Taxonomy, Phylogeny, and Wood anatomy of Alstonia (Apocynaceae)

PROEFSCHRIFT

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CONTENTS

SUMMARY

Alstonia is the largest and most widespread genus of trees and shrubs in the subtribe Alstoniinae of the tribe Plumerieae of the Apocynaceae. Many of its species provide important timbers of commerce, and several species are used in traditional local medicine. The genus occurs in Central America, tropical Africa, and from the Himalayas and China to New South Wales in Australia, and has its centre of diversity in the Malesian region. This study aims to contribute to our still fragmentary knowledge of the tropical biodiversity, and provides a comprehensive survey of the macromorphological and pollen morphological diversity within the genus *Alstonia* (Chapter 2), a cladistic analysis based on this diversity (Chapter 3), a comparative wood anatomical study of three of the five sections with analyses of ecological and phylogenetic trends in the wood anatomical data (Chapter 4), and a full taxonomic revision of the entire genus (Chapter 5).

In the taxonomic revision 43 species are recognised; five of them are new to science, including one which has previously been considered as var. *annamensis* of *A. angustifolia*. The five new species are *A. annamensis, A. beatricis, A. breviloba, A. penangiana*, and *A. rubiginosa*. Several species and taxa below the species level are reduced. For instance, *A. brassii* Monach. and *A. glabriflora* Markgr. appear to be synonyms of *A. macrophylla* Wall. ex G. Don; *A. montana* Turrill, *A. reineckeana* Lauterb., *A. roeperi* Van Heurck & Müll. Arg., *A. vitiensis* Seem., and *A. marquisensis* M.L. Grant to be the synonyms of *A. costata* (G. Forst.) R. Br. No taxa below the species level are maintained. Regional and synoptical keys to all taxa are given. Species descriptions incorporate full synonymy and data on geographical distribution, habitat and ecology. For most species notes are added to explain the variation of characters and/or to point to the differences with other taxa. Uses (especially medicinal) and vernacular names are given when known. An identification list of all c. 4,200 specimens examined is given.

The cladistic analysis, based on 68 characters (61 macromorphological and 7 palynological), using the closely related genus *Dyera* as outgroup, produced a single most parsimonious tree. The tree shows five distinct monophyletic groups which are maintained as the five sections recognised in the present study: *Alstonia, Blaberopus, Tonduzia, Monuraspermum*, and *Dissuraspermum*. *Tonduzia*, previously treated as a separate genus (Pittier, 1908), is nested in the cladogram, and is therefore treated here as a section of the genus *Alstonia*. The previously recognised section *Winchia* (Monachino, 1949) has to be united with section *Alstonia*. The cladogram is accepted as a working hypothesis for the phylogeny of *Alstonia* and the character transformations leading to the present morphological diversity are discussed.

The three sections that have been studied wood anatomically are *Alstonia*, *Monuraspermum*, and *Dissuraspermum*. The wood anatomical characters support the infrageneric classification recognised on the basis of macromorphological and pollen morphological features. Vessel frequency, mean tangential vessel diameter, L/D ratio, ray frequency, presence or absence of laticifers, parenchyma distribution, fibre wall thickness, and fibre wall pitting are all, in various degrees, diagnostic to separate the light Alstonia timber group (= section *Alstonia*) from the heavy Alstonia

group (including the other two sections studied). The sections *Monuraspermum* and *Dissuraspermum* can be separated on vessel frequency and mean tangential vessel diameter.

Among the light Alstonia group, the swamp-inhabiting species have lower multiseriate rays than the non-swamp species presumably rooting in well-aerated soils. Among the species of the heavy Alstonia group (sections *Monuraspermum* and *Dissuraspermum*), the small trees and shrubs show a higher vessel frequency, smaller vessel diameter, shorter fibres, higher ray frequency, and higher multiseriate rays than the species growing into big trees, confirming a well-documented general trend of wood anatomical correlations with plant size and stem diameter. Mutual correlations of character pairs such as vessel diameter and frequency, and quantitative ray and vessel attributes are also analysed and discussed with reference to findings in other woody plant families.

RINGKASAN

Alstonia merupakan marga terbesar yang anggotanya terdiri dari perdu dan pohon serta memiliki wilayah penyebaran terluas untuk tumbuhan yang termasuk ke dalam anak puak *Alstoniinae* puak *Plumerieae* suku Apocynaceae. Banyak jenisnya menghasilkan kayu perdagangan, dan beberapa jenis lainnya hanya menghasilkan bahan obat-obatan tradisional dan kayu bakar. Daerah penyebarannya meliputi Amerika Tengah, bagian tropik benua Afrika, dari pegunungan Himalaya dan China sampai New South Wales di Australia, dengan pusat keragamannya di kawasan Malesiana. Penelitian ini bertujuan untuk menambah wawasan pengetahuan tentang keanekaragaman hayati di kawasan tropik, menyajikan hasil kajian dari berbagai ragam sifat makromorfologi dan serbuk sari marga *Alstonia* (Bab 2), melakukan analisa kladistik berdasarakan keragaman sifat makromorfologi dan serbuk sari (Bab 3), membandingkan sifat-sifat anatomi kayu terhadap tiga dari lima seksi yang ada dengan menguraikan data ekologi dan gambaran filogenetik dari sifat-sifat anatomi kayu tersebut (Bab 4), dan revisi taksonomi untuk keseluruhan marga (Bab 5).

Dalam revisi taksonomi diakui sebanyak 43 jenis; lima diantaranya merupakan jenis baru, termasuk satu jenis yang sebelumnya merupakan varietas dari *A. angustifolia*. Kelima jenis baru tersebut adalah *A. annamensis*, *A. beatricis*, *A. breviloba*, *A. penangiana*, dan *A. rubiginosa*. Beberapa nama jenis dan varietas yang dahulu baku, saat ini hanya menjadi nama sinonim. Sebagai contoh, *A. brassii* Monach. dan *A. glabriflora* Markgr. menjadi sinonim dari *A. macrophylla* Wall. ex G. Don; *A. montana* Turrill, *A. reineckeana* Lauterb, *A. roeperi* van Heurck & Müll. Arg., *A. vitiensis* Seem., dan *A. marquisensis* M.L. Grant menjadi sinonim dari *A. costata* (G. Forst.) R. Br. Tidak ada taksa di bawah jenis ditetapkan dari hasil revisi ini. Kunci identifikasi yang bersifat regional dan kunci sinoptik dari semua jenis disajikan. Deskripsi jenis menyertakan semua nama sinonim dan wilayah penyebarannya, ekologi dan tempat tumbuh. Pada umumnya ditambahkan beberapa keterangan tentang variasi sifat yang membedakan dengan jenis-jenis lainnya. Kegunaan (terutama sebagai bahan obat) dan nama daerah juga dicantumkan apabila diketahui. Daftar identifikasi dari lebih kurang 4.200 spesimen yang dikaji dilampirkan.

Analisa kladistik berdasarkan 68 sifat (61 sifat makromorfologi dan 7 sifat palinologi), dengan menggunakan marga kerabat dekat *Dyera* sebagai kelompok luar ('outgroup'), menghasilkan kladogram tunggal. Kladogram ini memperlihatkan secara jelas 5 kelompok monofiletik yang selanjutnya ditetapkan sebagai 5 seksi dalam penelitian ini. Kelima seksi tersebut adalah *Alstonia, Blaberopus, Tonduzia, Monuraspermum*, dan *Dissuraspermum*. *Tonduzia*, yang sebelumnya dinyatakan sebagai marga tersendiri (Pittier, 1908) bersarang di dalam kladogram. Sehubungan dengan itu maka pada revisi ini *Tonduzia* ditetapkan sebagai salah satu seksi dari marga *Alstonia*. Nama yang sebelumnya disebut sebagai seksi *Winchia* (Monachino, 1949) harus disatukan dengan seksi *Alstonia*. Kladogram yang dihasilkan dijadikan hipotesa untuk filogeni marga *Alstonia*, dan transformasi sifat atau karakter dibahas.

Tiga seksi yang sifat anatomi kayunya diteliti adalah seksi *Alstonia, Monuraspermum*, dan *Dissuraspermum*. Sifat-sifat anatomi kayu tersebut mendukung penggolongan di bawah marga (seksi) seperti dihasilkan berdasarkan sifat-sifat makro-

morfologi dan serbuk sari. Frekuensi pembuluh, rata-rata diameter pembuluh tangensial, nisbah antara panjang dan diameter unsur pembuluh, frekuensi jari-jari, ada atau tidaknya saluran getah, penyebaran parenkim, ketebalan dinding serat, dan noktah pada serat, semuanya dalam berbagai tingkatan, merupakan ciri pengenal untuk membedakan kelompok Alstonia yang berkayu ringan ('light Alstonia group') (seksi *Alstonia*) dari kelompok Alstonia yang berkayu berat ('heavy Alstonia group') (meliputi dua seksi lainnya yang diteliti). Antara seksi *Monuraspermum* dan *Dissuraspermum* dapat dibedakan berdasarkan frekuensi pembuluh dan rata-rata diameter pembuluh tangensial.

Di antara kelompok Alstonia yang berkayu ringan, jenis-jenis yang tumbuh di rawa memiliki jari-jari yang berseri banyak (lebih dari satu seri) lebih rendah dibandingkan dengan jenis-jenis yang tumbuh di daerah bukan rawa yang diduga memiliki sistem perakaran pada tanah-tanah yang bersikulasi udara baik. Di antara kelompok Alstonia yang berkayu berat (seksi *Monuraspermum* dan *Dissuraspermum*), pohon-pohon yang berbatang kecil dan perdu memiliki frekuensi pembuluh yang lebih tinggi, diameter pembuluh lebih kecil, serat lebih pendek, serta frekuensi jari-jari dan jari-jari yang berseri banyak lebih tinggi dibandingkan dengan jenis-jenis yang mampu tumbuh menjadi pohon besar. Hasil ini menegaskan /memperkuat pendapat umum yang telah didokumentasikan dengan baik, tentang hubungan sifat anatomi kayu dengan ukuran batang suatu tumbuhan. Hubungan timbal balik suatu pasangan sifat, misalnya hubungan antara diameter dan frekuensi pembuluh, dan hubungan antara sifat-sifat kuantitatif dari jari-jari dan pembuluh juga diuraikan dan dibahas berkenaan dengan penemuan atau kesimpulan yang berlaku bagi suku tumbuhan berkayu lainnya.

Chapter 1

INTRODUCTION

The forests of the Malesian region are very species-rich in all kinds of biological organisms. Of the estimated 42,000 vascular plant species (Roos, 1993), the vast majority occurs in forest ecosystems, and a very high proportion are trees and large shrubs. Conservation and sustainable utilisation of the remaining but seriously endangered forest resources in the tropics require, i.a., a profound knowledge of the species that constitute the forest ecosystems, especially of the dominant life forms, that are trees. A sound taxonomy and user-friendly identification keys are prerequisites to access such knowledge. The long-term, multinational Flora Malesiana project was set up almost 50 years ago with this goal in mind, and has recently received a fresh impetus from the increased awareness of the need to conserve biodiversity at all levels of the hierarchy of life: genotypes, species and ecosystems (Lammerts van Bueren & Duivenvoorden, 1996). Many efforts have already been made to conserve more forests and species and their ecosystems (Anonymous, 1990; 1992; 1996; Boyle & Boontawee, 1994).

The genus *Alstonia* is an important timber producing taxon (Soerianegara & Lemmens, 1993), with as its main centre of distribution the lowland forests of Malesia. Also I.H. Burkill (1935), Heyne (1950), and H.M. Burkill (1985) did give information on the biology and other economic values of *Alstonia*. Guerrero (1920) and Henderson & Hancock (1988) stressed the importance of *Alstonia* for its medicinal uses. A taxonomic revision was much needed to complement the ongoing treatment of the family for Flora Malesiana by Leeuwenberg (Agricultural University of Wageningen) and Middleton (Rijksherbarium, Leiden). Proper species and higher taxon delimitation and phylogenetic reconstruction is only possible when we consider the variation in the genus as a whole, and for this purpose all species from continental Asia, the Pacific, Africa, and America were also included in the taxonomic revision.

The present work is the first comprehensive revision of *Alstonia* since Monachino (1949). For this study more than 4,200 herbarium numbers have been examined. These specimens were obtained from many herbaria (see Acknowledgements). A database with collecting data on all these specimens is available on request from the Rijksherbarium, P.O. Box 9514, 2300 RA Leiden, The Netherlands or from Wanariset Herbarium, P.O. Box 319, Balikpapan 76103, Indonesia. I had an opportunity to do some field collecting in Kalimantan and Sulawesi, Indonesia, and could study 7 species in the wild. This fieldwork provided additional information on habit and ecological data. Some wood samples were also collected during these trips.

In Chapter 2 a general overview of the macromorphological (vegetative and generative) and palynological characters of *Alstonia* is given. To explain more precisely certain morphological terms some of them are illustrated in line-drawings.

Another aim of this study was to produce a phylogenetic analysis of *Alstonia*. For this purpose all of the macromorphological characters gathered for the revision have

been used. The pollen morphological characters were selected from the data sets published by Kuijt & Van der Ham (1997). The wood anatomical characters were not included because of lack of available data for many species. The results of this phylogenetic analysis are presented in Chapter 3.

The wood anatomical characters of three of the five sections of *Alstonia* of which wood specimens could be obtained are also presented. This is in order to understand the wood structural diversity of relevance to wood properties, to enable wood identification (of commercial timbers to species groups), and to attempt reciprocal illumination of the phylogenetic analysis with wood anatomical results. Descriptions of the wood anatomy are given for each section, and afterwards were combined into a general survey of the entire genus. Ecological trends in wood anatomical characters are also included. The results are given in Chapter 4.

Chapter 5, the special part, presents the taxonomic revision with full descriptions of the genus, sections, and species. Synoptical, general, and regional keys are also given here.

The present study is carried out in the framework of the International MOF-Tropenbos Kalimantan Project based at the Wanariset I Research Station in Samboja, East Kalimantan, Indonesia. The aim of this project is to develop appropriate techniques and guidelines for sustainable forest management. The project is executed by the Indonesian Forestry Research and Development Agency of the Ministry of Forestry, the Institute for Forestry and Nature Research IBN-DLO, Wageningen, and the Rijksherbarium / Hortus Botanicus, Leiden, both in the Netherlands, and the Association of Indonesian Forest Concession Holders (APHI) and the state forestry enterprise P.T. Inhutani I.

1.1. Taxonomic history

The genus *Alstonia* was described by Robert Brown in 1810. The name is in honour of Charles Alston, a Scottish physician and professor of botany at the University of Edinburgh. Four species were referred to this genus by Brown, e.g., *A. scholaris, A. spectabilis, A. venenata*, and *A. costata*, each being the type species of a section of *Alstonia* (Monachino, 1949).

Before Brown two homonyms had already been published: *Alstonia* Scop. (1777) and *Alstonia* Mutis ex L. f. (1781). Against these two earlier homonyms conservation of *Alstonia* R. Br. was proposed by Rehder and executed at the 6th International Botanical Congress, Amsterdam (Rehder et al., 1935).

