008

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787		Litsea sp.16	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
788		Litsea sp.17	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
789		Litsea sp.18	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
790		Litsea sp.19	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
791		Litsea sp.20	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
792		Litsea staintonii Kosterm.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
793		Litsea subumbelliflora (Blume) Ng	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
794		Litsea timoriana Span.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
795		Litsea tomentosa Blume	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
796		Machilus philippinensis Merr.	Asian	phylogeogr.	Li et al. 2011
797		Machilus rimosa (Blume) Blume	Asian	phylogeogr.	Li et al. 2011
798		Neolitsea cassia (L.) Kosterm.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
799		Neolitsea javanica (Blume) Backer	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
800		Neolitsea sp.1	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
801		Neolitsea sp.2	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
802		Actinodaphne multiflora Benth.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
803		Neolitsea villosa (Blume) Merr.	Asian	dated phyl., undated phyl.	Chanderbali et al. 2001, Li et al. 2004, 2008
804		Nothaphoebe albipes Kosterm. ined	Asian	phylogeogr.	Li et al. 2011
805		Nothaphoebe heterophylla Merr.	Asian	phylogeogr.	Li et al. 2011
806		Nothaphoebe kingiana Gamble	Asian	phylogeogr.	Li et al. 2011
807		Nothaphoebe sarawacensis Gamble	Asian	phylogeogr.	Li et al. 2011
808		Nothaphoebe sp.1	Asian	phylogeogr.	Li et al. 2011
809		Nothaphoebe sp.nov.	Asian	phylogeogr.	Li et al. 2011
810		Phoebe cf. grandis (Nees) Merr.	Asian	phylogeogr.	Li et al. 2011
811		Phoebe sp.1	Asian	phylogeogr.	Li et al. 2011
812		Phoebe sp.2	Asian	phylogeogr.	Li et al. 2011

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813		Phoebe cf. sterculioides (Elmer) Merr.	Asian	phylogeogr.	Li et al. 2011
814	Lecythidaceae	Barringtonia calyptrocalyx K.Schum.	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
815		Barringtonia lanceolata (Ridl.) Payens	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
816		Barringtonia longisepala Payens	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
817		Barringtonia sp.1	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
818		Barringtonia sp.2	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
819		Barringtonia sp.3	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
820		Lecythidaceae sp.	Asian	undated phyl., distr./fossils	Mori et al. 2007, Payens 1967
821	Loganiaceae	Geniostoma rupestre J.R.Forst. & G.Forst.	Austr.	dated phyl., distr./fossils	Conn 1980, Foster et al. 2014
822		Norrisia major Soler.	Austr.	undated phyl., distr./fossils	Frasier 2008, Tropicos 2015, Yang et al. 2016
823	Lythraceae	Duabanga moluccana Blume	Asian	phylogeogr., distr./fossils	Berger et al. 2017, Graham 2013
824		Lagerstroemia piriformis Koehne	Asian	phylogeogr., distr./fossils	Berger et al. 2017, Graham 2013
825		Lagerstroemia sp.	Asian	phylogeogr., distr./fossils	Berger et al. 2017, Graham 2013
826	Magnoliaceae	Magnolia beccarii (Ridl.) ined.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
827		Magnolia borneensis Noot.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
828		Magnolia carsonii Dandy ex Noot.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
829		Magnolia elegans (Blume) H.Keng	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
830		Magnolia liliifera (L.) Baill.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
831		Magnolia macklottii (Korth.) Dandy	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
832		Magnolia montana (Blume) Figlar	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
833		Magnolia persuaveolens Dandy	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
834		Magnolia sp.1	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
835		Magnolia sp.2	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
836		Magnolia sp.3	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008

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837		Magnolia sp.4	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
838		Magnolia sp.5	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
839		Magnolia sulawesiana Brambach et al.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
840		Magnolia sumatrana (Miq.) Figlar & Noot.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
841		Magnolia tsiampacca (L.) Figlar & Noot.	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
842		Magnolia utilis (Dandy) V.S.Kumar	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
843		Magnolia vrieseana (Miq.) Baill. ex Pierre	Asian	phylogeogr.	Noteboom 2011, Nie et al. 2008
844	Malvaceae	Coelostegia griffithii Benth.	Asian	phylogeogr.	Richardson et al. 2015
845		Diplodiscus paniculatus Turcz.	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
846		Durio acutifolius (Mast.) Kosterm.	Asian	phylogeogr.	Richardson et al. 2015
847		Durio excelsus (Korth.) Bakh.	Asian	phylogeogr.	Richardson et al. 2015
848		Durio kutejensis (Hassk.) Becc.	Asian	phylogeogr.	Richardson et al. 2015
849		Durio malaccensis Planch. ex Mast.	Asian	phylogeogr.	Richardson et al. 2015
850		Durio oxleyanus Griff.	Asian	phylogeogr.	Richardson et al. 2015
851		Durio sp.1	Asian	phylogeogr.	Richardson et al. 2015
852		Durio sp.2	Asian	phylogeogr.	Richardson et al. 2015
853		Durio zibethinus L.	Asian	phylogeogr.	Richardson et al. 2015
854		Firmiana malayana Kosterm.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
855		Grewia cinnamomifolia (Burret) Stapf ex P.S.Ashton	Asian	phylogeogr.	Richardson et al. 2015
856		Grewia multiflora Juss.	Asian	phylogeogr.	Richardson et al. 2015
857		Heritiera simplicifolia (Mast.) Kosterm.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
858		Heritiera sumatrana (Miq.) Kosterm.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
859		Microcos antidesmifolia (King) Burret	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
860		Microcos hirsuta (Korth.) Burret	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
861		Microcos sp.1	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
862		Microcos sp.2	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015

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863		Microcos sp.3	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
864		Microcos triflora (Blanco) R.C.K.Chung	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
865		Neesia altissima (Blume) Blume	Asian	phylogeogr.	Richardson et al. 2015
866		Pentace laxiflora Merr.	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
867		Pterospermum niveum S.Vidal	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
868		Pterospermum sp.	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
869		Pterospermum sp.1	Asian	phylogeogr., distr./fossils	Bayer & Kubitzki 2003, Richardson et al. 2015
870		Pterocymbium tinctorium (Blanco) Merr.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
871		Scaphium macropodum (Miq.) Beumée ex K.Heyne	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
872		Scaphium sp.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
873		Sterculia coccinea Jack	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
874		Sterculia insularis R.Br.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
875		Sterculia longifolia Vent.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
876		Sterculia oblongata R.Br.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
877		Sterculia rubiginosa Vent.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
878		Sterculia scortechinii King	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
879		Sterculia sp.1	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
880		Sterculia sp.2	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
881		Sterculia urceolata Sm.	Asian	phylogeogr.	Carter 2011, Richardson et al. 2015
882	Melastomataceae	Astronia acuminatissima Merr.	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
883		Astronia atroviridis Mansf.	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
884		Astrocalyx calycina Merr.	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
885		Astronia gitingensis Elmer	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
886		Astronia macrophylla Blume	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013

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887		Astronia sp.1	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
888		Astronia sp.2	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
889		Astronia spectabilis Blume	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
890		Astronia stapfii Koord.	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
891		Astronia viridifolia Elmer	Austr.	phylogeogr.	Berger et al. 2016, Penneys 2013
892		Medinilla sp.1	Asian	phylogeogr., distr./fossils	Berger et al. 2016, Bodegom & Veldkamp 2001
893		Melastoma sanguineum Sims	Asian	phylogeogr.	Veranso-Libalah et al. 2018
894		Memecylon brachybotrys Merr	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
895		Memecylon cumingii Naudin	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
896		Memecylon excelsum Blume	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
897		Memecylon lanceolatum	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
898		Memecylon minutiflorum Miq.	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
899		Memecylon oligoneurum Blume	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
900		Memecylon sp.1	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
901		Memecylon sp.2	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
902		Memecylon sp.3	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
903		Memecylon sp.4	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
904		Memecylon sp.5	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
905		Memecylon sp.6	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
906		Memecylon sp.7	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
907		Memecylon sp.8	Asian	phylogeogr.	Berger et al. 2016, Stone 2014
908		Pternandra azurea (DC.) Burkill	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
909		Pternandra caerulescens Jack	Asian	phylogeogr.	Berger et al. 2016, Renner 2004