Alstonia Scop. was based on *Pacouria* Aubl., a name now rejected in favour of *Landolphia* Beauv. by the authors who do not maintain *Pacouria* as a distinct genus. *Alstonia* Mutis ex L. f. is typified by *A. theaeformis*. The latter species was transferred to *Symplocos* by Gürke, and this decision was accepted by Brand (1901) in his monograph of the Symplocaceae.

Some genera and some infrageneric taxa near or within the genus have been moved several times by several authors. A. de Candolle (1844) transferred *A. lucida* D. Don, *A. neriifolia* D. Don, *A. sericea* Blume, *A. theaeformis* L. f., and *A. venenata* R. Br. to the genus *Blaberopus*. They were transferred back to *Alstonia* as section *Blaberopus*

by Bentham (1876). At the same time Bentham also transferred the genus *Pala* (De Jussieu, 1810) to *Alstonia* and made it section *Pala*. He reduced the subgenus *Dissuraspermum* (Gray, 1862) to section *Dissuraspermum*, and described a new genus *Amblyocalyx* based on a single species, *Amblyocalyx beccarii*. *Pala* A. Juss. was rejected in favour of *Alstonia*. This genus was based on '*Pala*' Rheede (1678), which is *Alstonia scholaris*. It was published without a specific name and had never been adopted by any other author.

Pichon (1947) reduced the generic name *Amblyocalyx* Benth. to a synonym of section *Dissuraspermum*. Later, Monachino (1949) placed it in the synonymy of section *Monuraspermum*. In 1947 Pichon described the genus *Paladelpha*. This genus was typified by *Paladelpha angustiloba* (= *Alstonia angustiloba* Miq.). Again Monachino (1949) brought it back to *Alstonia*.

Pichon's revision resulted in some other confusing results. He distinguished subsection (= series) *Glabrae* and subsection (= series) *Pilosae* in the section *Pala*. According to the present revision (which is more or less in agreement with Monachino's, 1949) some parts of the classification made by Pichon turned out to be incorrect. He placed together *A. actinophylla* (A. Cunn.) K. Schum., *A. spatulata* Blume, and *A. pachycarpa* Merr. & Chun (= *A. rostrata* C.E.C. Fisch.) (section *Alstonia*), and *A. sericea* Blume (= *A. neriifolia* D. Don, section *Blaberopus*), under subsection (series) *Glabrae*. Moreover, he also maintained the genera *Blaberopus* and *Winchia*. The latter genus was represented by *Winchia glaucescens* (G. Don) K. Schum.

In section *Dissuraspermum*, Pichon (1947) also distinguished two subsections (series), *Occidentales* and *Orientales*, based on the ciliation of sepals and the leaf arrangement. This distinction was also rather weak. Monachino (1949) transferred most of the species of series *Occidentales* to the new section *Monuraspermum*.

Up to the present Monachino (1949) produced the most workable revision of *Alstonia*. He treated 39 species and 12 varieties in his revision. Some of them, especially the taxa at the varietal level, have been sunk into other taxa in the present revision. He reduced the genus *Winchia* to *Alstonia* as section *Winchia*. The genus *Winchia* was described by A. de Candolle (1844), who based it on a specimen mentioned in Wallich's list, no. 1607, called *Winchia calophylla*. When Monachino reduced *Winchia*, he maintained the name *Alstonia glaucescens* as the type species of section *Winchia*. The nomenclature of this species is complex and has been explained by Middleton & Gilbert (1994), who conclude that *Alstonia rostrata* is the correct name. The conclusion resulted from a typographical error by G. Don (1838) who substituted Wallich 1609 (an *Alyxia*) for 1607 (the taxon in question).

The correct name for section *Pala* (A. Juss.) Benth. is section *Alstonia* (Kochummen & Wong, 1984), as both *Pala* and *Alstonia* have *Alstonia scholaris* (L.) R. Br. as type species.

Since its inception in 1810, the number of species within the genus increased rapidly. Most of them were added by the authors mentioned above. In addition two species were described from Africa: *A. congensis* (Engler, 1886) and *A. boonei* (De Wildeman, 1914). In Asia (excluding Malesia) King & Gamble (1907), Diels (1912), Léveillé (1915), Kerr (1937), and Fang & Chen (1980) described additional species. For the Malesian flora several species were added by Blume (1826), Miquel (1856), Merrill

(1906), and Elmer (1912). In Australia, Mueller (1858), Schumann (1895), and Domin (1928) described taxa in *Alstonia*. Many new species from the Pacific Islands (Melanesia and Polynesia) were described by Van Heurck & Müller Argoviensis in Müller (1870), Moore (1921), Guillaumin (1941), and Boiteau et al. (1977).

1.2. Relationships with other genera

The genus *Alstonia* belongs to the tribe Plumerieae of the subfamily Plumerioideae. This tribe consists of 22 genera in 5 subtribes (Leeuwenberg, 1994). Most of these genera consist of less than 10 species; only *Alstonia, Amsonia, Aspidosperma*, and *Himatanthus* have more species.

Monachino (1949) mentioned that *Alstonia* is very closely related to *Dyera*, especially *Alstonia* section *Alstonia*. These similarities are not only observed from the habit and the vegetative characters, but also from the flowers, especially the dehiscence of the anthers.

Laxoplumeria (a Central American genus) is also related to *Alstonia* due to the similarities in flowers and the ciliation of the seeds. It differs mainly in the inflorescence which is always a single cyme (as opposed to several cymes in *Alstonia*) and in the arrangement of the leaves, which is alternate. Moreover, the long hairs in the seeds of *Laxoplumeria* are densely placed not only around the margin (cilia), but also on the side opposite the hilum.

The genera *Ochrosia, Rauvolfia*, and *Tabernaemontana* have frequently been confused with *Alstonia* (Monachino, 1949). On examination of the fruits and seeds no such confusion would be possible. These genera have a drupe or fleshy fruits, while *Alstonia* has follicle fruits. *Tabernaemontana* looks vegetatively very similar to *Alstonia* section *Dissuraspermum*, except for the species with the leaves in whorls of 3. *Ochrosia* (except for the species with opposite leaves) and *Rauvolfia* look very similar to *Alstonia* section *Alstonia*.

Phylogenetic studies on the family have been published by Sennblad & Bremer (1996) and by Endress et al. (1996). These studies indicate that *Alstonia* is considered the most primitive genus in the Apocynaceae. It is a sister to all the other genera. These results are based on data gathered only from *A. scholaris* (Sennblad & Bremer, 1996), and *A. longifolia* and *A. scholaris* (Endress et al., 1996).

1.3. Species concept

The species concept is on one hand fundamental to biology and on the other still one of the most disputed concepts. Various species concepts have been proposed in the past, the oldest one the morphological species concept. According to the morphological concept, the species is defined by morphological similarity. This concept does not allow an interpretation of species as historical entities (Stuessy, 1990; Ridley, 1993; Mayden, 1997).

Other well-known species concepts are the biological and the phylogenetic/evolutionary species concepts. In the biological species concept organisms are considered conspecific in virtue of their innate interbreeding ability (Mayr, 1942; Ridley, 1993;

Claridge et al., 1997). The phylogenetic/evolutionary species concept refers to the genealogical network (Bentham, 1861; Hennig, 1966; Wiley, 1981; Cracraft, 1983a; Nixon & Wheeler, 1990). In this concept species are defined as independent evolutionary lines. Species are real entities, they are natural individuals, having a beginning and an end in time (spatio-temporally restricted), exist in nature as cohesive wholes, and they can only be described by their characters (Geesink & Kornet, 1989). For more elaborations on these species concepts, see Kornet (1993).

Several modifications and amplifications on the phylogenetic species concept have been made, and the discussions are still going on in order to, on the one hand, refine the concept and, on the other hand, to get a better connection between theory and the real world, i.e., to obtain natural groupings (Nixon & Wheeler, 1990, based on Hennig, 1966). After Hennig (1966) and Nixon & Wheeler (1990), Kornet (1993) introduced another concept which she called the composite species concept.

The composite species concept is based on the distinction between temporary and permanent splits in a genealogical network. However, when a split first appears in a network, it is impossible to tell whether it will be a permanent one or only a temporary one. A permanent split is recognisable only in retrospect. The conclusive criterion for deeming a split permanent is of course the extinction of one of the resulting branches. This process is clearly illustrated by Kornet (1993, fig. 2). The composite species concept is adhered to this study, similarly as did Turner (1995) in his revision of *Arytera* and *Mischarytera* (Sapindaceae).

On a practical level the criterion on which species are distinguished is by the presence of a monothetic set of at least two characters by which any two species differ from each other (Van Steenis, 1957; Geesink, 1984; Van Welzen, 1989). Widespread species may not be recognised by monothetic sets of characters, they tend to be polythetic. In *Alstonia*, this situation is found in *A. costata*. This species occurs in the Pacific Islands, from the Solomons to the Marquesas. However, whenever two specimens from the same locality, belonging to different species, are compared, at least two differing characters can be observed. There is always a morphological gap between the sympatric species. Because of its polymorphic nature *A. costata* keys out three times in the general key.

Chapter 2

MORPHOLOGY

In this chapter, a general overview is presented of the various morphological characters of *Alstonia*, both macro- and pollen-morphological. Characters observed in live plants in the field are also included.

2.1. Macromorphological characters of *Alstonia*

Habit and trunk

The species of *Alstonia* are mostly trees. Only a few species are shrubs (mostly in section *Blaberopus* and sometimes in sections *Dissuraspermum* and *Tonduzia*). The height of the trees may be up to 60 m, and the diameter more than 200 cm. The crown of young trees of species in section *Alstonia* has a pagoda-shape and has a monopodial appearance; in mature trees it is typically sympodial. Buttresses are usually present in larger trees. These buttresses may be small, medium, or large in size; and are either thick, symmetrical, or steep. A fluted form at the base of the trunk is also found. The bark is smooth to rough, sometimes corky (in *A. angustiloba, A. iwahigensis,* and *A. spectabilis*). The inner bark is granular, usually yellowish on the outside and whitish on the inside. In *A. angustifolia* and *A. spectabilis* yellow or orange stripes on the inner bark are often observed.

Architecture or branching system

Fig. 2.1 gives an illustration of the branching system in *Alstonia* section *Alstonia* (A) and *Alstonia* section *Monuraspermum* (B). In section *Alstonia*, especially in young

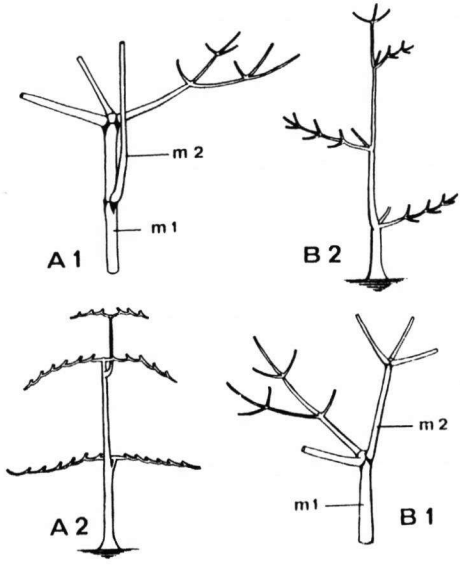


Fig. 2.1. Schematic drawing of the branching system in *Alstonia* (from Kochummen & Wong, 1984). – A: *Alstonia* section *Alstonia*. A1: the trunk module (new shoot) continuing height growth (m2) emerges from below the top of the previous module (m1); A2: idealised resulting modular construction in *Alstonia* section *Alstonia* (Prévost's model). – B: *Alstonia* section *Monuraspermum*. B1: the top of the branches terminating the earlier trunk module (m1) is composed of initially similar branches, one of which (m2) later assumes erect dominant growth to continue height extension; A2: idealised resulting modular construction in *Alstonia* section *Monuraspermum* (Koriba's model).

trees, the trunk module or new shoot(s) emerge from the axil that is located just below the top of the previous shoot. This shoot is mostly single, but sometimes two shoots emerge together and form a fork-like trunk. The length of the shoot(s) in one growth period is very variable, the longest one was measured in East Kalimantan, up to 7 m, on a tree of 22 cm in diameter.

According to Hallé et al. (1978), the branching system in section *Alstonia* is that of the so-called Prévost's model, while section *Monuraspermum* has Koriba's model. A comparison of the branching system of the two sections (*Alstonia* and *Monuraspermum*) has been published by Kochummen & Wong (1984). So far, there is no information about the branching in the sections *Blaberopus*, *Dissuraspermum* and *Tonduzia*.

Branches and branchlets

The branches are smooth to slightly rough, and may or may not be lenticellate. The branchlets are terete, slightly angular, laterally compressed, or sulcate when dried. In section *Alstonia*, the branchlets are usually terete; while in section *Monuraspermum* they are slightly angular, and in section *Dissuraspermum* they may be angular or slightly laterally compressed.

Indumentum

The indumentum in *Alstonia* is simple and always present at least inside the corolla, below the stamens. In some species the indumentum also occurs on the leaf surfaces, petioles, inflorescences and flowers, fruits and seeds. The simple hairs may be persistent or caducous and are variable in size and shape, even within species.

Latex

The latex is white. It is well-known that the species of section *Monuraspermum* have no latex in the trunk bark, in contrast to the species of section *Alstonia*, where latex may be observed in all parts of the plant. Information on this character for the other sections is incomplete. For *A. constricta* (an Australian species) and in some collections of *A. costata* from the Solomon Islands and Vanuatu (both species belong to section *Dissuraspermum*), the absence of latex in the trunk bark has also been reported.

The latex may be copious or scanty. Scanty latex is usually found in the branches of the species in sections which have no latex in the trunk bark. There is no information available with respect to the latex presence in the trunk bark for the species of section *Blaberopus* so far.

Leaves

The leaves vary in their arrangement, shape, size, and ornamentation (especially the indumentum and venation), and therefore are often supposed to yield important vegetative characters for the recognition of the species or species groups (sections) within the genus.

The leaves of *Alstonia* are opposite or whorled. Opposite leaves are found in most species of section *Dissuraspermum* and whorled leaves are found in the other sections. Exceptionally *A. coriacea* and *A. legouixiae* (section *Dissuraspermum*) have

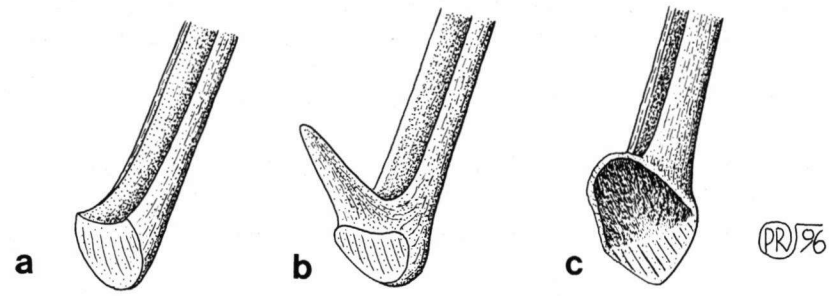


Fig. 2.2. Petioles and the intrapetiolar stipule at the base. a: Petiole without intrapetiolar stipule; b: narrow intrapetiolar stipule; c: rounded intrapetiolar stipule.

both opposite and whorled leaves. These species are endemic to New Caledonia. Another slightly different form occurs in *A. quaternata* (which also belongs to section *Dissurapermum*), in which the leaves are consistently in whorls of 3 except on the very narrow and short inflorescence branchlets, where the leaves are always opposite. Leaves of species in section *Alstonia* are in whorls of 4–9 (rarely of 3). This section is distributed from Africa across Asia up to South China, throughout Malesia, Australia, and the Solomon Islands. The other sections (*Blaberopus, Monuraspermum*, and *Tonduzia*) usually have a lower number of leaves in a whorl (3 or 4, rarely 5 or 6). Leaves in whorls of 5 or 6 are found only in *A. mairei, A. venenata*, and *A. yunnanensis*. The leaves are whorled and sometimes alternate on the same branchlet only known from *A. guangxiensis*.

The leaves are usually petiolate, but sessile or subsessile leaves are found in *A. congensis, A. curtisii, A. guangziensis, A. mairei, A. pneumatophora, A. rupestris*, and *A. yunnanensis*, and sometimes in *A. actinophylla, A. deplanchei, A. macrophylla*, and *A. spectabilis*. The length of the petioles varies from very short to rather long, and from slender to rather stout. The length of the petioles does not usually provide a good characteristic for identification.

The petioles are usually flattened or shallowly caniculate above, sometimes winged. In transverse section, they are more or less triangular. Intrapetiolar stipules may be distinct or obscure and are located at the base of the petiole. In principle, there are two kinds of intrapetiolar stipules in *Alstonia*: either narrow and rounded or suborbicular (Fig. 2.2). The narrow intrapetiolar stipules are unique to *A. scholaris*. Rounded or suborbicular intrapetiolar stipules are found in *A. boulindaensis, A. coriacea*, and *A. costata*, or in many specimens of *A. lenormandii* and *A. rostrata*. Some species, especially in section *Dissuraspermum*, have petioles slightly widened at the base and more or less clasping the branchlet.

The shape of the leaf blades varies from ovate to obovate and from narrowly ovate to narrowly obovate or linear. Even within a single species these variations can be observed. In general, the obovate form is more common than the other forms. The leaf size also varies and is therefore not a good character for identification at the species or sectional level.

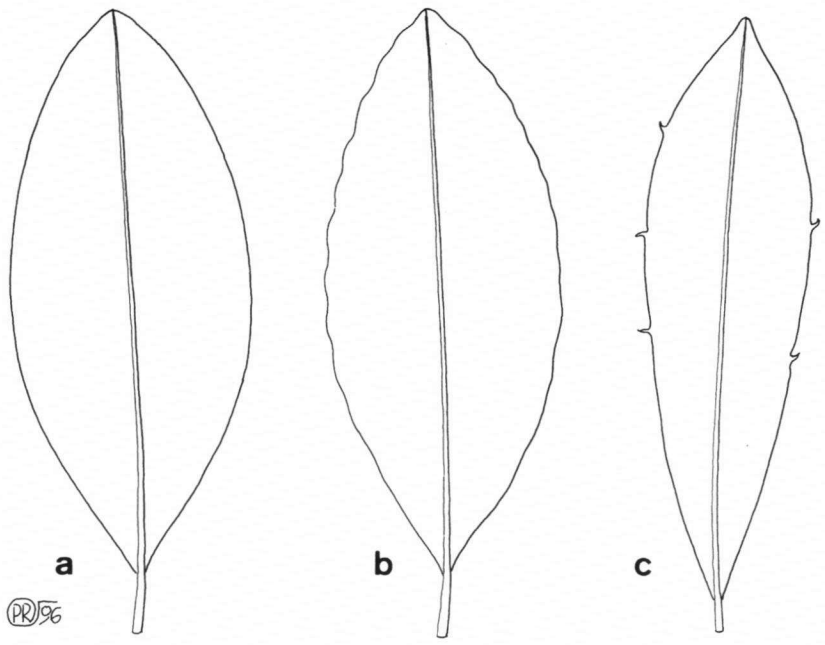


Fig. 2.3. Leaf margin. a: Entire; b: sinuate and/or undulate; c: irregularly dentate.

The base of the leaves mainly varies from acute to decurrent, rarely obtuse or subtruncate. In some cases, the decurrent form may be continuous along the petiole and then forms a distinctly winged petiole. The latter character can be observed in most species of section *Alstonia*. The obtuse or subtruncate form is found in several species of section *Dissuraspermum*, rarely in the other sections. The leaf base may be (slightly) oblique, as is sometimes found in *A. balansae, A. costata,* and *A. sphaerocapitata*. The same variation is also found in the leaf apex which can vary from retuse to acuminate and with a blunt or a pointed tip.

The leaf margin is usually entire, and may or may not be revolute. In *A. rostrata, A. balansae, A. costata,* and *A. sphaerocapitata*, the leaf margin may be undulate and/or sinuate. An irregularly dentate margin (probably abnormal) (Fig. 2.3) is sometimes observed in *A. odontophora.*

The venation (including the midrib, secondary veins, and tertiary venation) is usually impressed above. A longitudinally canaliculate raised midrib on the upper surface is found only in *A. rupestris* and *A. curtisii*. Both species are endemic to Thailand. The secondary veins are mostly numerous, well-spaced or close together (Fig. 2.4). In many species, the ends of the secondary veins are joined together and form a submarginal vein. This character is sometimes important for identification. In some species, mostly of section *Dissuraspermum*, the secondary veins are branched. A very rough and distinctly branched form is found in *A. odontophora* (Fig. 2.4f). Inconspicuous secondary veins and tertiary venation are typical for *A. coriacea* and *A. legouixiae.* A different character, in which the secondary veins are conspicuous but

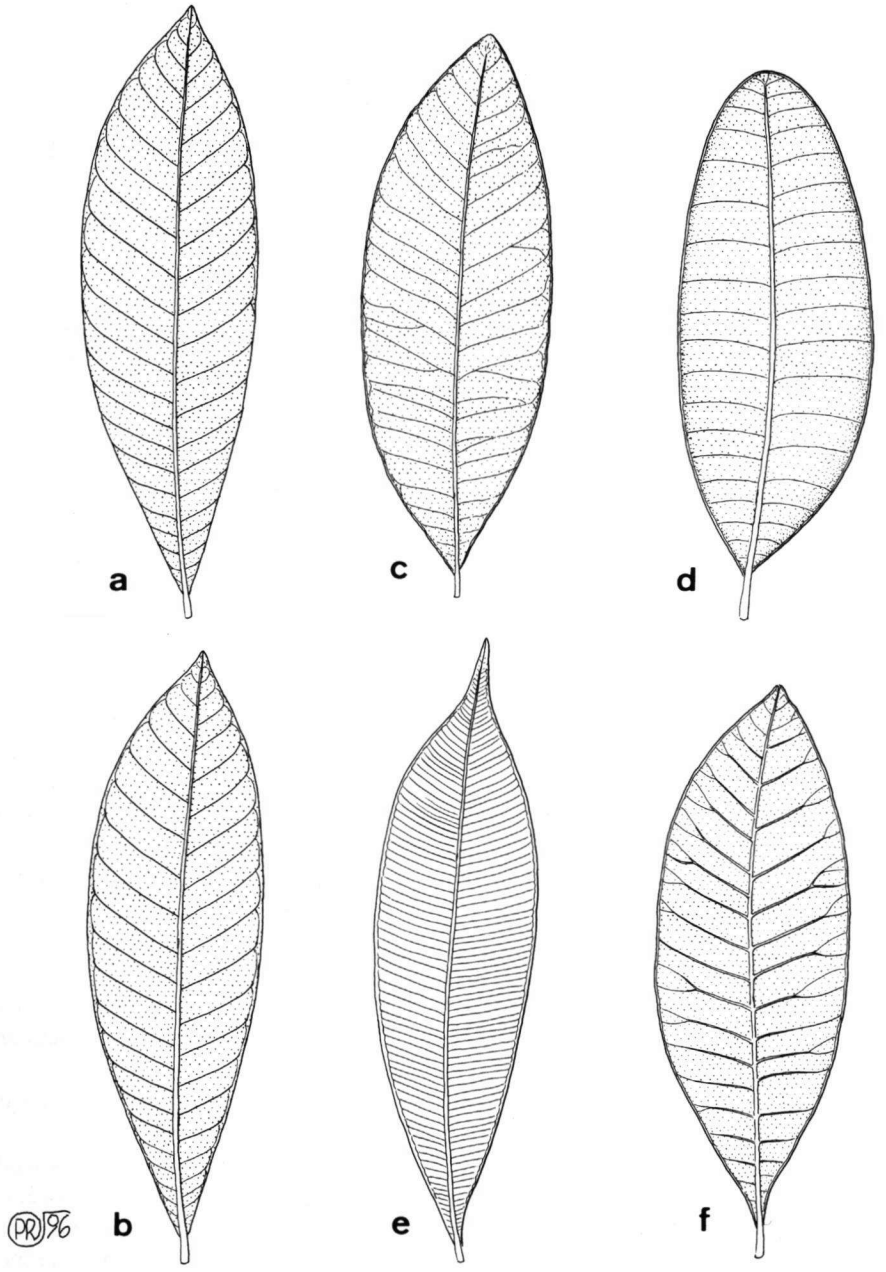


Fig. 2.4. Form of the secondary veins. a & b: *Alstonia macrophylla*, well spaced (a: the submarginal vein only at the apical part; b: submarginal vein from base to apex of the leaf); c: *A. lenormandii*, with some irregularities in direction; d: *A. legouixiae*, recurved; e: *A. neriifolia*, closely spaced; f: *A. odontophora*, roughly branched.

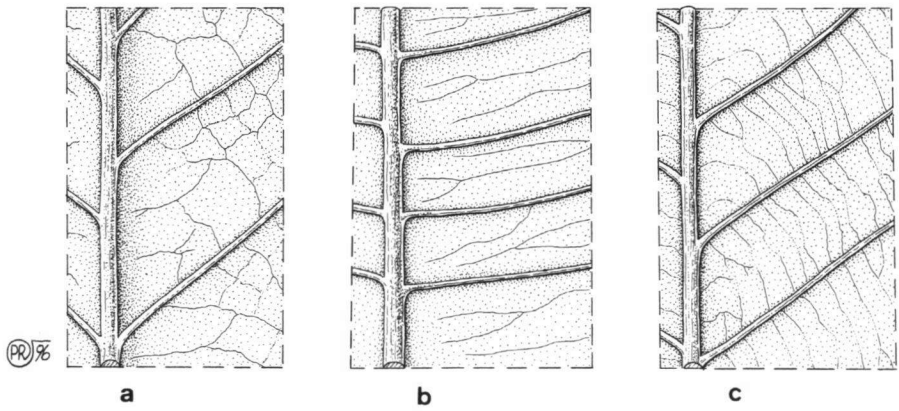


Fig. 2.5. Form of the tertiary venation. a: Reticulate; b: admedial ramified; c: scalariform.

the tertiary venation is inconspicuous, is found in most species of section *Alstonia,* and sometimes in section *Dissuraspermum* in those species which possess very narrow or linear leaves. Tertiary venation maybe reticulate, admedial ramified (Hickey, 1979), or scalariform (Fig. 2.5). The admedial ramified is typical for section *Alstonia*, while the scalariform usually occurs in *A. costata.*

Colleters

There are three forms of colleters: deltoid, narrowly triangular, and minute and/or linear (Fig. 2.6). They are located in the leaf-axils, sometimes extended and forming a ring-like arrangement at the node. In section *Blaberopus*, the colleters also occur in the bract-axils.

Deltoid and narrowly triangular colleters are found in section *Alstonia.* Narrowly triangular colleters are found only in *A. boonei, A. congensis*, and *A. scholaris.* The minute or linear form is typical for the other sections. Colleters in section *Blaberopus* are usually linear and up to 4 or 5 mm long. The colleters may be free or sticking together by resin. Sticking colleters are common in section *Alstonia.*

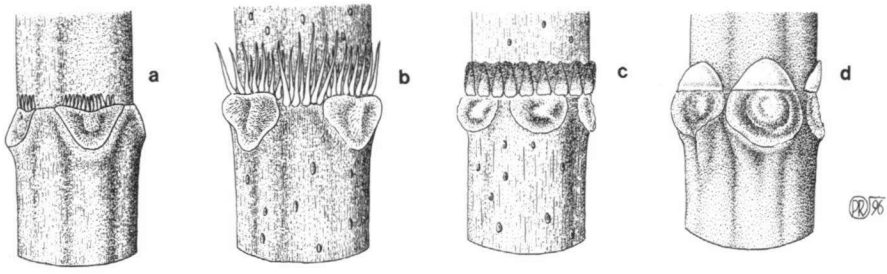


Fig. 2.6. Form of the colleters. a: Minute; b: linear; c: narrowly triangular; d: deltoid.

Inflorescences

The inflorescences of *Alstonia* are terminal, distinctly pedunculate, corymbose or cymose, and few- to many-flowered. The flowers may be sparse or crowded and dense. In the dense form, one bunch or more may be formed and is only found in *A. pneumatophora, A. iwahigensis,* and rarely in *A. scholaris.*

Bracts and bracteoles

The bracts and bracteoles are deciduous, but still present at anthesis; they are usually scale- or sepal-like, ciliate or not, and with or without colleters at the base. The bracts or bracteoles with some or several colleters at the base are found only in section *Blaberopus.* At the base of the inflorescence, or on the peduncles of certain species, the bracts may be linear or leafy. Distinct leafy bracts occur in *A. quaternata.* The bracteoles, which usually occur in sections *Dissuraspermum* and *Monuraspermum* (rarely in section *Alstonia*) are located around the middle of the pedicel or just below the calyx.

Flowers

General — The flowers of *Alstonia* are small, narrow, and are up to 40 mm long in the mature bud (usually less than 15 mm); in diameter they are up to 2.5 mm. They are bisexual, 5-merous, and actinomorphic except for the subequal sepals. The flowers are mostly fragrant and open during the day.

Pedicels — The pedicels are glabrous or pubescent, sometimes very short (subsessile), e.g., in some species of section *Alstonia,* but usually much longer in the other sections; and sometimes slender to rather stout. If they are hairy, the pedicels are usually less densely so than the calyx.

Sepals — The sepals are connate at the base, equal or subequal, and imbricate. Exceptions exist in some specimens of *A. angustifolia* where the margins do not overlap. The pubescence on the sepals is a diagnostic character. Sepals which are densely pubescent outside are found in some species of the sections *Alstonia* and *Monuraspermum.* Those of the other sections are puberulous or entirely glabrous. The externally pubescent sepals are usually persistent in fruit. In section *Dissuraspermum,* the sepals are always glabrous.

The pubescence on the inside of the sepals is also a very important character for identification. Sepals densely pubescent inside (only on the fused part) are found in *A. angustifolia, A. beatricis,* and *A. parvifolia,* and sometimes in *A. boonei* and *A. muelleriana.* Puberulous or very sparsely-hairy sepals are sometimes found in *A. angustiloba, A. annamensis,* (also in *A. boonei* and *A. muelleriana*), *A. pneumatophora* and *A. scholaris.*

Cilia which occur along the margin are present in all species of section *Alstonia* and *Monuraspermum,* in some species of section *Blaberopus,* and only in one species in section *Dissuraspermum* (*A. constricta*).