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910		Pternandra cordata Baill.	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
911		Pternandra jackiana Ridl.	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
912		Pternandra rostrata M.P.Nayar	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
913		Pternandra sp.1	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
914		Pternandra sp.2	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
915		Pternandra sp.3	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
916		Pternandra sp.4	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
917		Pternandra tesellata M.P.Nayar	Asian	phylogeogr.	Berger et al. 2016, Renner 2004
918	Meliaceae	Aglaia argentea Blume	Asian	phylogeogr.	Grudinski et al. 2014
919		Aglaia edulis (Roxb.) Wall.	Asian	phylogeogr.	Grudinski et al. 2014
920		Aglaia elliptica (C.DC.) Blume	Asian	phylogeogr.	Grudinski et al. 2014
921		Aglaia grandis Korth. ex Miq.	Asian	phylogeogr.	Grudinski et al. 2014
922		Aglaia lancilimba Merr.	Asian	phylogeogr.	Grudinski et al. 2014
923		Aglaia leptantha Miq.	Asian	phylogeogr.	Grudinski et al. 2014
924		Aglaia leucophylla King	Asian	phylogeogr.	Grudinski et al. 2014
925		Aglaia luzoniensis (Vidal) Merr. & Rolfe	Asian	phylogeogr.	Grudinski et al. 2014
926		Aglaia malaccensis (Ridl.) Pannell	Asian	phylogeogr.	Grudinski et al. 2014
927		Aglaia odoratissima Blume	Asian	phylogeogr.	Grudinski et al. 2014
928		Aglaia oligophylla Miq.	Asian	phylogeogr.	Grudinski et al. 2014
929		Aglaia palembanica Miq.	Asian	phylogeogr.	Grudinski et al. 2014
930		Aglaia rimosa (Blanco) Merr.	Asian	phylogeogr.	Grudinski et al. 2014
931		Aglaia silvestris (M.Roem.) Merr.	Asian	phylogeogr.	Grudinski et al. 2014
932		Aglaia sp.01	Asian	phylogeogr.	Grudinski et al. 2014
933		Aglaia sp.02	Asian	phylogeogr.	Grudinski et al. 2014
934		Aglaia sp.03	Asian	phylogeogr.	Grudinski et al. 2014
935		Aglaia sp.04	Asian	phylogeogr.	Grudinski et al. 2014
936		Aglaia sp.05	Asian	phylogeogr.	Grudinski et al. 2014
937		Aglaia sp.06	Asian	phylogeogr.	Grudinski et al. 2014
938		Aglaia sp.07	Asian	phylogeogr.	Grudinski et al. 2014
939		Aglaia sp.08	Asian	phylogeogr.	Grudinski et al. 2014
940		Aglaia sp.09	Asian	phylogeogr.	Grudinski et al. 2014
941		Aglaia sp.10	Asian	phylogeogr.	Grudinski et al. 2014
942		Aglaia sp.11	Asian	phylogeogr.	Grudinski et al. 2014

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943		Aglaia sp.13	Asian	phylogeogr.	Grudinski et al. 2014
944		Aglaia spectabilis (Miq.) S.S.Jain & Bennet	Asian	phylogeogr.	Grudinski et al. 2014
945		Aglaia squamulosa King	Asian	phylogeogr.	Grudinski et al. 2014
946		Aglaia tomentosa Teijsm. & Binn.	Asian	phylogeogr.	Grudinski et al. 2014
947		Aphanamixis borneensis (Miq.) Merr.	Asian	phylogeogr.	Grudinski et al. 2014
948		Aphanamixis polystachya (Wall.) R.Parker	Asian	phylogeogr.	Grudinski et al. 2014
949		Azadirachta excelsa (Jack) Jacobs	Asian	phylogeogr.	Grudinski et al. 2014
950		Chisocheton cumingianus (C.DC.) Harms	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
951		Chisocheton medusae Airy Shaw	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
952		Chisocheton patens Blume	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
953		Chisocheton pentandrus (Blanco) Merr.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
954		Chisocheton sp.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
955		Dysoxylum acutangulum Miq.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
956		Dysoxylum alliaceum (Blume) Blume	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
957		Dysoxylum arborescens (Blume) Miq.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
958		Dysoxylum cauliflorum Hiern	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
959		Dysoxylum cumingianum C.DC.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
960		Dysoxylum cyrtobotryum Miq.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
961		Dysoxylum densiflorum (Blume) Miq.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
962		Dysoxylum excelsum Blume	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
963		Dysoxylum macrocarpum Blume	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
964		Dysoxylum nutans (Blume) Miq.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
965		Dysoxylum parasiticum (Osbeck) Kosterm.	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
966		Dysoxylum rugulosum King	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
967		Dysoxylum sp.1	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015

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968		Dysoxylum sp.2	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015
969		Meliaceae sp.1	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015, Muellner-Riehl et al. 2016
970		Meliaceae sp.2	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015, Muellner-Riehl et al. 2016
971		Meliaceae sp.3	Asian	phylogeogr.	Koenen 2011, Koenen et al. 2015, Muellner-Riehl et al. 2016
972		Reinwardtiodendron humile (Hassk.) Mabb.	Asian	phylogeogr.	Grudinski et al. 2014
973		Reinwardtiodendron sp.1	Asian	phylogeogr.	Grudinski et al. 2014
974		Sandoricum borneense Miq.	Asian	phylogeogr.	Koenen 2011, Muellner-Riehl et al. 2016
975		Sandoricum koetjape (Burm.f.) Merr.	Asian	phylogeogr.	Koenen 2011, Muellner-Riehl et al. 2016
976		Toona calantas Merr. & Rolfe	Asian	phylogeogr.	Koecke et al. 2013, Muellner et al. 2006
977		Toona sureni (Blume) Merr.	Asian	phylogeogr.	Koecke et al. 2013, Muellner et al. 2006
978	Metteniusaceae	Platea excelsa Blume	Asian	undated phyl., distr./fossils	Manchester et al. 2015, Potgieter + Duno 2016, Stull et al. 2015
979		Platea latifolia Blume	Asian	undated phyl., distr./fossils	Manchester et al. 2015, Potgieter + Duno 2016, Stull et al. 2015
980	Monimiaceae	Kibara coriacea (Blume) Tul.	Austr.	phylogeogr.	Renner et al. 2010
981		Levieria montana Becc.	Austr.	phylogeogr.	Renner et al. 2010
982		Matthaea sancta Blume	Austr.	phylogeogr.	Renner et al. 2010
983		Steganthera hirsuta (Warb.) Perkins	Austr.	phylogeogr.	Renner et al. 2010
984	Moraceae	Antiaris toxicaria Lesch.	Asian	phylogeogr.	Zerega et al. 2005
985		Artocarpus chama Buch.-Ham.	Asian	phylogeogr.	Zerega et al. 2005
986		Artocarpus dadah Miq.	Asian	phylogeogr.	Zerega et al. 2005
987		Artocarpus elasticus Reinw. ex Blume	Asian	phylogeogr.	Zerega et al. 2005
988		Artocarpus gomezianus Wall. ex Trécul	Asian	phylogeogr.	Zerega et al. 2005
989		Artocarpus integer (Thunb.) Merr.	Asian	phylogeogr.	Zerega et al. 2005
990		Artocarpus kemando Miq.	Asian	phylogeogr.	Zerega et al. 2005
991		Artocarpus lacucha Roxb. ex Buch.-Ham.	Asian	phylogeogr.	Zerega et al. 2005

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992		Artocarpus lanceifolius Roxb.	Asian	phylogeogr.	Zerega et al. 2005
993		Artocarpus nitidus Trécul	Asian	phylogeogr.	Zerega et al. 2005
994		Artocarpus odoratissimus Blanco	Asian	phylogeogr.	Zerega et al. 2005
995		Artocarpus ovatus Blanco	Asian	phylogeogr.	Zerega et al. 2005
996		Artocarpus rigidus Blume	Asian	phylogeogr.	Zerega et al. 2005
997		Artocarpus sp.1	Asian	phylogeogr.	Zerega et al. 2005
998		Artocarpus sp.2	Asian	phylogeogr.	Zerega et al. 2005
999		Artocarpus sp.3	Asian	phylogeogr.	Zerega et al. 2005
1000		Artocarpus tamaran Becc.	Asian	phylogeogr.	Zerega et al. 2005
1001		Artocarpus teysmannii Miq.	Asian	phylogeogr.	Zerega et al. 2005
1002		Artocarpus tomentosulus F.M.Jarrett	Asian	phylogeogr.	Zerega et al. 2005
1003		Ficus ampelas Burm.f.	Asian	phylogeogr.	Cruaud et al. 2012
1004		Ficus annulata Blume	Asian	phylogeogr.	Cruaud et al. 2012
1005		Ficus balete Merr.	Asian	phylogeogr.	Cruaud et al. 2012
1006		Ficus beccarii King	Asian	phylogeogr.	Cruaud et al. 2012
1007		Ficus benjamina L.	Asian	phylogeogr.	Cruaud et al. 2012
1008		Ficus botryocarpa Miq.	Asian	phylogeogr.	Cruaud et al. 2012
1009		Ficus buntaensis C.C.Berg	Asian	phylogeogr.	Cruaud et al. 2012
1010		Ficus callosa Willd.	Asian	phylogeogr.	Cruaud et al. 2012
1011		Ficus chrysolepis Miq.	Asian	phylogeogr.	Cruaud et al. 2012
1012		Ficus congesta Roxb.	Asian	phylogeogr.	Cruaud et al. 2012
1013		Ficus crassiramea (Miq.) Miq.	Asian	phylogeogr.	Cruaud et al. 2012
1014		Ficus drupacea Thunb.	Asian	phylogeogr.	Cruaud et al. 2012
1015		Ficus fistulosa Reinw. ex Blume	Asian	phylogeogr.	Cruaud et al. 2012
1016		Ficus grossularioides Burm.f.	Asian	phylogeogr.	Cruaud et al. 2012
1017		Ficus gul K.Schum. & Lauterb.	Asian	phylogeogr.	Cruaud et al. 2012
1018		Ficus heteropleura Blume	Asian	phylogeogr.	Cruaud et al. 2012
1019		Ficus lumutana C.C.Berg	Asian	phylogeogr.	Cruaud et al. 2012
1020		Ficus minahassae (Teijsm. & Vriese) Miq.	Asian	phylogeogr.	Cruaud et al. 2012
1021		Ficus montana Burm.f.	Asian	phylogeogr.	Cruaud et al. 2012
1022		Ficus nervosa B.Heyne ex Roth	Asian	phylogeogr.	Cruaud et al. 2012
1023		Ficus nota (Blanco) Merr.	Asian	phylogeogr.	Cruaud et al. 2012
1024		Ficus punctata Thunb.	Asian	phylogeogr.	Cruaud et al. 2012
1025		Ficus ribes Reinw. ex Blume	Asian	phylogeogr.	Cruaud et al. 2012
1026		Ficus septica Burm.f.	Asian	phylogeogr.	Cruaud et al. 2012
1027		Ficus sp.1	Asian	phylogeogr.	Cruaud et al. 2012
1028		Ficus sp.2	Asian	phylogeogr.	Cruaud et al. 2012

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1029		Ficus sp.3	Asian	phylogeogr.	Cruaud et al. 2012
1030		Ficus sp.4	Asian	phylogeogr.	Cruaud et al. 2012
1031		Ficus sp.5	Asian	phylogeogr.	Cruaud et al. 2012
1032		Ficus sp.6	Asian	phylogeogr.	Cruaud et al. 2012
1033		Ficus sp.7	Asian	phylogeogr.	Cruaud et al. 2012
1034		Ficus sp.8	Asian	phylogeogr.	Cruaud et al. 2012
1035		Ficus sp.9	Asian	phylogeogr.	Cruaud et al. 2012
1036		Ficus tinctoria G.Forst.	Asian	phylogeogr.	Cruaud et al. 2012
1037		Ficus ulmifolia Lam.	Asian	phylogeogr.	Cruaud et al. 2012
1038		Ficus variegata Blume	Asian	phylogeogr.	Cruaud et al. 2012
1039		Ficus villosa Blume	Asian	phylogeogr.	Cruaud et al. 2012
1040		Parartocarpus venenosus (Zoll. & Moritzi) Becc.	Asian	phylogeogr.	Zerega et al. 2005
1041		Streblus glaber (Merr.) Corner	Asian	phylogeogr.	Zerega et al. 2005
1042		Streblus ilicifolius (Vidal) Corner	Asian	phylogeogr.	Zerega et al. 2005
1043		Trophis philippinensis (Bureau) Corner	Asian	phylogeogr.	Zerega et al. 2005
1044	Myricaceae	Morella javanica (Blume) I.M.Turner	Asian	phylogeogr.	Herbert 2005
1045	Myristicaceae	Gymnacranthera contracta Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1046		Gymnacranthera farquhariana (Wall. ex Hook.f. & Thomson) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1047		Gymnacranthera forbesii (King) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1048		Gymnacranthera sp.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1049		Horsfieldia borneensis W.J.de Wilde	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1050		Horsfieldia costulata (Miq.) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1051		Horsfieldia crassifolia (Hook.f. & Thomson) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1052		Horsfieldia glabra (Blume) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1053		Horsfieldia irya (Gaertn.) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1054		Horsfieldia parviflora (Roxb.) J.Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1055		Horsfieldia polyspherula (Hook.f. ex King) J.Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1056		Horsfieldia punctatifolia J.Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008

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1057		Horsfieldia reticulata Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1058		Horsfieldia sp.1	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1059		Horsfieldia sp.2	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1060		Horsfieldia sp.3	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1061		Horsfieldia spicata (Roxb.) J.Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1062		Horsfieldia subalpina J.Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1063		Horsfieldia tomentosa Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1064		Horsfieldia wallichii (Hook.f. & Thomson) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1065		Knema cinerea (Poir.) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1066		Knema conferta (King) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1067		Knema intermedia (Blume) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1068		Knema kinabaluensis J.Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1069		Knema korthalsii Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1070		Knema latericia Elmer	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1071		Knema laurina (Blume) Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1072		Knema linguiformis (J.Sinclair) W.J.de Wilde	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1073		Knema membranifolia H.J.P.Winkl.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1074		Knema oblongata Merr.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1075		Knema percoriacea Sinclair	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1076		Knema sp.1	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1077		Knema sp.2	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1078		Knema sp.3	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1079		Knema sp.4	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008