The shape of the sepals is usually ovate, sometimes suborbicular, broadly ovate, narrowly ovate, or subtriangular. A turbinate form is also observed, e.g., in *A. angustifolia, A. beatricis,* and sometimes in *A. boonei.* Sepals almost translucent around the margins are quite commonly observed within the genus. Sepals in the genus *Alstonia* are mostly persistent in fruit.

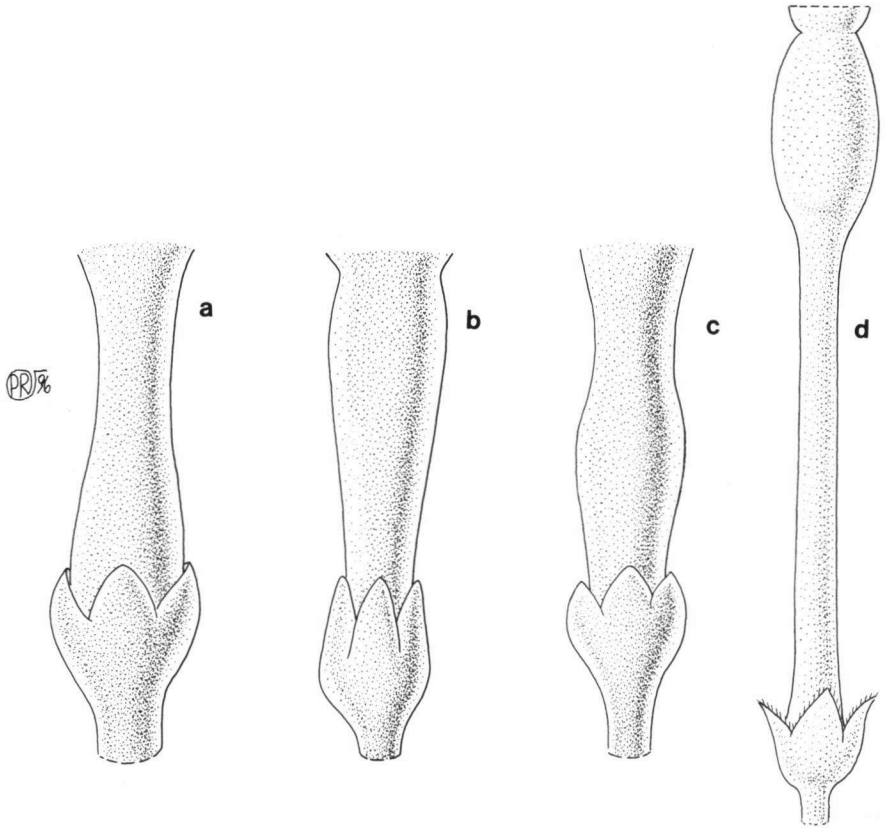


Fig. 2.7. The widened part of the corolla tube. a: Below the middle; b: above the middle; c: about the middle; d: above the middle and with abrupt widening.

Corolla — The corollas, especially the corolla lobes, are mostly white, sometimes yellow, cream, or pink. There are two main parts of the corolla: the corolla tube and corolla lobes. Both vary in shape and size. Usually the corolla tube is almost cylindrical and slightly widened around the stamens, but it is not twisted. The widened part may be below, around or above the middle of the corolla tube (Fig. 2.7). Most species of section *Blaberopus* have a long tube (more than 12 mm), in contrast to the other sections, which have tubes usually less than 10 mm long. The species with long corolla tubes also have a distinct (abruptly) widened part around the stamens (Fig. 2.7d).

The corolla lobes vary from broadly to very narrowly ovate and are sometimes slightly oblique or slightly falcate. They are spreading at maturity. Only in *A. annamensis* are the corolla lobes somewhat erect. The margins overlap basally. The lobes overlap in the bud to the left or to the right (Fig. 2.8). Overlapping to the left is found in sections *Alstonia*, *Blaberopus*, and *Tonduzia*; and to the right in sections *Dissuraspermum* and *Monuraspermum*. The base of the corolla lobes is more or less auriculate on the side where they overlap (observed from inside).

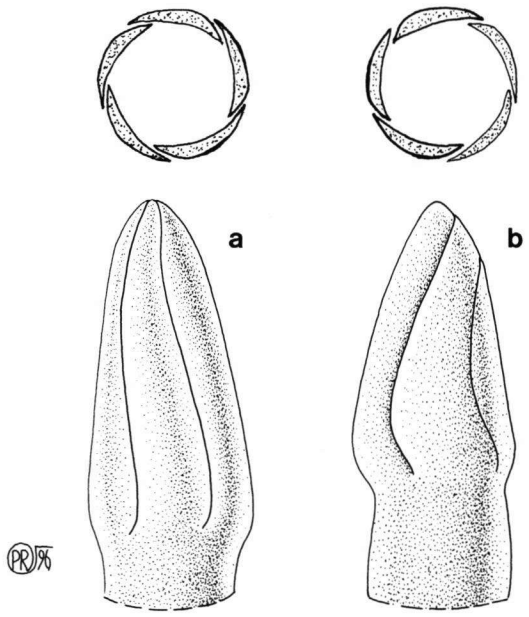


Fig. 2.8. Corolla lobes. a. Overlap to the right; b: overlap to the left.

The indumentum (if present) also varies greatly, especially on the outside. It may be pubescent, puberulent, or of very sparse hairs. In many species, the corolla lobes are glabrous outside and pilose inside at least at the base. Where the indumentum is dense, it may form a moustache-like formation surrounding the mouth of the corolla tube. Ciliation is also present in certain species.

Stamens — Always 5, and free from the pistil. The insertion of stamens varies with the position of the widened part of the corolla tube. The apex is always below the mouth of the corolla tube except in *A. rupestris* where it is sometimes at the level of the mouth of the corolla tube. The filaments are distinct, short to rather long, and filiform.

The anthers are ovate or narrowly ovate, obtuse, acute, or mucronulate at the apex, and cordate at the base. Two more or less equal locules are present in each anther. The locules open by longitudinal slits and lack appendages.

Pistil — The apex of the pistil is at the level of the base or below the middle of the anthers. In this position pollination can happen easily. So far no information is available on pollinators. The ovary is superior and apocarpous (syncarpous only in *A. rostrata*). The disk or disk-like thickening is usually distinct. The distinctly two-lobed disk alternates with the carpels in section *Blaberopus*, in contrast to the disk-like thickening which is located at the base of the ovary (sometimes obscure) in the other sections.

The ovary is mostly glabrous, less often very sparsely hairy or pubescent. The presence of an indumentum on the ovary is an important character to recognise certain species within the sections *Alstonia* and *Monuraspermum*. For instance, in section *Alstonia*, the ovary is densely pubescent only in *A. scholaris* and *A. boonei*; the

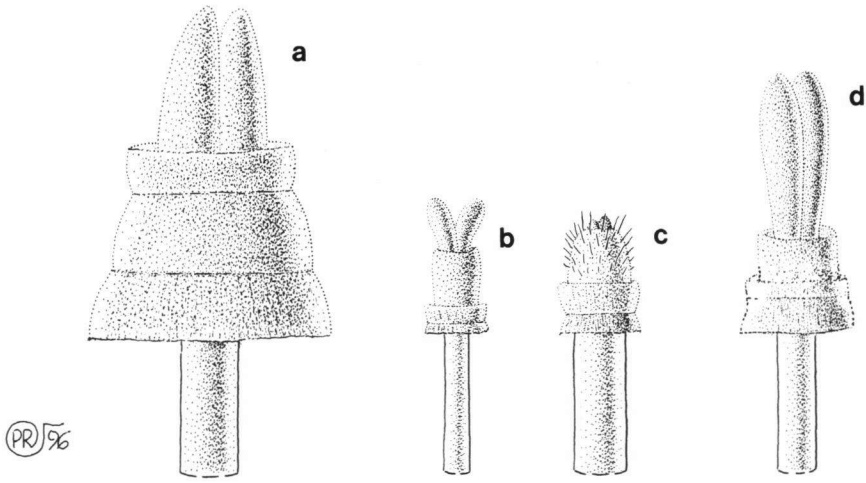


Fig. 2.9. Pistil head. a: Pagoda-like in section *Blaberopus* (*A. yunnanensis*); b: *A. angustiloba*; c: *A. vieillardii*; d: *A. scholaris*.

ovary is sometimes sparsely hairy (usually around the apex) in *A. angustiloba* and *A. congensis*. In section *Monuraspermum*, a sparsely hairy ovary is sometimes found only in *A. muelleriana*.

The style varies from short to long, and is usually distinct (absent or obscure only in *A. quaternata*). It is mostly filiform, slightly laterally compressed, shallowly caniculate on both sides, and glabrous.

The pistil head is also variable and may be ovoid or pagoda-like (Fig. 2.9). In section *Blaberopus*, the pistil head is pagoda-like and much bigger than the other sections (Fig. 2.9a). In general, the pistil head is composed of a narrow membranous basal veil (which is usually united to the basal ring), a narrow basal ring, a conical or cylindrical central part (sometimes formed by two rings in section *Blaberopus*), and a small, narrow, or robust cleft stigmoid apex.

Fruits

The fruits are paired follicles, except in *A. rostrata* where they are united and therefore appear as a single follicle (Fig. 2.10). Many species of section *Dissuraspermum* have the follicles spreading horizontally, or even reflexed, especially if they are short and rather stout (Fig. 2.10f). If the follicles are long, they tend to be pendulous (Fig. 2.10b). This form is found in all species of sections *Alstonia* and *Monuraspermum*. In section *Blaberopus* the follicles may also be spreading (especially in *A. yunnannensis*), but they usually form an angle of up to 45°, usually less (Fig. 2.10d & e). In *A. longifolia* (section *Tonduzia*), the angle formed by the follicles is very variable from almost parallel and pendulous to almost horizontal.

The follicles are mostly glabrous with pubescent ones known only in some species of section *Alstonia* (*A. boonei, A. angustiloba,* and *A. pneumatophora*). Apart from the pubescence the surface varies from smooth to roughly striate. Smooth or

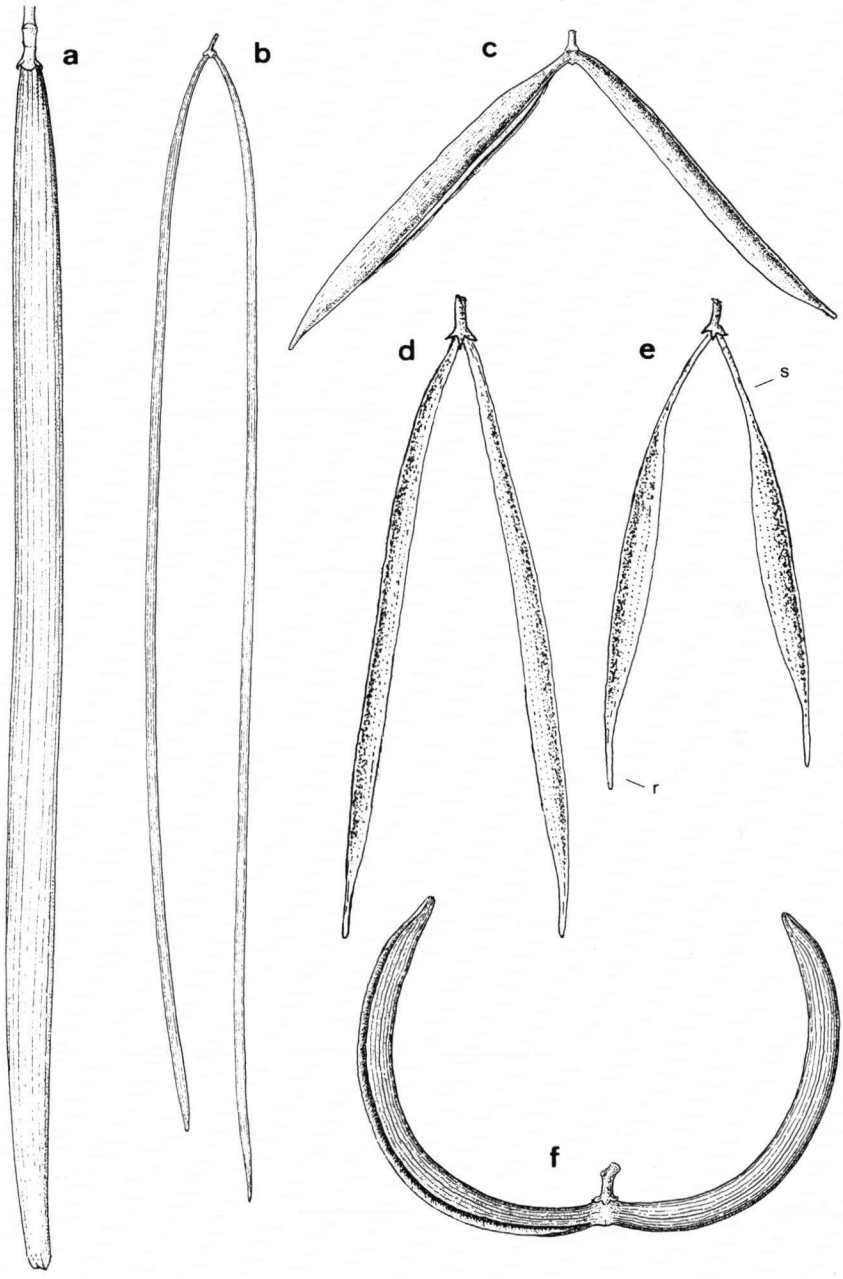


Fig. 2.10. Follicles. a: Single follicle; b–f: paired follicles; b: pendent and without stipe or rostrum; c–e: stipitate (s = stipe) and rostrate (r = rostrum) follicles; c: distinctly stipitate and non-stipitate follicles occur side by side; d: rostrate but without stipe follicles; e: both stipe and rostrum present; f: reflexed follicles.

very fine striation is found in section *Blaberopus* and in most species which have small diameter follicles with rougher striation in species with thick follicles.