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1080		Knema stellata Merr.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1081		Myristica borneensis Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1082		Myristica cumingii Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1083		Myristica elliptica Wall. ex Hook.f. & Thomson	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1084		Myristica iners Blume	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1085		Myristica maxima Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1086		Myristica mindanaensis Warb.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1087		Myristica philippensis Lam.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1088		Myristica simiarum A.DC.	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1089		Myristicaceae sp.1	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1090		Myristicaceae sp.2	Asian	phylogeogr., distr./fossils	Doyle et al. 2004, 2008
1091	Myrtaceae	Decaspermum fruticosum J.R.Forst. & G.Forst.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1092		Leptospermum javanicum Blume	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1093		Leptospermum recurvum Hook.f.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1094		Myrtaceae sp.1	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1095		Myrtaceae sp.2	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1096		Myrtaceae sp.3	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1097		Rhodamnia cinerea Jack	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1098		Syzygium acuminatissimum (Blume) DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1099		Syzygium antisepticum (Blume) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1100		Syzygium aphanomyrtoides Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1101		Syzygium arcuatinervium (Merr.) Craven & Biffin	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1102		Syzygium aff. baeuerlenii (F.Muell.) Craven & Biffin	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1103		Syzygium sp. nov.3	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1104		Syzygium bankense (Hassk.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1105		Syzygium benjaminum Diels	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1106		Syzygium castaneum (Merr.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1107		Syzygium caudatilimbum (Merr.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1108		Syzygium celebicum (Blume) Widodo	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1109		Syzygium chloranthum (Duthie) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1110		Syzygium clavellatum (Merr.) Merr.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1111		Syzygium confertum (Korth.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1112		Syzygium corymbosum (Blume) DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1113		Syzygium cuneiforme Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1114		Syzygium decipiens (Koord. & Valeton) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1115		Syzygium effusum (A.Gray) Müll.Berol.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1116		Syzygium elliptilimbum (Merr.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1117		Syzygium fastigiatum (Blume) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1118		Syzygium filiforme Chantar. & J.Parn.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1119		Syzygium flosculiferum (M.R.Hend.) Sreek.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1120		Syzygium sp. nov.4	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1121		Syzygium garciae (Merr.) Merr.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1122		Syzygium glabratum (DC.) Veldkamp	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1123		Syzygium grande (Wight) Walp.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1124		Syzygium griffithii (Duthie) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1125		Syzygium havilandii (Merr.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1126		Syzygium hirtum (Korth.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1127		Syzygium houttuynii Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1128		Syzygium kinabaluense (Stapf) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1129		Syzygium kunstleri (King) Bahadur & R.C.Gaur	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1130		Syzygium laxiflorum (Blume) DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1131		Syzygium cf. leptopodium Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1132		Syzygium leucocladum Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1133		Syzygium lineatum (DC.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1134		Syzygium magnoliifolium (Blume) DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1135		Syzygium mainitense (Elmer) Merr.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1136		Syzygium medium (Korth.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1137		Syzygium myrtilloides Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1138		Syzygium napiforme (Koord. & Valeton) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1139		Syzygium nervosum A.Cunn. ex DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1140		Syzygium nigricans (King) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1141		Syzygium nitidum Benth.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1142		Syzygium oligomyrum Diels	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1143		Syzygium pachysepalum Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1144		Syzygium palawanense (C.B.Rob.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1145		Syzygium paraiense Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1146		Syzygium paucipunctatum (Koord. & Valeton) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1147		Syzygium perspicuinervium (Merr.) Masam.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1148		Syzygium petakense Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1149		Syzygium phaeostictum Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1150		Syzygium polyanthum (Wight) Walp.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1151		Syzygium pterophorum Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1152		Syzygium punctilimbum (Merr.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1153		Syzygium pycnanthum Merr. & L.M.Perr	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1154		Syzygium racemosum (Blume) DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1155		Syzygium aff. rosenbluthii (C.B.Rob.) Merr.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1156		Syzygium scortechinii (King) Chantar. & J.Parn.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1157		Syzygium sp.01	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1158		Syzygium sp.02	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1159		Syzygium sp.03	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1160		Syzygium sp.04	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1161		Syzygium sp.05	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1162		Syzygium sp.06	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1163		Syzygium sp.07	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1164		Syzygium sp.08	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1165		Syzygium sp.09	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1166		Syzygium sp.10	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1167		Syzygium sp.11	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1168		Syzygium sp.12	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1169		Syzygium sp.13	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1170		Syzygium sp.14	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1171		Syzygium sp.15	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1172		Syzygium sp.16	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1173		Syzygium sp.17	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1174		Syzygium sp.18	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1175		Syzygium sp.19	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1176		Syzygium sp.20	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1177		Syzygium sp.21	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1178		Syzygium sp.22	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1179		Syzygium sp.23	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1180		Syzygium sp.24	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1181		Syzygium sp.25	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1182		Syzygium sp.26	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1183		Syzygium sp.27	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1184		Syzygium sp.28	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1185		Syzygium sp.29	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1186		Syzygium sp.30	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1187		Syzygium sp.31	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1188		Syzygium sp.32	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1189		Syzygium sp.33	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1190		Syzygium sp.34	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1191		Syzygium sp.35	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1192		Syzygium sp.36	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1193		Syzygium sp.37	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1194		Syzygium sp.38	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1195		Syzygium sp.39	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1196		Syzygium sp.40	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1197		Syzygium sp.41	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1198		Syzygium sp.42	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1199		Syzygium sp.43	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1200		Syzygium sp.44	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1201		Syzygium sp.45	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1202		Syzygium sp.46	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1203		Syzygium sp.48	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1204		Syzygium sp.49	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1205		Syzygium sp.50	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1206		Syzygium sp.51	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1207		Syzygium sp.52	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1208		Syzygium sp.53	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1209		Syzygium sp.54	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1210		Syzygium sp.55	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1211		Syzygium sp.56	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1212		Syzygium sp.57	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1213		Syzygium sp.58	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1214		Syzygium sp.59	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1215		Syzygium sp.60	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1216		Syzygium sp.61	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1217		Syzygium sp.62	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1218		Syzygium steenisii Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1219		Syzygium stipulare (Blume) Craven & T.G.Hartley	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1220		Syzygium subcrenatum Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1221		Syzygium suringarianum (Koord. & Valeton) Amshoff	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1222		Syzygium tawahense (Korth.) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1223		Syzygium tripinnatum (Blanco) Merr.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1224		Syzygium valdevenosum (Duthie) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1225		Syzygium viridifolium (Elmer) Merr. & L.M.Perry	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1226		Syzygium zeylanicum (L.) DC.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015

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1227		Tristaniopsis elliptica (Stapf) Peter G.Wilson & J.T.Waterh.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1228		Tristaniopsis obovata (Benn.) Peter G.Wilson & J.T.Waterh.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1229		Tristaniopsis sp.1	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1230		Tristaniopsis sp.2	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1231		Tristaniopsis sp.3	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1232		Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1233		Xanthomyrtus angustifolia A.J.Scott	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1234		Xanthomyrtus diplycosiifolia (C.B.Rob.) Merr.	Austr.	phylogeogr.	Berger et al. 2016, Sytsma et al. 2004, Thornhill et al. 2015
1235	Nyctaginaceae	Pisonia umbellifera (J.R. Forst. & G. Forst.) Seem.	Austr.	dated phyl., distr./fossils	Douglas & Spellenberg 2010, Hayward & Horton, 2014, Stemmerik 1964
1236	Nyssaceae	Mastixia pentandra Blume	Asian	dated phyl., distr./fossils	Matthew 1976, Xiang et al. 2011
1237		Mastixia rostrata Blume	Asian	dated phyl., distr./fossils	Matthew 1976, Xiang et al. 2011
1238		Mastixia sp.1	Asian	dated phyl., distr./fossils	Matthew 1976, Xiang et al. 2011
1239		Mastixia sp.2	Asian	dated phyl., distr./fossils	Matthew 1976, Xiang et al. 2011
1240		Mastixia trichotoma Blume	Asian	dated phyl., distr./fossils	Matthew 1976, Xiang et al. 2011
1241	Ochnaceae	Brackenridgea palustris Bartell.	Asian	phylogeogr.	Bissiengou 2014
1242		Brackenridgea sp.	Asian	phylogeogr.	Bissiengou 2014
1243	Olacaceae	Anacolosa frutescens (Blume) Blume	Asian	dated phyl., distr./fossils	Malécot & Lobreau-Callen 2005, Sleumer 1980, Vidal-Russell & Nickrent 2008
1244		Ochanostachys amentacea Mast.	Asian	dated phyl., distr./fossils	Magallón et al. 2015, Nickrent et al. 2010

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1245		Scorodocarpus borneensis (Baill.) Becc.	Asian	dated phyl., distr./fossils	Nickrent et al. 2010, Su et al. 2015, Vidal-Russell & Nickrent 2008
1246		Strombosia ceylanica Gardner	Asian	dated phyl., distr./fossils	Nickrent et al. 2010, Su et al. 2015, Vidal-Russell & Nickrent 2008
1247	Oleaceae	Chionanthus celebicus Koord.	Asian	dated phyl.	Hong-Wa & Besnard 2013
1248		Chionanthus crispus Kiew	Asian	dated phyl.	Hong-Wa & Besnard 2013
1249		Chionanthus nitens Koord. & Valeton	Asian	dated phyl.	Hong-Wa & Besnard 2013
1250		Chionanthus polygamus (Roxb.) Kiew	Asian	dated phyl.	Hong-Wa & Besnard 2013
1251		Chionanthus ramiflorus Roxb.	Asian	dated phyl.	Hong-Wa & Besnard 2013
1252		Chionanthus sp.	Asian	dated phyl.	Hong-Wa & Besnard 2013
1253		Chionanthus sp.1	Asian	dated phyl.	Hong-Wa & Besnard 2013
1254		Chionanthus sp.2	Asian	dated phyl.	Hong-Wa & Besnard 2013
1255		Chionanthus spicatus Blume	Asian	dated phyl.	Hong-Wa & Besnard 2013
1256		Chionanthus sulawesicus Kiew	Asian	dated phyl.	Hong-Wa & Besnard 2013
1257		Ligustrum glomeratum Blume	Asian	dated phyl.	Li et al. 2002, 2012
1258		Olea javanica (Blume) Knobl.	Asian	dated phyl.	Besnard et al. 2009
1259		Olea rubrovenia (Elmer) Kiew	Asian	dated phyl.	Besnard et al. 2009
1260	Pandanaceae	Pandanus cf. brachyspathus Martelli	Asian	phylogeogr.	Gallaher et al. 2015
1261		Pandanus sulawesicus B.C.Stone	Asian	phylogeogr.	Gallaher et al. 2015
1262	Paracryphiaceae	Quintinia apoensis (Elmer) Schltr.	Austr.	phylogeogr.	Beaulieu et al. 2013
1263		Sphenostemon papuanus (Lauterb.) Steenis & Erdtman	Austr.	phylogeogr.	Beaulieu et al. 2013
1264	Pentaphylacaceae	Adinandra acuminata Korth.	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1265		Adinandra borneensis Kobuski	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1266		Adinandra celebica Koord.	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016

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1267		Adinandra clemensiae Kobuski	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1268		Adinandra cordifolia Ridl.	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1269		Adinandra dumosa Jack	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1270		Adinandra elliptica C.B.Rob.	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1271		Adinandra excelsa Korth.	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1272		Adinandra eymae Kobuski	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1273		Adinandra luzonica Merr.	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1274		Adinandra masambensis Kobuski	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1275		Adinandra sp.1	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1276		Adinandra sp.2	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1277		Adinandra sp.3	Asian	undated phyl., distr./fossils	Kobuski 1947, Tsou et al. 2016
1278		Eurya acuminata DC.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1279		Eurya chinensis R.Br.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1280		Eurya coriacea Merr.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1281		Eurya glabra (Blume) Korth.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1282		Eurya obovata (Blume) Korth.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1283		Eurya sp.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1284		Eurya trichocarpa Korth.	Asian	undated phyl., distr./fossils	de Wit 1947, Tsou et al. 2016
1285		Ternstroemia coriacea Scheff.	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004
1286		Ternstroemia elongata (Korth.) Koord.	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004
1287		Ternstroemia lowii Stapf	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004
1288		Ternstroemia philippinensis Merr.	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004
1289		Ternstroemia sp.	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004
1290		Ternstroemia toquian Fern.-Vill.	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004

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1291		Ternstroemia urdanetensis (Elmer) Kobuski	Asian	undated phyl., distr./fossils	Tsou et al. 2016, Weitzman et al. 2004
1292	Peraceae	Trigonopleura malayana Hook.f.	Asian	dated phyl., distr./fossils	van Welzen & Esser 2013, Xi et al. 2012
1293	Phyllanthaceae	Antidesma excavatum Miq.	Asian	dated phyl., distr./fossils	Li et al. 2009, WCSP 2017
1294		Antidesma neurocarpum Miq.	Asian	dated phyl., distr./fossils	Li et al. 2009, WCSP 2017
1295		Antidesma tetrandrum Blume	Asian	dated phyl., distr./fossils	Li et al. 2009, WCSP 2017
1296		Antidesma velutinosum Blume	Asian	dated phyl., distr./fossils	Li et al. 2009, WCSP 2017
1297		Aporosa antennifera (Airy Shaw) Airy Shaw	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1298		Aporosa arborea (Blume) Müll.Arg.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1299		Aporosa elmeri Merr.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1300		Aporosa falcifera Hook.f.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1301		Aporosa frutescens Blume	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1302		Aporosa grandistipula Merr.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1303		Aporosa lagenocarpa Airy Shaw	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1304		Aporosa lucida (Miq.) Airy Shaw	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1305		Aporosa lunata (Miq.) Kurz	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1306		Aporosa maingayi Hook.f.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1307		Aporosa sp.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1308		Aporosa sp.1	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1309		Aporosa sp.2	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1310		Aporosa sp.3	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1311		Aporosa sphaeridiophora Merr.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1312		Aporosa stellifera Hook.f.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1313		Aporosa subcaudata Merr.	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1314		Aporosa symplocoides (Hook.f.) Gage	Asian	phylogeogr.	Li et al. 2009, Schot 1998
1315		Baccaurea brevipes Hook.f.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1316		Baccaurea deflexa Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1317		Baccaurea dulcis (Jack) Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1318		Baccaurea lanceolata (Miq.) Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009

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1319		Baccaurea macrocarpa (Miq.) Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1320		Baccaurea multiflora Burck ex J.J.Sm.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1321		Baccaurea nanihua Merr.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1322		Baccaurea odoratissima Elmer	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1323		Baccaurea pubera (Miq.) Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1324		Baccaurea racemosa (Reinw. ex Blume) Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1325		Baccaurea sp.1	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1326		Baccaurea sp.2	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1327		Baccaurea sp.3	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1328		Baccaurea sp.4	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1329		Baccaurea tetrandra (Baill.) Müll.Arg.	Asian	phylogeogr., dated phyl.	Haegens 2000, Li et al. 2009
1330		Bischofia javanica Blume	Asian	dated phyl., distr./fossils	Li et al. 2009, van Welzen 2016
1331		Breynia sp.	Asian	phylogeogr.	van Welzen et al. 2015
1332		Bridelia glauca Blume	Asian	phylogeogr.	Li et al. 2009
1333		Bridelia insulana Hance	Asian	phylogeogr.	Li et al. 2009
1334		Bridelia sp.	Asian	phylogeogr.	Li et al. 2009
1335		Cleistanthus sp.	Asian	phylogeogr.	Li et al. 2009
1336		Glochidion cyrtostylum Miq.	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1337		Glochidion insectum Airy Shaw	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1338		Glochidion lucidum Blume	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1339		Glochidion macrocarpum Blume	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1340		Glochidion moluccanum Blume	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1341		Glochidion rubrum Blume	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1342		Glochidion sp.1	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1343		Glochidion sp.2	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009
1344		Glochidion sp.3	Asian	phylogeogr.	Hembry et al. 2013, Li et al. 2009

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1345	Pittosporaceae	Pittosporum pentandrum (Blanco) Merr.	Austr.	phylogeogr.	Beaulieu et al. 2013, Chandler et al. 2007
1346	Polygalaceae	Xanthophyllum adenotus Miq.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1347		Xanthophyllum discolor Chodat	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1348		Xanthophyllum flavescens Roxb.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1349		Xanthophyllum montanum Meijden	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1350		Xanthophyllum obscurum A.W.Benn.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1351		Xanthophyllum parvum Chodat	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1352		Xanthophyllum penibukanense Heine	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1353		Xanthophyllum purpureum Ridl.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1354		Xanthophyllum rufum A.W.Benn.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1355		Xanthophyllum sp.1	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1356		Xanthophyllum sp.2	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1357		Xanthophyllum sp.3	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1358		Xanthophyllum sp.4	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1359		Xanthophyllum sp.5	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1360		Xanthophyllum stipitatum A.W.Benn.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001

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1361		Xanthophyllum tenue Chodat	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1362		Xanthophyllum velutinum Chodat	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1363		Xanthophyllum vitellinum (Blume) D.Dietr.	Austr.	dated phyl., distr./fossils	Forest et al. 2007, van der Meijden 1988, Persson 2001
1364	Primulaceae	Ardisia copelandii Mez	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1365		Ardisia darlingii Merr.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1366		Ardisia elliptica Thunb.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1367		Ardisia javanica A.DC.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1368		Ardisia macrophylla Reinw. ex Blume	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1369		Ardisia paniculata Roxb.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1370		Ardisia pterocaulis Miq.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1371		Ardisia sanguinolenta Blume	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1372		Ardisia sp.1	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1373		Ardisia sp.2	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1374		Ardisia sp.3	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1375		Ardisia sp.4	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1376		Ardisia tayabensis Merr.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009

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1377		Ardisia ternatensis Scheff.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1378		Ardisia tuberculata Wall. ex A.DC.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1379		Embelia sp.	Asian	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1380		Myrsine affinis A.DC.	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1381		Myrsine amorosoana Pipoly	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1382		Myrsine avenis (Blume) A.DC.	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1383		Myrsine forbesii (Mez) Pipoly	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1384		Myrsine hasseltii Blume ex Scheff.	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1385		Myrsine involucrata (Mez) Pipoly	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1386		Myrsine minutifolia (Knoester et al.) Pipoly	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1387		Myrsine cf. rawacensis A.DC.	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1388		Myrsine sp.	Austr.	dated phyl., distr./fossils	Ståhl & Anderberg 2004, Strijk et al. 2014, Yesson et al. 2009
1389	Proteaceae	Heliciopsis artocarpoides (Elmer) Sleumer	Austr.	undated phyl.	Weston & Barker 2006
1390		Helicia attenuata (Jack) Blume	Austr.	phylogeogr.	Barker et al. 2007
1391		Helicia celebica Sleumer	Austr.	phylogeogr.	Barker et al. 2007
1392		Helicia excelsa (Roxb.) Blume	Austr.	phylogeogr.	Barker et al. 2007
1393		Helicia petiolaris Benn.	Austr.	phylogeogr.	Barker et al. 2007
1394		Helicia robusta (Roxb.) R.Br. ex Blume	Austr.	phylogeogr.	Barker et al. 2007
1395		Helicia serrata (R.Br.) Blume	Austr.	phylogeogr.	Barker et al. 2007