The stipitation and rostration of the follicles (Fig. 2.10c–e) are also important characters for identification. These characters are found only in section *Blaberopus* and *Tonduzia*. The shape and size of the stipe is very variable within the species. In one specimen (*Tonduz 11619*, *A. longifolia*) distinctly stipitate and non stipitate follicles also occur side by side (Fig. 2.10c)

The length and diameter of the follicles varies greatly, even within the species. The widest follicles (to more than 10 mm in diameter) are found only in *A. rostrata*. This width is much more than in the other species which have follicles up to 6.5 mm in diameter (*A. quaternata*). The length of follicles varies from 2 cm (in *A. legouixiae*) to more than 60 cm (in *A. macrophylla* and *A. scholaris*)

Seeds

The seeds of *Alstonia*, except in some species of section *Blaberopus*, are numerous, elliptic, narrowly elliptic or oblong and with rounded to acuminate or caudate ends (Fig. 2.11). Three main groups are encountered based on the form of the ends of the seeds: rounded on both ends (Fig. 2.11c & f) in sections *Alstonia, Blaberopus,* and sometimes *Tonduzia*; one end rounded and the other end acuminate or caudate (Fig. 2.11e) in section *Monuraspermum*; and acuminate or caudate on both ends

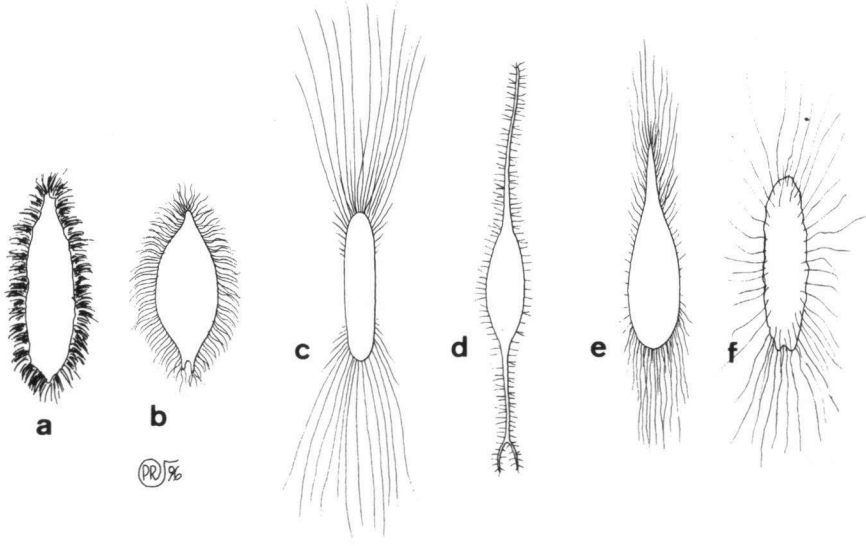


Fig. 2.11. Seeds. a: One end rounded and the other end shortly acuminate; note that the cilia are arranged in groups of various shapes and sizes; b: shortly acuminate on both ends; c: rounded on both ends; note that the cilia on the lateral margins are absent; d: long-caudate on both ends; note that the cilia surrounding the seed margin are very short (mostly less than 2 mm long); e: one end rounded and the other end acuminate; f: rounded on both ends; note that the cilia on the lateral margins are also long.

Table 2.1. Pollen morphological characters of *Alstonia* (from Kuijt & Van der Ham, 1997) and *Dyera costulata*.

Species	P	E	Aperture number	H-endo-aperture	Orna-mentation	Intine ghosts
Alstonia						
actinophylla	24.2	28.3	2	–	A–B	+
angustifolia	24.5	29.7	3	+	A–B	–
angustiloba	22.2	23.8	2	–	A	+
annamensis	21.4	26.2	3	+	A–B	–
balansae	20.1	23.1	3	+	B	–
beatricis	25.9	30.4	3	+	A–B	–
boonei	24.4	30.2	3	–	A–B	–
boulindaensis	18.1	25.1	3	+	B	–
breviloba	31.1	35.8	3	+	B	–
congensis	22.5	26.1	3	–	A	+
constricta	23.6	25.9	3	+	B	–
coriacea	23.1	28.1	3	+	B	–
costata	22.2	26.8	3 (4)	+	A/B	–
curtisii	40.7	53.1	3	++	A–B	–
deplanchei	22.4	25.4	3 (4)	+	A–B	–
iwahigensis	22.6	26.3	2	–	A–B	+
lanceolata	22.1	26.7	3 (4)	+	B	–
lanceolifera	21.9	26.3	3	+	B	–
legouixiae	25.6	31.1	(2) 3	+	B	–
lenormandii	18.4	22.6	3	+	B	–
longifolia	26.5	34.0	3	+	A–B	–
macrophylla	27.1	32.6	3	+	A–B	–
mairei	39.7	52.9	3	++	A	–
muelleriana	26.1	29.3	3	+	A–B	–
neriifolia	39.4	51.7	3	++	A	–
odontophora	26.9	33.7	3	+	B	–
parvifolia	26.4	33.3	3 (4)	+	B	–
penangiana	24.5	30.5	3 (4)	+	A–B	+
pneumatophora	24.4	27.9	2	–	A–B	+
quaternata	25.2	28.9	3 (4)	+	B	–
rostrata	26.0	31.4	3	–	A–B	–
rubiginosa	26.2	34.4	3 (4)	+	A	–
rupestris	34.2	50.6	3	++	A	–
scholaris	22.0	25.8	3	–	A	+
sebusi	37.2	49.1	3	++	A–B	–
spatulata	21.8	27.4	2	–	A–B	+
spectabilis	26.6	32.4	3 (4)	+	A–B	–
sphaerocapitata	19.6	23.9	3	+	A	–
stenophylla	19.9	23.7	3	+	B	–
venenata	46.1	58.9	3	++	A–B	–
vieillardii	25.4	25.8	3	+	B	–
yunnanensis	38.3	51.9	3	++	A	–
Dyera						
costulata	27.2	33.9	3	–	A	–

P = average length polar axis (µm); E = average equatorial diameter (µm). — + = present; ++ = present and more or less bulging at some distance of the colpi; – = absent. — A = ornamentation type A (more or less similar throughout pollen grain); B = ornamentation type B (mesocolpium centres different from remaining exine). A hyphen (–) between two states denotes an intermediate condition; a slash (/) between two states means both states as well as intermediate present.

(Fig. 2.11b & d) in section *Dissuraspermum*. In the last form some variation may occur. They can vary from unequally lobed to irregularly dentate, or rarely obtuse with an entire margin. However they seem to be modifications from the elongate form.

The seeds are glabrous or pubescent and mostly with long cilia along the margin. In the species of sections *Alstonia* and *Monuraspermum* the cilia are tufted at both ends and are usually much longer than the cilia that occur on the lateral margins. There are two different maximum lengths of cilia: those up to 2 mm long are found only in section *Dissuraspermum*, those in the remaining sections are much longer (up to 18–20 mm in *A. boonei* and *A. congensis*). In section *Tonduzia*, the cilia are arranged in groups of various shapes and sizes and therefore look different from the cilia of other species. Glabrous seeds are found in section *Alstonia* and sometimes in section *Blaberopus*. In the other sections they are pubescent or sometimes glabrescent.

2.2. Pollen morphology

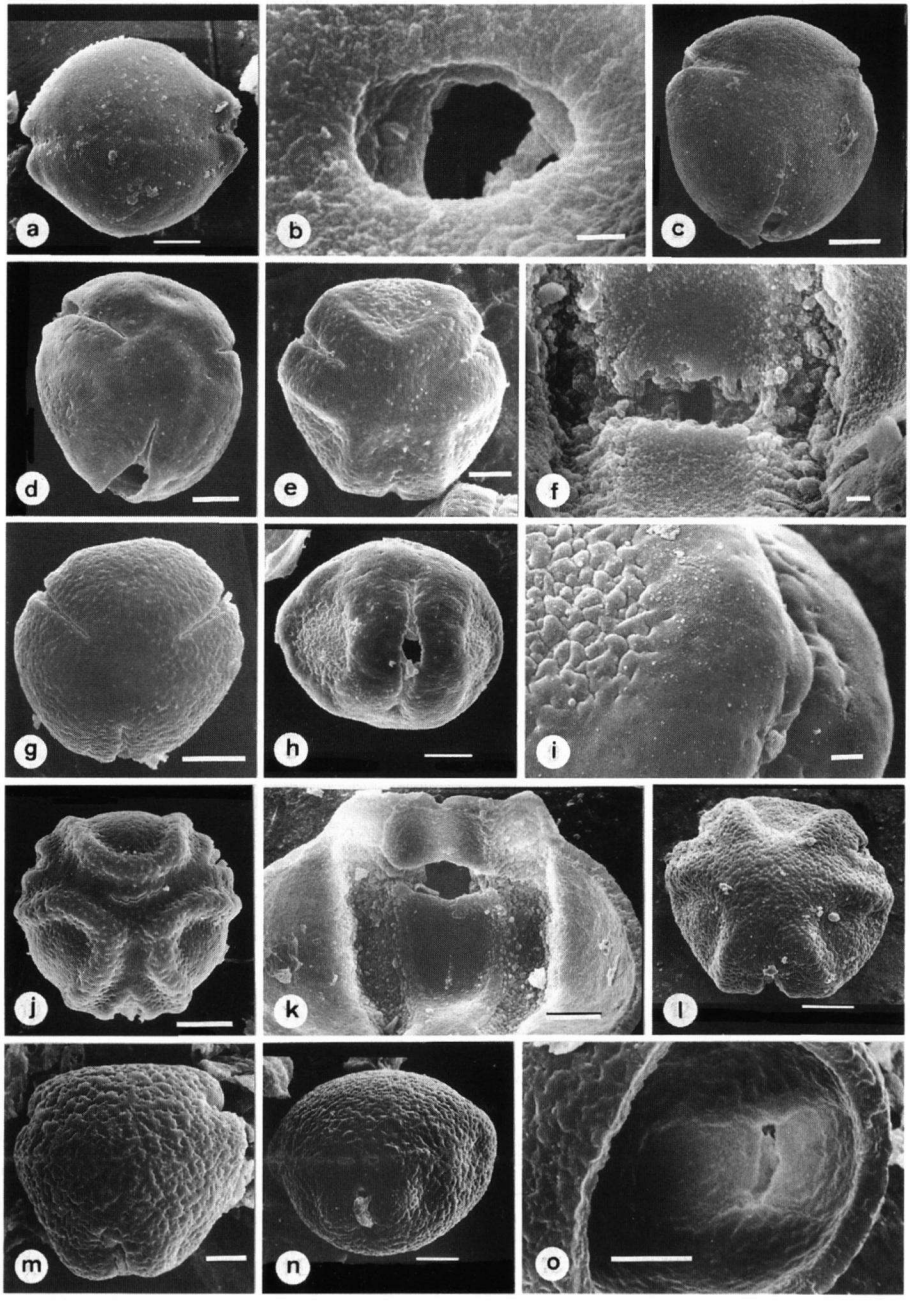
2.2.1. *Alstonia*

The pollen morphology of *Alstonia* was studied by Kuijt & Van der Ham (1997). Only the pollen of *A. guangxiensis* was not available. Four distinct pollen types could be recognised: type 1 (2-aperturate, Fig. 2.12a) and type 2 (3-aperturate, Fig. 2.12c) have porate endoapertures (Fig. 2.12b), while type 3 (E < 36 µm, Fig. 2.12d, e, g–i) and type 4 (E > 49 µm, Fig. 2.12j & l) possess H-endoapertures (Fig. 2.12f & k). A short description of the pollen morphology is given below. Table 2.1 shows only the characters that have been used in the cladistic analysis.

Fig. 2.12. SEM photographs of *Alstonia* (a–l) and *Dyera* (m–o) pollen. Bars: 10 µm (j, l); 5 µm (a, c–e, g, h, k, m–o); 1 µm (b, f, i).

a, b: *A. pneumatophora* (*Kostermans 4537*). a: Polar view of 2-aperturate grain; b: inner aspect of a porate endoaperture.
c: *A. rostrata* (*Sririrugsa 457*). Oblique polar view.
d: *A. beatricis* (*van Royen 5535*). Oblique polar view; note the slightly different ornamentation in the mesocolpium centres.
e, f: *A. longifolia* (*Castillo 1758*). e: Polar view; note the slightly different ornamentation in the mesocolpium centres; f: inner aspect of an H-endoaperture.
g: *A. sphaerocapitata* (*MacKee 32140*). Polar view; note the similar ornamentation throughout the pollen grain.
h: *A. quaternata* (*McPherson 5935*). Equatorial view; note the distinct ornamentation in the mesocolpium centres.
i: *A. constricta* (*Forsyth 1099*). Detail, showing finely fossulate ornamentation in the mesocolpium centre merging with psilate ornamentation of the margin.
j, k: *A. neriifolia* (*Estrada 1951*). j: Polar view; k: inner aspect of an H-endoaperture.
l: *A. sebusi* (*Henry 11932*). Polar view.
m–o: *D. costulata* (*Endert 37E iP 627*; L). m: Oblique polar view; n: oblique equatorial view; note the equatorial 'pits'; o: inner aspect of an endoaperture.

Description: Pollen grains (Fig. 2.12a–l) mostly small to medium-sized, sometimes large (polar axis P = 18.1 (26.4) 46.1 µm, equatorial axis E = 22.6 (32.4) 58.9 µm), oblate to oblate spheroidal (P/E = 0.68 (0.82) 0.98), 2- or 3-aperturate, a few largely 3-aperturate samples contain up to 10% 2- or 4-aperturate grains. The pollen grains



are always colporate. The colpi measure 13.7–24.1 × 1–6.3 μm. Two *endoaperture types* can be distinguished. One is a circular to lalongate pore (3.3–4.6 × 4.1–5.7 μm) (Fig. 2.12b). The other is an H-endoaperture (Fig. 2.12f & k). The central, equatorially oriented part of an H-aperture measures 1–7.6 × 6.6–14.1 μm. *Ornamentation* more or less microfossulate to perforate to psilate. Two intergrading distribution types can be distinguished, type A: ornamentation more or less similar throughout the pollen grain (Fig. 2.12g), type B: mesocolpium centres different from remaining exine (Fig. 2.12h & i). Intermediate states (A–B) are illustrated in Fig. 2.12d & e).

2.2.2. *Dyera* (by: R.W.J.M. van der Ham, Rijksherbarium / Hortus Botanicus, Leiden)

The pollen of *Dyera* has been studied by Polak (1933), Pichon (1948) and Rao & Tian (1974). The concise descriptions in these studies concern *D. costulata*, and include more or less detailed drawings. The pollen was described as medium-sized (27–33 μm), ± triangular in polar view, suboblate, 3-porate with heavy costae (Pichon) or 3-zonocolporate with lalongate endopores (Rao & Tian), and with reticulate ornamentation.

In order to provide a dataset that may be compared with that of *Alstonia*, the pollen of *D. costulata* was restudied, including scanning electron microscopy (Fig. 2.12 m–o). Pollen was obtained from *Endert 37E iP 627* (L), from Sumatra. The pollen grains of this collection are medium-sized (P = 27.2 μm, E = 33.9 μm), suboblate (P/E = 0.80), obtusely triangular to inter-hexagonal in polar view, and always 3-colporate (Fig. 2.12m). The colpi are short (c. 10 × 1.5 μm), and distinct only with scanning electron microscopy (Fig. 2.12n). The endoapertures are relatively large (c. 12 μm wide) lalongate pores, slightly constricted meridionally, with rather heavy polar costae and indistinct lateral sides (Fig. 2.12o). Scanning electron micrographs of the outer side of the exine show slightly indented areas in the equatorial zone at or near the lateral sides of the endoapertures (Fig. 2.12n). The ornamentation is finely fossulate to perforate, and is similar throughout the pollen grain. Intine remains were not observed.

The pollen of *D. costulata* does not match any of the pollen types recognised in *Alstonia*. The large, heavily costate endoapertures with indistinct lateral sides and associated equatorial 'pits' are unknown in *Alstonia*. On account of the pollen size, the aperture number and the absence of H-endoapertures, the pollen of *D. costulata* seems to be nearest to pollen type 2 of *Alstonia*.

Chapter 3

PHYLOGENETIC ANALYSIS

3.1. Introduction

To arrive at a sound classification of *Alstonia*, a cladistic analysis has been performed. The aim was to reconstruct the phylogenetic relationships between the different species recognised and express these in a classification. The present study is the first attempt to construct a phylogenetic classification at the species level in the Apocynaceae so far. Cladistic studies at the genus and family level have been published by Sennblad & Bremer (1996) and Endress et al. (1996).

Cladistic methodology, and the theory of phylogenetic systematics and biogeography has been widely discussed since the seventies, e.g., Nelson & Platnick (1981), Wiley (1981), Cracraft (1983b), Zandee & Roos (1987), Brooks & McLennan (1991), and Forey et al. (1992). The concepts have been translated into a number of computer programmes to analyse both morphological and molecular data, i.e., PAUP (Swofford, 1991, 1993), Hennig86 (Farris, 1988), and CAFCA (Zandee 1994). PAUP and Hennig86 start from the parsimony criterion, whereas CAFCA is based on group compatibility. Another difference is that the former two programmes need the designation of an outgroup to polarise the character states.

3.2. Monophyly of *Alstonia*

In a strict phylogenetic classification, genera and other taxa recognised above the species level should be monophyletic (Hennig, 1966; Wiley, 1981; Adema, 1991; Van Welzen et al., 1992; Turner, 1995). A monophyletic group of species includes an ancestor and all of its descendants. The descendants all share one or more unique evolutionary novelties (apomorphies), i.e., character states that have been newly developed in their most recent common ancestor and have been inherited by all its descendants. Therefore, monophyletic groups are in principle recognisable by a set of shared unique character states (presumed synapomorphies). The presence of one unique character is sufficient to assume monophyly (Wiley, 1981). However, apomorphies developed in the most recent common ancestor can be altered subsequently in one of the descendant branches into a new apomorphy. This and reversals and parallel or convergent evolution may blur the recognition of monophyletic groups.

Testing the monophyly of *Alstonia* as such could not be included in the present study, as this can only be done by including higher taxonomic levels. However, it seems not too difficult to underpin the plausibility of the monophyly of *Alstonia* as there are some presumed synapomorphic characters. *Alstonia* differs from *Dyera* mainly in having ciliate seeds, more slender follicles, without colleters on the inside of the sepals, being pubescent around the mouth of the corolla tube, and the inflores-

cences always being terminal. From *Diplorhynchus* (an African genus), *Alstonia* differs by the presence of colleters in the leaf axils, ciliate seeds, and also the more slender follicles. *Rhazya* has no cilia on the seeds, and the leaves are spiral.

Another closely related (American) genus, *Laxoplumeria*, shares the ciliate seeds, but the pubescence of the seed surfaces is different, with long densely set hairs on the adaxial surface, a condition that does not occur in *Alstonia*. Moreover, the leaf arrangement of *Laxoplumeria* is spiral, while in *Alstonia* it is opposite or in whorls.

Cataranthus and *Vinca,* which also belong to the tribe Plumerieae, are less closely related to *Alstonia*, especially due to their habit. *Cataranthus* comprises annual or perennial herbs only, while *Vinca* comprises herbs and shrubs. Both genera have axillary inflorescences, in contrast to *Alstonia,* which has terminal ones.

3.3. Character delimitation and data matrix

The data matrix (Table 3.2) accommodates 68 characters, 61 macromorphological and 7 palynological (Table 3.1). The characters are numbered according to the cladistic programme used (Hennig86) and thus start from zero (0); character state 'a' in Table 3.1 is equivalent to '0' in Table 3.2, character state 'b' to '1', 'c' to '2', and so on. Wood anatomical characters have not been included because as yet no data are available for most of the species (only for 13 out of a total of 43 species). However, the results of the cladistic analyses will be used to illuminate the wood anatomical diversity pattern in Chapter 4.

The data matrix should be based on discrete characters. However, some quantitative characters have been included as well, after being divided into states on the basis of no or minor overlap in the species ranges. The character states were treated as unordered, i.e., there is no *a priori* designation of the sequence of character states nor of a transformation series (Forey et al., 1992).

Character states which are absent are always coded as unknown data. Polymorphism (in case more than one character state is present in a species) is mostly coded as unknown (see Ryding & Bremer, 1992; Wiegmann et al., 1993; Turner, 1995), but when possible coded as a separate character state in a multistate transformation series (see Van Welzen, 1989; Schot, 1991; Adema & Van der Ham, 1993; Wen & Stuessy, 1993; Hill & Jordan, 1993). Including too many missing data in the phylogenetic analysis can be problematical and may sometimes produce resolutions that are not supported by the data at hand (Pimentel & Riggins, 1987; Platnick et al., 1991; Forey et al., 1992; Maddison, 1993).

All data in Table 3.1 are coded in agreement with the descriptions and keys in Chapter 5 (except for the pollen for which the data are presented in Chapter 2). However, there may not be a one-to-one correspondence. This is because the keys are intended for easy-to-use identification tools rather than for the phylogenetic analysis. Sometimes, the distinctions made in the keys are too subtle to be of use in the phylogenetic analysis; in other cases the states distinguished have been regrouped in order to be phylogenetically informative.

Table 3.1. Characters and their states used in the phylogenetic analyses of *Alstonia*.

0. Lenticels on branches / branchlets
   a = absent
   b = sometimes present
   c = always present

1. Leaf arrangement
   a = opposite
   b = opposite and in whorls of 3
   c = in whorls of 3–4
   d = in whorls up to more than 4
   e = in whorls more than 4

2. Leaf petiolate
   a = sessile or subsessile
   b = petiolate

3. Tertiary venation scalariform
   a = absent
   b = usually present

4. Leaf apex
   a = pointed
   b = blunt
   c = sometimes or often retuse

5. Leaf base
   a = acute to decurrent
   b = acute to obtuse
   c = obtuse to subtruncate

6. Leaf margin
   a = entire
   b = undulate or/and sinuate present
   c = irregularly dentate sometimes present

7. Leaves above (pubescence)
   a = glabrous
   b = puberulous or pubescent

8. Leaves beneath (pubescence)
   a = glabrous
   b = puberulous or pubescent

9. Colleters in the leaf axils
   a = absent
   b = present

10. Colleters in leaf axils
   a = minute to linear
   b = narrowly triangular
   c = deltoid

11. Colleters in bract axils
   a = absent
   b = present

12. Intra-petiolar stipule
   a = absent
   b = sometimes present
   c = always present

13. Secondary veins
   a = conspicuous
   b = inconspicuous

14. Recurved secondary veins
   a = absent
   b = sometimes present
   c = very often

15. Tertiary venation
   a = conspicuous
   b = inconspicuous

16. Admedial ramified tertiary venation
   a = absent
   b = present

17. Inflorescences
   a = axilary
   b = terminal

18. Flowers very densely clustered
   a = absent
   b = present

19. Pedicels (pubescence)
   a = glabrous
   b = puberulous or pubescent

20. Leafy bracts on peduncles
   a = absent
   b = present

21. Bracteole(s) on pedicels
   a = absent
   b = sometimes present
   c = common

22. Sepals
   a = free
   b = connate at the base

23. Sepal margin
   a = thick, sometimes reflexed
   b = thin, not reflexed

24. Sepal outside
   a = glabrous
   b = pubescent

25. Sepals inside (on the lobed part)
   a = glabrous
   b = puberulous or pubescent

(Table 3.1 continued)

26. Colleters on sepals inside
    a = absent
    b = present

27. Ciliation on sepals
    a = absent
    b = present

28. Corolla bud length
    a = < 15 mm
    b = > 15 mm

29. Corolla outside
    a = glabrous
    b = puberulous
    c = pubescent

30. Corolla lobes (shape)
    a = broadly ovate to ovate, < 1.5 × as long as wide
    b = broadly ovate to ovate, but sometimes > 1.5 × as long as wide
    c = elliptic to (very) narrowly ovate, 1.5 × as long as wide

31. Corolla lobes (thickness)
    a = thin (papery)
    b = thick (fleshy when fresh)

32. Corrola lobes inside
    a = glabrous, except arround the mouth
    b = glabrous or pilose up to about basal half
    c = basal half to completely hairy
    d = completely hairy

33. Corolla lobes overlapping
    a = to the right
    b = to the left

34. Corolla lobes ciliation
    a = absent or very sparse
    b = sparse
    c = dense, distinct

35. Corolla tube
    a = 12 mm long
    b = > 12 mm long

36. Hairs surrounding mouth of corolla tube
    a = absent
    b = present

37. Stamen insertion (of the tube)
    a = below the middle
    b = below to about the middle
    c = below to above the middle
    d = at the middle to above the middle
    e = above the middle

38. Apex of stamens
    a = exceded or about as high as mouth of corolla tube
    b = below mouth of corolla tube

39. Ovary
    a = apocarpous
    b = syncarpous

40. Indumentum on ovary
    a = glabrous
    b = glabrous or very sparsely hairy
    c = villous

41. Disk
    a = obscure or annular
    b = distinctly 2-lobed

42. Disk with wavy/irregularly lobed margin
    a = absent
    b = present

43. Pistil
    a = shorter than sepals
    b = longer than sepals

44. Style
    a = as long as or longer than ovary
    b = as long as or shorter than ovary
    c = absent or obscure

45. Pistil head (central part)
    a = ± conical
    b = cylindrical or ring-like

46. Stigmoid apical part
    a = minute or narrow
    b = robust, 0.3 mm long
    c = robust, up to > 0.3 mm long

47. Fruits
    a = a pair of follicles
    b = single follicle

48. Follicle length
    a = up to 15 cm
    b = more than 15 cm

49. Follicle diameter
    a = up to 2.5 mm
    b = up to 7.5 mm
    c = 7.6–15 mm
    d = > 15 mm

50. Stipitation of follicles
    a = absent
    b = present

(Table 3.1 continued)

51. Follicles (rostrate)
    a = absent
    b = present

52. Follicles (pubescence)
    a = glabrous
    b = pubescent

53. Fruit surface
    a = smooth or minutely striate
    b = roughly striate

54. Seeds
    a = rounded on both ends
    b = one end rounded, other end acuminate
    c = tending to be acuminate or caudate on both ends

55. Seeds surrounded by membranous glabrous wing
    a = absent
    b = present

56. Seed on side margin
    a = entire
    b = wavy or irregularly dentate

57. Seeds with long hairs near the margin
    a = absent
    b = present

58. Cilia on side margin of the seeds
    a = long or ± as long as the cilia at the ends
    b = glabrous or very short

59. Cilia (maximum length)
    a = up to 2 mm
    b = 2.1–7.5 mm
    c = 7.6 mm
    d = arranged in various shapes and seem to be branched

60. Surface of seeds (apart from the long hairs near the margin)
    a = glabrous
    b = puberulous or pubescent

Pollen morphology:

61. Equatorial axis (mean length)
    a = < 40 µm
    b = > 40 µm

62. Polar axis (mean length)
    a = < 20 µm
    b = 20–30 µm
    c = > 30 µm

63. Number of apertures
    a = 2
    b = 3

64. H-endoapertures type
    a = absent
    b = present and bulging along the colpi
    c = present and bulging at some distance of the colpi

65. Ornamentation type A (ornamentation similar throughout pollen)
    a = absent
    b = present

66. Ornamentation type B (mesocolpium centres different from remaining exine)
    a = absent
    b = present

67. Intine ghosts
    a = absent
    b = present

Table 3.2. Data matrix of character states of *Alstonia* used in the phylogenetic analysis.

	0 1 2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19	20 21 22 23 24 25 26 27 28 29	30 31 32 33 34 35 36 37 38 39	40 41 42 43 44 45 46 47 48 49	50 51 52 53 54 55 56 57 58 59	60 61 62 63 64 65 66 67
Dyera costulata	0410120000	?020000000	0001001000	2001000000	1000211013	0001010017	00110100
A. actinophylla	04?0?00001	2000011100	0211000100	2001001410	0001011010	0000000012	00100111
A. angustifolia	2210100071	0000000101	0210110102	1030201410	0001010011	0000100002	10111110
A. angustiloba	1410110001	2000011171	00111?0100	2001001410	1001011010	0010000012	00100101
A. annamensis	1210100001	0000000101	0211110102	1110201210	00010?0011	0001100001	10111110
A. balansae	2011211001	0000000100	0211000000	2020001210	0001001001	0001200000	10111010
A. beatricis	0210100001	0000010101	0211110101	2010201410	000000007?	?????0????	?0111110
A. boonei	2410110001	1000001101	0011110102	0031001410	2001012010	0010000012	00110110
A. boulindaensis	001010?001	0020010100	0211000000	2030001010	0001100001	0001200000	10011010
A. breviloba	2210110011	0000000101	0211?00107	0010001410	0001000011	0001100001	10211010
A. congensis	14?0100001	1000001107	0011000102	0031001410	1001012011	0000000012	00110101
A. constricta	0010?1???1	0001010100	0011000100	2010001310	000110007?1	0000200000	10111010
A. coriacea	1110102001	0021210100	0211000000	2010001310	000110007?1	0001200000	10111010
A. costata	101121?0?1	00100?0100	?211000000	20?0001210	000110007?1	000?20?000	10111110
A. curtisii	0210000001	0100010100	0011000010	2001011410	0100001001	0100001101	?1212110
A. deplanchei	20?0110001	0010100100	0211000000	2110001010	0001000000	0000200000	10111110
A. guangxiensis	2200020011	0100010100	0011000110	2001011410	0101011007?	??????????	????????
A. iwahigensis	1410110001	2000011121	00111?0100	2001001410	0001011010	0000000012	00100111
A. lanceolata	101010?001	0000100100	0211000000	2030101310	000100007?1	0000200000	10111010
A. lanceolifera	0010100001	0000110100	0211000000	0010001310	000110007?1	0001200000	10111010
A. legouixiae	1110100001	0001110100	0211000000	2010001110	000?100001	0001200000	10111010
A. lenormandii	001011?001	0010100100	0211000000	2010001210	0001100001	000120?000	10011010

(Table 3.2 continued)