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1396		Helicia sp.1	Austr.	phylogeogr.	Barker et al. 2007
1397		Helicia sp.2	Austr.	phylogeogr.	Barker et al. 2007
1398		Helicia sp.3	Austr.	phylogeogr.	Barker et al. 2007
1399		Lasjia hildebrandii (Steenis) P.H.Weston & A.R.Mast	Austr.	phylogeogr.	Mast et al. 2008
1400	Putranjivaceae	Drypetes kikir Airy Shaw	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1401		Drypetes longifolia (Blume) Pax & K.Hoffm.	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1402		Drypetes microphylla (Merr.) Pax & K.Hoffm.	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1403		Drypetes minahassae (Boerl. & Koord.) Pax & K.Hoffm.	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1404		Drypetes pendula Ridl.	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1405		Drypetes polyneura Airy Shaw	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1406		Drypetes sibuyanensis (Elmer) Pax & K.Hoffm.	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1407		Drypetes sp.1	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1408		Drypetes sp.2	Asian	phylogeogr., distr./fossils	Davis et al. 2005, Levin 2014, Xi et al. 2012
1409	Rhamnaceae	Alphitonia excelsa (Fenzl) Reissek ex Benth.	Austr.	phylogeogr.	Hauenschild et al. 2018
1410		Ziziphus angustifolia (Miq.) Hatus. ex Steenis	Asian	phylogeogr.	Hauenschild et al. 2018
1411		Ziziphus suluensis Merr.	Asian	phylogeogr.	Hauenschild et al. 2018
1412		Zizyphus sp.	Asian	phylogeogr.	Hauenschild et al. 2018
1413	Rhizophoraceae	Gynotroches axillaris Blume	Asian	dated phyl., distr./fossils	Graham 2006, Hou 1958, Sun et al. 2016, Xu et al. 2017
1414		Pellacalyx pustulatus Merr.	Asian	dated phyl., distr./fossils	Graham 2006, Hou 1958, Sun et al. 2016, Xu et al. 2017
1415	Rosaceae	Prunus arborea (Blume) Kalkman	Asian	phylogeogr.	Chin et al. 2014
1416		Prunus beccarii (Ridl.) Kalkman	Asian	phylogeogr.	Chin et al. 2014
1417		Prunus fragrans (Elmer) Kalkman	Asian	phylogeogr.	Chin et al. 2014
1418		Prunus grisea (Blume ex Müll.Berol.) Kalkman	Asian	phylogeogr.	Chin et al. 2014
1419		Prunus mirabilis Kalkman	Asian	phylogeogr.	Chin et al. 2014
1420		Prunus oocarpa (Stapf) Kalkman	Asian	phylogeogr.	Chin et al. 2014

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1421		Prunus rubiginosa (Elmer) Kalkman	Asian	phylogeogr.	Chin et al. 2014
1422		Prunus sp.1	Asian	phylogeogr.	Chin et al. 2014
1423		Prunus sp.2	Asian	phylogeogr.	Chin et al. 2014
1424		Prunus sp.3	Asian	phylogeogr.	Chin et al. 2014
1425		Prunus sp.4	Asian	phylogeogr.	Chin et al. 2014
1426		Rosaceae sp.	Asian	phylogeogr.	Campbell et al. 2007, Chin et al. 2014, Guo et al. 2011
1427	Rubiaceae	Adina multifolia Havil.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1428		Adina sp.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1429		Aidia corymbosa (Blume) K.M.Wong	Asian	phylogeogr.	Kainulainen et al. 2017
1430		Aidia racemosa (Cav.) Tirveng.	Asian	phylogeogr.	Kainulainen et al. 2017
1431		Canthium confertum Korth.	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1432		Canthium sp.1	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1433		Canthium sp.2	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1434		Diplospora tinagoensis (Elmer) Ali & Robbr.	Asian	phylogeogr.	Kainulainen et al. 2017
1435		Discospermum abnorme (Korth.) Ali & Robbr.	Asian	phylogeogr.	Kainulainen et al. 2017
1436		Gardenia forsteniana Miq.	Asian	phylogeogr.	Kainulainen et al. 2017
1437		Gardenia jasminoides J.Ellis	Asian	phylogeogr.	Kainulainen et al. 2017
1438		Gardenia sp.1	Asian	phylogeogr.	Kainulainen et al. 2017
1439		Gardenia sp.2	Asian	phylogeogr.	Kainulainen et al. 2017
1440		Gardenia sp.3	Asian	phylogeogr.	Kainulainen et al. 2017
1441		Gardenia tubifera Wall. ex Roxb.	Asian	phylogeogr.	Kainulainen et al. 2017
1442		Randia sp.	Asian	phylogeogr.	Kainulainen et al. 2017
1443		Randia sp.	Asian	phylogeogr.	Kainulainen et al. 2017
1444		Hypobathrum frutescens Blume	Asian	phylogeogr.	Kainulainen et al. 2017
1445		Lasianthus laevigatus Blume	Asian	phylogeogr.	Smedmark et al. 2014
1446		Lasianthus latifolius Blume ex Miq.	Asian	phylogeogr.	Smedmark et al. 2014
1447		Lasianthus sp.	Asian	phylogeogr.	Smedmark et al. 2014
1448		Lasianthus sp.1	Asian	phylogeogr.	Smedmark et al. 2014
1449		Lasianthus sp.2	Asian	phylogeogr.	Smedmark et al. 2014
1450		Nauclea sp.1	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012

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1451		Nauclea sp.2	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1452		Nauclea subdita (Korth.) Steud.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1453		Neonauclea calycina (Bartl. ex DC.) Merr.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1454		Neonauclea excelsa (Blume) Merr.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1455		Neonauclea lanceolata (Blume) Merr.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1456		Neonauclea media (Havil.) Merr.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1457		Neonauclea sp.	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1458		Neonauclea sp.1	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1459		Neonauclea sp.2	Asian	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1460		Porterandia anisophylla (Jack ex Roxb.) Ridl.	Asian	phylogeogr.	Kainulainen et al. 2017
1461		Porterandia celebica M.S.Zahid	Asian	phylogeogr.	Kainulainen et al. 2017
1462		Psychotria sp.1	Asian	phylogeogr.	Razafimandimbison et al. 2017
1463		Psychotria sp.2	Asian	phylogeogr.	Razafimandimbison et al. 2017
1464		Psychotria sp.nov.2	Asian	phylogeogr.	Razafimandimbison et al. 2017
1465		Psydrax glabra (Blume) Deb & M.Gangop.	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1466		Psydrax dicoccos Gaertn.	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1467		Psydrax sp.1	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1468		Psydrax sp.2	Asian	dated phyl., distr./fossils	Verstraete et al. 2017, WCSP 2017
1469		Rothmannia merrillii (Elmer) J.T.Pereira & Ridsdale	Asian	phylogeogr.	Kainulainen et al. 2017
1470		Tarenna arborea (Elmer) Elmer	Asian	phylogeogr.	Kainulainen et al. 2017
1471		Tarenna confusa (Blume) Valeton	Asian	phylogeogr.	Kainulainen et al. 2017
1472		Tarenna sp.	Asian	phylogeogr.	Kainulainen et al. 2017
1473		Timonius borneensis Valeton	Austr.	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1474		Timonius flavescens (Jacq.) Baker	Austr.	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012

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1475		Timonius minahassae Koord.	Austr.	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1476		Timonius sp.	Austr.	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1477		Timonius teysmanii Valeton	Austr.	phylogeogr.	Manns & Bremer 2010, Manns et al. 2012
1478		Urophyllum arboreum (Reinw. ex Blume) Korth.	Asian	phylogeogr.	Smedmark et al. 2010
1479		Urophyllum macrophyllum (Blume) Korth.	Asian	phylogeogr.	Smedmark et al. 2010
1480		Urophyllum sp.	Asian	phylogeogr.	Smedmark et al. 2010
1481		Wendlandia dasythyrsa Miq.	Asian	phylogeogr., distr./fossils	Kainulainen et al. 2013, 2017, WCSP 2017
1482		Wendlandia glabrata DC.	Asian	phylogeogr., distr./fossils	Kainulainen et al. 2013, 2017, WCSP 2017
1483	Rutaceae	Acronychia pedunculata (L.) Miq.	Austr.	phylogeogr.	Appelhans et al. 2012, Holzmeyer et al. 2015
1484		Melicope clemensiae T.G.Hartley	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1485		Melicope denhamii (Seem.) T.G.Hartley	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1486		Melicope frutescens (Blanco) Appelhans & J.Wen	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1487		Melicope glabella T.G.Hartley	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1488		Melicope latifolia (DC.) T.G. Hartley	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1489		Melicope maxii T.G.Hartley	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1490		Melicope triphylla (Lam.) Merr.	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1491		Tetradium celebicum (Koord.) T.G.Hartley ined.	Asian	phylogeogr.	Appelhans et al. 2018
1492		Tetractomia tetrandra (Roxb.) Merr.	Austr.	phylogeogr.	Appelhans et al. 2012, 2014
1493	Sabiaceae	Meliosma lanceolata Blume	Asian	undated phyl., distr./fossils	van Beusekom 1971, Zúñiga 2015
1494		Meliosma pinnata (Roxb.) Maxim.	Asian	undated phyl., distr./fossils	van Beusekom 1971, Zúñiga 2015
1495		Meliosma rufopilosa M.R.Hend.	Asian	undated phyl., distr./fossils	van Beusekom 1971, Zúñiga 2015
1496		Meliosma sp.	Asian	undated phyl., distr./fossils	van Beusekom 1971, Zúñiga 2015
1497		Meliosma sumatrana (Jack) Walp.	Asian	undated phyl., distr./fossils	van Beusekom 1971, Zúñiga 2015