	0 1 2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19	20 21 22 23 24 25 26 27 28 29	30 31 32 33 34 35 36 37 38 39	40 41 42 43 44 45 46 47 48 49	50 51 52 53 54 55 56 57 58 59	60 61 62 63 64 65 66 67
A. longifolia	1210000001	0000010100	0211000000	2011001210	000000100?1	?100201003	10111110
A. macrophylla	12?01000?1	0000010101	0211?00010?	2010201310	0001000011	000110000?	10111110
A. mairei	0310000001	0100010100	0011000010	2001011410	0101012000	1100001101	01212100
A. muelleriana	2210100111	0000000101	02111?0102	2030201210	100?1000?1	0000100002	10111110
A. neriifolia	221000001?1	0100010100	0011000110	2001011410	0100012?1	0100001110?	?1212100
A. odontophora	2010102001	0000110100	?211000000	2110001210	0001000?1	0001200000	10111010
A. parvifolia	0210100001	0000010101	0210110107	2000001410	000?010011	0000100001	10111010
A. penangiana	0210100001	0000000101	0211110102	2030201410	0001000011	0001100002	10111111
A. pneumatophora	03?0210001	2000011121	00111?0100	1001001410	0001011?0	0010000012	00100111
A. quaternata	0110100001	0000000100	1210000000	2110001010	00002?0001	0001200000	10111010
A. rostrata	1310111001	2000001100	0011000101	0031001311	1001012112	0001000012	00110110
A. rubiginosa	0210100111	0000000101	0?11100107	2010001410	0001010011	0001100001	10111100
A. rupestris	2200020001	0100010100	0111000000	0001001410	0111012001	0100001101	?1212100
A. scholaris	24102100?1	1020011111	00111?0102	0001001410	2001012010	0000000012	00110101
A. sebusi	221000017?1	010001010?	0011?00100	1001001410	0101012001	2100001101	?1212110
A. spatulata	0310210001	2000011100	0011000100	1001001410	000101107?1	0000000012	00100111
A. spectabilis	12?0?00??1	0000000101	02111?0102	1030201210	000?000011	000110000?	10111110
A. sphaerocapitata	1010?0?001	0000000100	0211000000	0020001310	0001100011	0001201000	10011100
A. stenophylla	1210100001	0000010100	0211000000	0000001410	000111007?	??????????	?0011010
A. venenata	231000017?1	010001010?	0011?00110	2001011410	0101011001	2100001102	?1212110
A. vieillardii	101111?001	0000000100	021100000?	2020001010	0001000011	0000200000	10111010
A. yunnanensis	2300010111	010001010?	0011?00107	2001201410	0101012001	0100001101	01212100

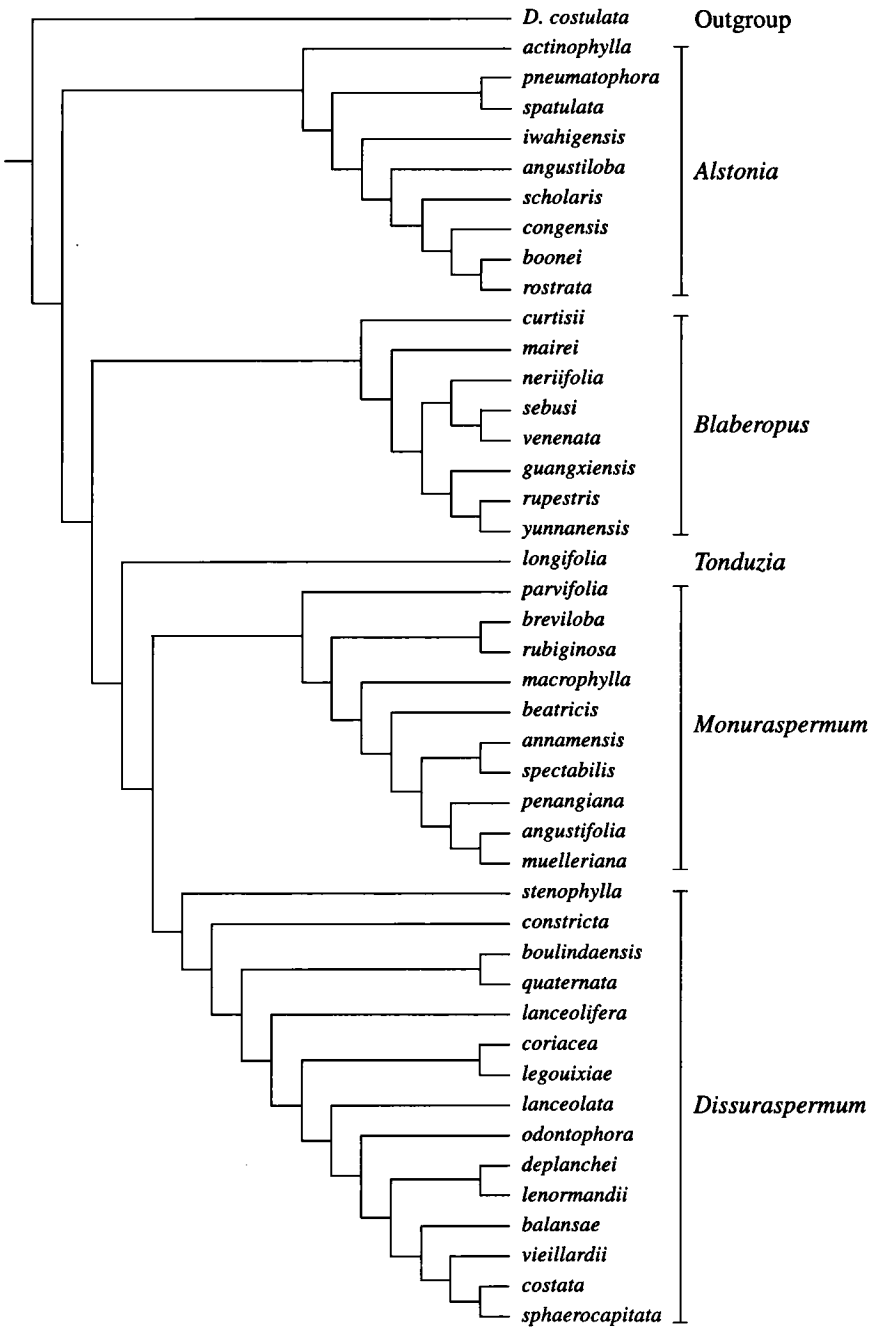


Fig. 3.1. The single most parsimonious cladogram obtained from the analysis of the dataset in Table 3.2.

3.4. Outgroup

Dyera costulata has been selected as an outgroup for the phylogenetic analysis. Morphologically, this species is very close to *Alstonia*, especially to *Alstonia* section *Alstonia,* as also mentioned by Monachino (1949). Only this species is used as an outgroup in this study. *Laxoplumeria* is another, presumably closely related to the genus *Alstonia*. Unfortunately, the specimens available are very poor, and no complete data could be obtained on flowers. Both genera are regarded related due to the similar follicle and the ciliate seeds.

Ochrosia and *Tabernaemontana,* which vegetatively look quite similar, were regarded more distantly related (see also Leeuwenberg, 1991, 1994).

3.5. Computer programme

Two computer programmes, Hennig86 (Farris, 1988) and PAUP 3.1.1 (Swofford, 1993) were used in the phylogenetic analysis of *Alstonia*. For Hennig86, the option mh* (multiple run of the data matrix) was employed to obtain starting trees, followed by bb* (branch swapping). In PAUP the heuristic search settings were employed, applying the random addition sequences with 10 replications, and followed by branch swapping using the tree-bisection-reconnection algorithm. These restrictions were necessary to avoid an overflow in number of trees.

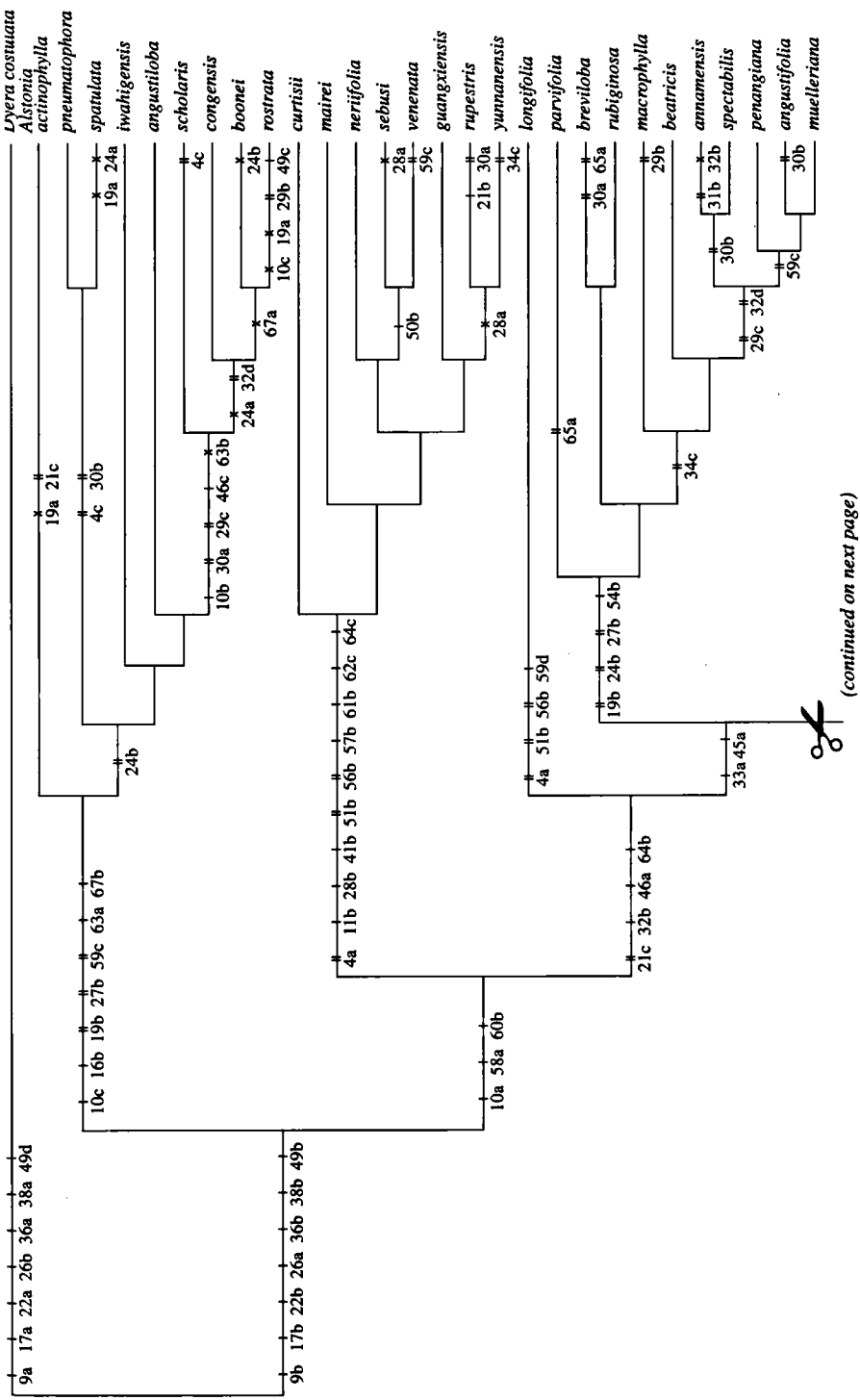
3.6. Results

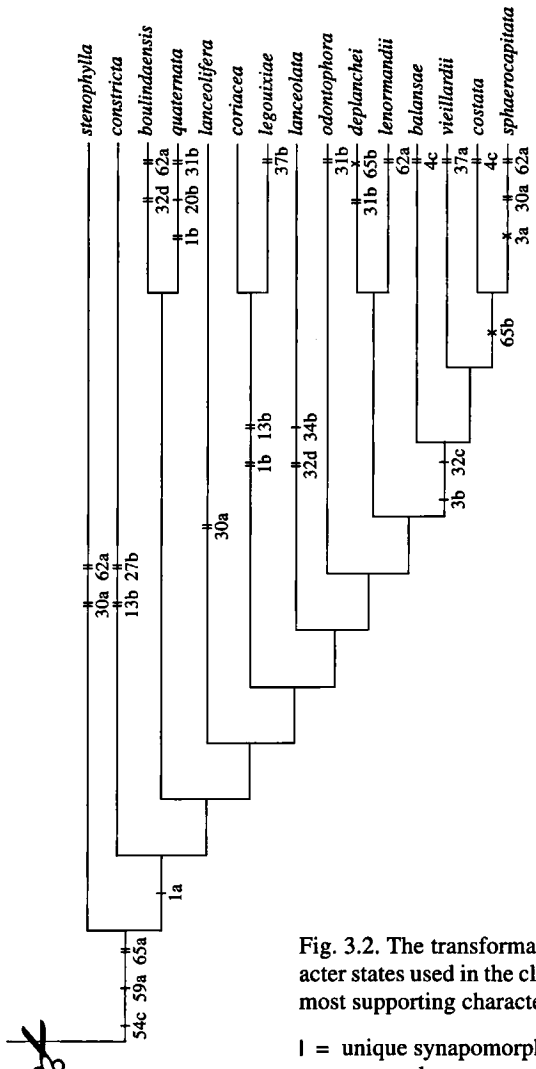
Both the analyses using Hennig86 or PAUP 3.1.1 resulted in a similar, single most parsimonious tree (Fig. 3.1 & 3.2). The tree has a length of 256 steps (ci = 0.38 and ri = 0.71).

The tree comprises five main monophyletic groups. With a few exceptions these groups are strikingly congruent with the sectional grouping recognised by Monachino (1949). Only section *Winchia*, represented by *A. rostrata,* has to be united into another group belonging to section *Alstonia*. The main monophyletic groups are: 1) *Alstonia*, comprising 9 species; 2) *Blaberopus*, consisting of 8 species; 3) *Tonduzia*, a monotypic group represented only by *A. longifolia*; 4) *Monuraspermum*, consisting of 10 species; 5) *Dissuraspermum*, consisting of 15 species. These groups are discussed in more detail in the next paragraph.

To arrive at a well-corroborated cladogram, a long and sometimes very complicated procedure of reciprocal illumination was necessary, i.e., checking and rechecking of the data and data matrix, re-evaluation of characters and character states, and excluding uninformative characters. The following presents a brief elaboration on the procedures followed and decisions made.

From the start, four species (*A. beatricis, A. guangxiensis, A. penangiana*, and *A. stenophylla*) have been excluded from the analysis because of lack of data on mainly fruits, seeds and palynological characters. The tree topology obtained in the first analysis was slightly different from the accepted tree, of which *A. rostrata* was separated


Lyera cosnuata
Alstonia actinophylla
pneumatophora
spatulata
iwahigensis
angustiloba
scholaris
congensis
boonei
rostrata
curtisii
mairei
nerifolia
sebusi
venenata
guangxiensis
rupestris
yunnanensis
longifolia
parvifolia
breviloba
rubiginosa
macrophylla
beatricis
annamensis
spectabilis
penangiana
angustifolia
muelleriana
9a 17a 22a 26b 36a 38a 49d
9b 17b 22b 26a 36b 38b 49b
10c 16b 19b 27b 59c 63a 67b
24b
19a 21c
4c 30b
10b 30a 29c 46c 63b
24a 32d
67a
10c 19a 29b 49c
24b
19a 24a
4c
50b
28a
59c
21b 30a
28a
34c
4a 11b 28b 41b 51b 56b 57b 61b 62c 64c
10a 58a 60b
4a 51b 56b 59d
65a
19b 24b 27b 54b
34c
21c 32b 46a 64b
33a 45a
30a 65a
29b
31b 32b
30b
29c 32d
59c
30b
(continued on next page)



(Fig. 3.2 continued)

Fig. 3.2. The transformation series of characters and character states used in the cladistic analysis. Note that only the most supporting characters are mentioned.