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1498	Salicaceae	Ahernia glandulosa Merr.	Asian	undated phyl., distr./fossils	Alford 2005
1499		Casearia fuliginosa (Blanco) Blanco	Austr.	phylogeogr.	Samarakoon 2015
1500		Casearia hosei Merr.	Austr.	phylogeogr.	Samarakoon 2015
1501		Casearia rugulosa Blume	Austr.	phylogeogr.	Samarakoon 2015
1502		Casearia tuberculata Blume	Austr.	phylogeogr.	Samarakoon 2015
1503		Flacourtia kinabaluensis Sleumer	Asian	undated phyl., distr./fossils	Alford 2005, Sleumer 1954
1504		Flacourtia rukam Zoll. & Moritzi	Asian	undated phyl., distr./fossils	Alford 2005, Sleumer 1954
1505		Homalium sp.	Asian	undated phyl., distr./fossils	Alford 2005
1506	Santalaceae	Dendrotrophe sp.	Austr.	dated phyl., distr./fossils	Su et al. 2015, Vidal-Russell & Nickrent 2008
1507		Scleropyrum pentandrum (Dennst.) Mabb.	Asian	dated phyl., distr./fossils	Su et al. 2015, Vidal-Russell & Nickrent 2008
1508	Sapindaceae	Acer laurinum Hassk.	Asian	phylogeogr.	Buerki et al. 2011, Harris et al. 2017b
1509		Arytera littoralis Blume	Austr.	phylogeogr.	Buerki et al. 2011
1510		Dimocarpus longan Lour.	Asian	phylogeogr.	Buerki et al. 2011
1511		Dimocarpus sp.	Asian	phylogeogr.	Buerki et al. 2011
1512		Gloeocarpus patentivalvis (Radlk.) Radlk.	Austr.	phylogeogr.	Buerki et al. 2011
1513		Guioa diplopetala (Hassk.) Radlk.	Austr.	phylogeogr.	Buerki et al. 2011
1514		Guioa hirsuta Welzen	Austr.	phylogeogr.	Buerki et al. 2011
1515		Guioa pleuropteris (Blume) Radlk.	Austr.	phylogeogr.	Buerki et al. 2011
1516		Guioa pterorhachis Welzen	Austr.	phylogeogr.	Buerki et al. 2011
1517		Harpullia cupanioides Roxb.	Austr.	phylogeogr.	Buerki et al. 2011
1518		Lepisanthes fruticosa (Roxb.) Leenh.	Asian	phylogeogr.	Buerki et al. 2011
1519		Lepisanthes kinabaluensis Leenh.	Asian	phylogeogr.	Buerki et al. 2011
1520		Lepisanthes schizolepis Radlk.	Asian	phylogeogr.	Buerki et al. 2011
1521		Lepisanthes tetraphylla Radlk.	Asian	phylogeogr.	Buerki et al. 2011
1522		Litchi chinensis Sonn.	Asian	phylogeogr.	Buerki et al. 2011
1523		Mischocarpus pentapetalus (Roxb.) Radlk.	Austr.	phylogeogr.	Buerki et al. 2011
1524		Nephelium cuspidatum Blume	Asian	phylogeogr.	Buerki et al. 2011

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1525		Nephelium lappaceum L.	Asian	phylogeogr.	Buerki et al. 2011
1526		Nephelium mangayi Hiern	Asian	phylogeogr.	Buerki et al. 2011
1527		Nephelium ramboutan-ake (Labill.) Leenh.	Asian	phylogeogr.	Buerki et al. 2011
1528		Nephelium sp.1	Asian	phylogeogr.	Buerki et al. 2011
1529		Nephelium sp.2	Asian	phylogeogr.	Buerki et al. 2011
1530		Nephelium sp.3	Asian	phylogeogr.	Buerki et al. 2011
1531		Pometia pinnata J.R.Forst. & G.Forst.	Asian	phylogeogr.	Buerki et al. 2011
1532		Xerospermum laevigatum Radlk.	Asian	phylogeogr.	Buerki et al. 2011
1533		Xerospermum noronhianum (Blume) Blume	Asian	phylogeogr.	Buerki et al. 2011
1534	Sapotaceae	Donella lanceolata (Blume) Aubrév.	Asian	phylogeogr.	Bartish et al. 2011
1535		Madhuca endertii H.J.Lam	Asian	phylogeogr.	Richardson et al. 2014
1536		Madhuca glabrescens H.J.Lam	Asian	phylogeogr.	Richardson et al. 2014
1537		Madhuca kingiana (Brace ex King & Gamble) H.J.Lam	Asian	phylogeogr.	Richardson et al. 2014
1538		Madhuca sericea (Miq.) S.Moore	Asian	phylogeogr.	Richardson et al. 2014
1539		Madhuca sp.1	Asian	phylogeogr.	Richardson et al. 2014
1540		Madhuca sp.2	Asian	phylogeogr.	Richardson et al. 2014
1541		Palaquium foxworthyi Merr.	Asian	phylogeogr.	Richardson et al. 2014
1542		Palaquium gutta (Hook.) Baill.	Asian	phylogeogr.	Richardson et al. 2014
1543		Palaquium herveyi King & Gamble	Asian	phylogeogr.	Richardson et al. 2014
1544		Palaquium hexandrum (Griff.) Baill.	Asian	phylogeogr.	Richardson et al. 2014
1545		Palaquium lanceolatum Blanco	Asian	phylogeogr.	Richardson et al. 2014
1546		Palaquium luzoniense (Fern.-Vill.) Vidal,	Asian	phylogeogr.	Richardson et al. 2014
1547		Palaquium merrillii Dubard	Asian	phylogeogr.	Richardson et al. 2014
1548		Palaquium obovatum (Griff.) Engl.	Asian	phylogeogr.	Richardson et al. 2014
1549		Palaquium philippense (Perr.) C.B.Rob.	Asian	phylogeogr.	Richardson et al. 2014
1550		Palaquium quercifolium (de Vriese) Burck	Asian	phylogeogr.	Richardson et al. 2014
1551		Palaquium rostratum (Miq.) Burck	Asian	phylogeogr.	Richardson et al. 2014

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1552		Palaquium sp.1	Asian	phylogeogr.	Richardson et al. 2014
1553		Palaquium sp.2	Asian	phylogeogr.	Richardson et al. 2014
1554		Palaquium sp.3	Asian	phylogeogr.	Richardson et al. 2014
1555		Payena acuminata (Blume) Pierre	Asian	phylogeogr.	Richardson et al. 2014
1556		Payena gigas A.Bruggen	Asian	phylogeogr.	Richardson et al. 2014
1557		Payena leerii (Teijsm. & Binn.) Kurz	Asian	phylogeogr.	Richardson et al. 2014
1558		Payena microphylla (de Vriese) Burck	Asian	phylogeogr.	Richardson et al. 2014
1559		Payena sp.1	Asian	phylogeogr.	Richardson et al. 2014
1560		Payena sp.2	Asian	phylogeogr.	Richardson et al. 2014
1561		Planchonella chartacea (F.Muell. ex Benth.) H.J.Lam	Austr.	phylogeogr.	Swenson et al. 2014
1562		Planchonella duclitan (Blanco) Bakh.f.	Austr.	phylogeogr.	Swenson et al. 2014
1563		Planchonella maingayi (C.B.Clarke) P.Royen	Austr.	phylogeogr.	Swenson et al. 2014
1564		Planchonella malaccensis (C.B.Clarke) Swenson)	Austr.	phylogeogr.	Swenson et al. 2014
1565		Planchonella sp.1	Austr.	phylogeogr.	Swenson et al. 2014
1566		Planchonella sp.2	Austr.	phylogeogr.	Swenson et al. 2014
1567		Planchonella sp.3	Austr.	phylogeogr.	Swenson et al. 2014
1568		Planchonella sp.4	Austr.	phylogeogr.	Swenson et al. 2014
1569		Pleioluma firma (Miq.) Swenson	Austr.	phylogeogr.	Swenson et al. 2014
1570		Pleioluma moluccana (Burck) Swenson	Austr.	phylogeogr.	Swenson et al. 2014
1571		Sarcosperma paniculatum (King) Stapf & King	Asian	phylogeogr., distr./fossils	Richardson et al. 2014, WCSP 2017
1572	Schisandraceae	Illicium kinabaluense A.C.Sm.	Asian	phylogeogr.	Clayton et al. 2009
1573	Simaroubaceae	Ailanthus integrifolia Lam.	Asian	phylogeogr.	Clayton et al. 2009
1574		Eurycoma apiculata A.W.Benn.	Asian	phylogeogr.	Clayton et al. 2009
1575		Eurycoma longifolia Jack	Asian	phylogeogr.	Clayton et al. 2009
1576		Eurycoma sp.	Asian	phylogeogr.	Clayton et al. 2009
1577		Simaroubaceae sp.	Asian	phylogeogr.	Clayton et al. 2009
1578	Staphyleaceae	Turpinia ovalifolia Elmer	Asian	undated phyl., distr./fossils	Harris et al. 2017a
1579		Turpinia sp.1	Asian	undated phyl., distr./fossils	Harris et al. 2017a
1580		Turpinia sp.2	Asian	undated phyl., distr./fossils	Harris et al. 2017a
1581		Turpinia sp.3	Asian	undated phyl., distr./fossils	Harris et al. 2017a

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1582		Turpinia sphaerocarpa Hassk.	Asian	undated phyl., distr./fossils	Harris et al. 2017a
1583	Stemonuraceae	Gomphandra mappioides Valeton	Austr.	phylogeogr.	Beaulieu et al. 2013
1584		Medusanthera laxiflora (Miers) R.A.Howard	Austr.	phylogeogr.	Beaulieu et al. 2013
1585		Stemonurus malaccensis (Mast.) Sleumer	Austr.	phylogeogr.	Beaulieu et al. 2013
1586		Stemonurus sp.	Austr.	phylogeogr.	Beaulieu et al. 2013
1587		Stemonurus umbellatus Becc.	Austr.	phylogeogr.	Beaulieu et al. 2013
1588	Styracaceae	Bruinsmia styracoides Boerl. & Koord.	Asian	phylogeogr.	Fritsch et al. 2001
1589		Styrax paralleloneurus Perkins	Asian	phylogeogr.	Fritsch et al. 2001
1590	Symplocaceae	Symplocos adenophylla Wall. ex G.Don	Asian	phylogeogr.	Fritsch et al. 2015
1591		Symplocos anomala Brand	Asian	phylogeogr.	Fritsch et al. 2015
1592		Symplocos buxifolia Stapf	Asian	phylogeogr.	Fritsch et al. 2015
1593		Symplocos cf. cochinchinensis (Lour.) S.Moore	Asian	phylogeogr.	Fritsch et al. 2015
1594		Symplocos costata Choisy ex Zoll.	Asian	phylogeogr.	Fritsch et al. 2015
1595		Symplocos deflexa Stapf	Asian	phylogeogr.	Fritsch et al. 2015
1596		Symplocos fasciculata Zoll.	Asian	phylogeogr.	Fritsch et al. 2015
1597		Symplocos lancifolia Siebold & Zucc.	Asian	phylogeogr.	Fritsch et al. 2015
1598		Symplocos odoratissima (Blume) Choisy	Asian	phylogeogr.	Fritsch et al. 2015
1599		Symplocos ophirensis Clarke	Asian	phylogeogr.	Fritsch et al. 2015
1600		Symplocos pendula Wight	Asian	phylogeogr.	Fritsch et al. 2015
1601		Symplocos sp.1	Asian	phylogeogr.	Fritsch et al. 2015
1602		Symplocos sp.2	Asian	phylogeogr.	Fritsch et al. 2015
1603		Symplocos sp.3	Asian	phylogeogr.	Fritsch et al. 2015
1604		Symplocos sp.4	Asian	phylogeogr.	Fritsch et al. 2015
1605		Symplocos vidalii Rolfe	Asian	phylogeogr.	Fritsch et al. 2015
1606		Symplocos whitfordii Brand	Asian	phylogeogr.	Fritsch et al. 2015
1607	Tetramelaceae	Octomeles sumatrana Miq.	Asian	dated phyl., distr./fossils	Farjon 2010, Leslie et al. 2012, Liu et al. 2011
1608	Theaceae	Camellia sp.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1609		Polyspora amboinensis (Miq.) Orel et al.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014

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1610		Polyspora excelsa (Blume) Orel et al.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1611		Polyspora grandiflora (Merr.) Orel et al.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1612		Polyspora havilandii (Burkill) Orel et al.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1613		Polyspora integerrima (Miq.) Orel et al.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1614		Polyspora luzonica (S. Vidal) Orel et al.	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1615		Polyspora sp.1	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1616		Polyspora sp.2	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1617		Polyspora sp.3	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1618		Polyspora sp.4	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1619		Polyspora sp.5	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1620		Polyspora sp.6	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1621		Pyrenaria serrata Blume	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1622		Schima brevifolia (Hook.f.) Baill. ex Stapf	Asian	phylogeogr.	Li et al. 2013
1623		Schima sp.	Asian	phylogeogr.	Li et al. 2013
1624		Schima wallichii (DC.) Korth.	Asian	phylogeogr.	Li et al. 2013
1625		Theaceae sp.1	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1626		Theaceae sp.2	Asian	phylogeogr.	Li et al. 2013, Zhang et al. 2014
1627	Thymelaeaceae	Aquilaria malaccensis Lam.	Asian	dated phyl.	Eurlings & Gravendeel 2005, Motsi 2009
1628		Aquilaria sp.	Asian	dated phyl.	Eurlings & Gravendeel 2005, Motsi 2009
1629		Thymelaeaceae sp.	Asian	dated phyl.	Eurlings & Gravendeel 2005, Herber 2003, Motsi 2009
1630		Gonystylus acuminatus Airy Shaw	Asian	dated phyl., distr./fossils	Herber 2003, Motsi 2009
1631		Gonystylus consanguineus Airy Shaw	Asian	dated phyl., distr./fossils	Herber 2003, Motsi 2009
1632		Gonystylus forbesii Gilg	Asian	dated phyl., distr./fossils	Herber 2003, Motsi 2009
1633		Gonystylus macrophyllus (Miq.) Airy Shaw	Asian	dated phyl., distr./fossils	Herber 2003, Motsi 2009

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1634		Gonostylus sp.	Asian	dated phyl., distr./fossils	Herber 2003, Motsi 2009
1635		Wikstroemia polyantha Merr.	Asian	dated phyl., distr./fossils	Herber 2003, Motsi 2009
1636	Trigoniaceae	Trigoniastrum hypoleucum Miq.	Asian	dated phyl., distr./fossils	Bittrich 2014, Xi et al. 2012
1637	Trimeniaceae	Trimenia papuana Ridl.	Austr.	distr./fossils	Philipson 1993
1638	Urticaceae	Debregeasia longifolia (Burm.f.) Wedd.	Asian	undated phyl., distr./fossils	Wu et al. 2013
1639		Dendrocnide luzonensis (Wedd.) Chew	Asian	undated phyl., distr./fossils	Wu et al. 2013
1640		Dendrocnide luzonensis (Wedd.) Chew	Asian	undated phyl., distr./fossils	Wu et al. 2013
1641		Dendrocnide stimulans (L.f.) Chew	Asian	undated phyl., distr./fossils	Wu et al. 2013
1642		Leucosyke capitellana (Poir.) Wedd.	Asian	undated phyl., distr./fossils	Wu et al. 2013
1643		Oreocnide rubescens (Blume) Miq.	Asian	undated phyl., distr./fossils	Wu et al. 2013
1644		Pipturus arborescens (Link) C.B. Rob.	Asian	undated phyl., distr./fossils	Wu et al. 2013
1645	Vitaceae	Leea sp.	Asian	phylogeogr.	Molina et al. 2013
1646	Winteraceae	Tasmannia piperita (Hook.f.) Miers	Austr.	phylogeogr.	Thomas et al. 2014