I = unique synapomorphies; II = parallel developments; x = reversals.

from the other species of the *Alstonia* group. The tree length was 276 steps (ci = 0.45, ri = 0.69). It appeared that some characters were divided into too many states (multistate characters leading to much polymorphism and homoplasy). Therefore, these characters were re-evaluated and the number of states was reduced in the next analyses. For instance, character no. 1 (leaf arrangement) originally comprised 8 character states, whereas only 4 remain in the present final data matrix. Meanwhile, many polymorphisms were still coded as separate character states. Errors present in the data entered into the matrix were also corrected.

The next analysis was based on a revised data matrix (with a minimised number of character states and polymorphisms coded as unknown data). This analysis was also an attempt to eliminate or non-activate uninformative characters in order to get a stable, most parsimonious tree. It started with excluding only one species, *A. stenophylla* (because of lack of data on follicles and seeds), to produce a single most parsimonious tree. Excluding the (uninformative) characters 6, 18, 23, 31, 43 and 52, the tree has a length of 254 steps (ci = 0.38, ri = 0.72). The topology of the tree was exactly similar to the accepted cladogram.

Finally, it was possible to include all species after reduction of the states of characters 50 (stipitation on follicles) and 60 (seed surfaces) and coding unknown for polymorphisms. Reduction of the number of states for characters 0 (lenticels on branches or branchlets), 30 (shape of the corolla lobes), 32 (indumentum on the inside of the corolla lobes) or 37 (insertion of the stamens), and other presumably less informative (with low values of ci and ri) characters from the analysis would lead again to an increased number of trees without any further stability or information content.

3.7. Monophyletic groups

The *Alstonia* group, which is identical to section *Alstonia* (including *A. rostrata*) is characterised by the presence of deltoid colleters in the leaf axils (character no. 10c), the admedial ramified pattern of the tertiary venation (16b), glabrous or very short cilia on the seed margins (58b; plesiomorphic) and seed surfaces glabrous (60a; plesiomorphic), and the presence of intine ghosts in the pollen grains (67b). The inclusion of *A. rostrata* in this group was unexpected. This species possesses quite different characters compared to the other species within the genus, like a syncarpous ovary and a single follicle. However, the present study revealed shared apomorphic characters with the species of section *Alstonia* (= section *Pala* sensu Monachino, 1949) that outnumber incongruent distribution patterns of character states and consequently *A. rostrata* is united with this group.

The two-aperturate pollen grains and glabrous outside of the corolla in *A. actinophylla, A. angustiloba, A. iwahigensis, A. pneumatophora*, and *A. spatulata* are here regarded not sufficiently distinctive to classify them into a separate (sub)group as suggested by Kuijt & Van der Ham (1997). Actually, they form a paraphyletic group, whereas the other species (*A. boonei, A. congensis, A. rostrata*, and *A. scholaris*) form a monophyletic group at the end of the clade of the *Alstonia* group. This group is characterised by the presence of narrowly triangular colleters in the leaf axils (10b), the pubescent outside corolla (29c), the corolla lobes always being broadly ovate and less than 1.5 × as long as wide (30a), the stigmoid apical part robust and more than 0.3 mm long (46c), and pollen grains with three apertures (63b). The second state is not very distinctive because ovate corolla lobes ranging from less to more than 1.5 × as long as wide (30b) are observed (sometimes) in *A. pneumatophora* and *A. spatulata*.

The *Blaberopus* group is another very distinct group, recognised by the presence of colleters in the axils of the bracts (11b), a lobed disk (41b), seed margins wavy or irregularly dentate (56b), presence of long hairs near the seed margins (57b), and

pollen grains with a mean length of the equatorial axis of the pollen grains over 40 µm (61b), a mean lenght of the polar axis over 30 µm (62c), and a H-endoaperture bulging at some distance of the colpi (64c). This group is the sister group of the other three: the *Tonduzia, Dissuraspermum*, and *Monuraspermum* groups. These three groups together are supported by the presence of bracteole(s) on the pedicels (21c), minute or narrow apical parts of the stigmas (46a), and the presence of H-endoapertures along the colpi in the pollen grains (64b).

The position of *A. sebusi* (sister species of *A. venenata*) is rather unexpected. This species possesses corolla tubes less than 12 mm long (35a), and therefore a sister group relation to *A. rupestris* and *A. yunnanensis* would have been expected. However, the common presence of a very consistent character state, the follicle stipitate (50b), supports this clade.

The *Tonduzia* group is monotypic, only comprising *A. longifolia*. Monachino (1949) supposed that this group should be classified as a separate genus due to the differing shape of the cilia. However, the present, more detailed study supports the view of Pichon (1947), i.e., that *Tonduzia* belongs to the genus *Alstonia*. The shape of the cilia (59d) and the rostrate follicles (51b) in *A. longifolia* are the only good characters to split this species from the *Monuraspermum* and *Dissuraspermum* groups.

The *Monuraspermum* group is supported by puberulous or pubescent pedicels and sepals (19b and 24b) and the shape of the seeds which are elongate or acuminate only at one end (54b). In some species, character state 24b is rather weak. For instance in *A. macrophylla* and *A. breviloba,* the glabrous form is also observed.

The *Dissuraspermum* group is supported by the leaf arrangement which is opposite (1a) in the majority of the species, seeds acuminate or caudate on both ends (54c), and short cilia up to 2 mm long (59a). Within this group, the New Caledonian species (except *A. stenophylla*) form a monophyletic group; they differ from *A. constricta* (the only species from outside New Caledonia) by the absence of ciliate sepals (27b) and mostly have more rough striate follicles (53b). The position of *A. stenophylla* at the base of the clade is also rather unexpected. Except for the leaves, which are in whorls of 3, the flowers look quite similar to those of *A. lanceolifera*, and therefore a sister group relation to the latter species seems more plausible. This should be tested by further data on the follicles and seeds.

3.8. Transformation series of characters

The cladogram produced dictates the transformation series of the characters used. The following is a summary of these evolutionary changes (see also Fig. 3.2 and Table 3.1).

The number of leaves in each whorl or node (1) tends to be reduced from more than 4 in the outgroup and the species of the *Alstonia* group to opposite in most species of the *Dissuraspermum* group. The transformation series of this character seems to be quite clear with a gradual change via in whorls of 3 up to more than 4 in (some) species of the *Blaberopus* group, consistently in whorls of 3 to 4 in the *Monuraspermum* group, and mixed between opposite and in whorls of 3 in a few species of the *Dissuraspermum* group.

The leaf apex (4) is plesiomorphically blunt to retuse. The derived state, pointed, is found as a synapomorphy for the *Blaberopus* group, with a parallel autapomorphy in *A. longifolia*, and sometimes also in *A. actinophylla, A. constricta, A. spectabilis*, and *A. sphaerocapitata.*

The presence of colleters in the leaf axils (10) is an apomorphy for the genus *Alstonia*. Three forms of colleters have been recognised here: deltoid, narrowly triangular, and minute to linear. The deltoid form (10c) is regarded the most primitive one. This character is found in the basal species of the *Alstonia* group, derived into narrowly triangular colleters (10b), which is a synapomorphy for *A. boonei, A. congensis*, and *A. scholaris* with a reversal in *A. rostrata.* The minute to linear form of the colleters (10a) is a synapomorphy of the *Blaberopus, Tonduzia, Monuraspermum*, and *Dissuraspermum* groups. The presence of colleters in the bract axils (11b) is a synapomorphy for the *Blaberopus* group.

The presence of intrapetiolar stipules (12b) is a plesiomorphy, whereas the reduced condition or absence in many species is regarded derived. In *A. costata, A. deplanchei*, and *A. lenormandii*, both states (presence and absence) were observed. Their consistent presence constitutes an autapomorphy in *A. boulindaensis, A. coriacea*, and *A. scholaris.*

The secondary veins are often inconspicuous (13b). This character is synapomorphic for the *A. coriacea* and *A. legouixiae* clade, with a parallel autapomorphy in *A. constricta.* All of these species belong to the *Dissuraspermum* group. Slightly recurved secondary veins (14) are also a synapomorphy for some species of this group.

The absence of the admedial ramified form of tertiary venation (16a) is plesiomorphic. Therefore the presence of this character in the *Alstonia* group is apomorphic. In *A. angustiloba, A. rostrata*, and *A. scholaris*, this character is usually clearly represented.

The inflorescence (17) is plesiomorphically axillary. The presence of terminal inflorescences in *Alstonia* is an apomorphic character state. The flowers are plesiomorphically loose; distinct bunches (18b) are found in *A. iwahigensis, A. pneumatophora*, and rarely in *A. scholaris.*

Glabrous pedicels (19a) is the plesiomorphic character state, while puberulous or pubescent pedicels (19b) is the derived one. The latter is synapomorpic for the *Monuraspermum* group with parallel developments in most species of the *Alstonia* group, except in *A. actinophylla, A. rostrata,* and *A. spatulata.* In *A. sebusi, A. venenata*, and *A. yunnanensis*, both character states were observed. The presence of bracteole(s) on the pedicels (21c) is a synapomorphy for *Monuraspermum, Dissuraspermum* (reversal in *A. constricta*), and *Tonduzia*, and with a parallel development in *A. actinophylla.* In the *Blaberopus* group this character state is (sometimes) found in *A. rupestris* only.

Sepals of *Alstonia* are connate at the base, without any colleters, while in the outgroup (*Dyera costulata*) they are free and with some colleters. Sepal margins (23) are mostly thin as found in the outgroup. The thick margins (a derived character) were observed in *A. angustifolia, A. parvifolia*, and *A. quaternata*, all parallel developments.

The other important characters of the sepals supporting the cladogram are the pubescence of both surfaces (24 and 25) and the ciliation (27). Glabrous sepals on both sides without any ciliae is the plesiomorphic condition. The puberulous or pubescent sepals outside is a synapomorphy for the *Monuraspermum* group (although sometimes the glabrous condition occurs in *A. breviloba* and *A. macrophylla*), independently developed in some species of the *Alstonia* group. The ciliation on the sepals shows more or less congruent patterns with the puberulous or pubescent sepals outside (adaxially). However, this character was also observed in the species with glabrous sepals within these groups; with parallel development in the clade composed of *A. neriifolia, A. sebusi*, and *A. venenata*, and in *A. yunnanensis* (in the *Blaberopus* group) and *A. constricta* (in the *Dissuraspermum* group).

The length of mature corolla buds (28) is mostly less than 15 mm, and regarded a plesiomorphic character. The longer corolla buds (a derived character) is present only in basal species of the *Blaberopus* group, with reversals in the *A. rupestris* and *A. yunnanensis* clade and in *A. sebusi*. A similar trend as in the length of the corolla buds also occurs not surprisingly in the length of the corolla tube (35).

The outside of the corolla (29) is plesiomorphically glabrous. The trend in this character seems to be quite clear in the *Monuraspermum* group, starting from the polymorphic condition in the basal species and ending with consistently pubescent in the terminal species of the clade. Parallel development is found in the clade composed of *A. boonei, A. congensis, A. rostrata*, and *A. scholaris* and sometimes in *A. vieillardii*. The lobes (30) are plesiomorphically ovate to very narrowly ovate. These character states reduce into ovate (less than 1.5 × as long as wide) to broadly ovate in most species of the *Alstonia* group and sometimes in the other groups. Thick, more or less fleshy corolla lobes (31b) have independently developed in *A. annamensis, A. deplanchei*, and *A. quaternata*.

The corolla lobes overlapping to the left (33b) is a plesiomorphic character. The overlapping to the right (33a) is a synapomorphy for the *Monuraspermum* and *Dissuraspermum* groups. The ciliation (34c) is found as a derived character in most species of the *Monuraspermum* group, with parallel development in *A. lanceolata* and *A. yunnanensis*.

The syncarpous ovary (39b) and single or solitary follicle (47b) are autapomorphies for *A. rostrata*. Sennblad & Bremer (1996) and Endress et al. (1996) also note that these characters tend to be the derived condition for the family Apocynaceae.

The presence of a distinctly lobed disk (41b) is a synapomorphy for the *Blaberopus* group. In *A. rupestris*, the margin of the disk (42) is somewhat wavy or irregularly lobed. The plesiomorphic character state for the central part of the pistil head (45) is cylindrical or ring-like. The derived state, more or less conical, is a synapomorphy for the *Dissuraspermum* group, with parallel development in most species of the *Monuraspermum* group and *A. curtisii*. The apex (a cleft of the stigmoid apical part) (46) is plesiomorphically robust and usually less than 3 mm long. The apex tends to be longer in the clade of *A. boonei, A. congensis, A. rostrata*, and *A. scholaris*; longer apices have originated parallel in the *Blaberopus* group, except in *A. curtisii* and *A. yunnanensis*. In the *Monuraspermum* and *Dissuraspermum* groups this character is reduced to a minute or narrow form.

The stipitate and rostrate follicles (50b and 51b) are a synapomorphy for the *Blaberopus* group, with parallelism in *A. longifolia*. In some species, as also in *A. longifolia*, the stipitation may be obscure, sometimes even mixed with the distinctly stipitate follicles. In the *A. sebusi* and *A. venenata* clade the stipitation in the follicles is distinct and rather long.

Pubescent follicles (52b) are an uncommon character in *Alstonia*, and may be so even for the Apocynaceae in general. Therefore, the presence of this character in *A. angustiloba, A. boonei*, and *A. pneumatophora* is regarded a derived condition.

A slightly similar trend of the transformation series as occurs in the number of leaves on each node (1) is also found in the seed ends (54). The seed ends vary from rounded on both ends, which is regarded as a plesiomorphy (present in the outgroup and in the *Alstonia* and *Blaberopus* groups), to acuminate or caudate only on one end in the *Monuraspermum* group, and acuminate or caudate on both ends in the *Dissuraspermum* group with a parallel development in *A. longifolia* (*Tonduzia* group). The seed margins (56) are usually entire, slightly wavy or irregularly dentate is a synapomorphy for the *Blaberopus* group, with parallel development in *A. longifolia, A. sphaerocapitata*, and rarely in *A. costata* and *A. lenormandii*. In addition, the *Blaberopus* group shows sparsely set soft long hairs (57b) near the seed margins, especially on the distal surface. Again, this character seems to be derived within the group.

The presence of cilia on the seed margins (59) is an apomorphy for *Alstonia*. This character seems to show three parallel developments: in the *Dissuraspermum* group the cilia length is up to 2 mm; in the *Alstonia*, *Blaberopus*, and *Monuraspermum* groups it is 2.1–10 mm; and in the *Tonduzia* group (*A. longifolia*) the cilia are irregularly grouped along the margin (59d).

Seed surfaces (60) are plesiomorphically glabrous. The *Blaberopus* group (except *A. mairei* and *A. yunnanensis*) shows much polymorphism, while in the *Monuraspermum, Dissuraspermum* and *Tonduzia* groups seeds are always puberulous or pubescent.

Pollen grains with the mean equatorial axis (61) less than 40 μm and the mean polar axis (62) up to 30 μm are regarded plesiomorphic. Bigger pollen grains constitute a synapomorphy for the *Blaberopus* group. In *A. boulindaensis, A. lenormandii*, and *A. sphaerocapitata*, the polar axis is usually shorter; may be this is another derived character in the genus *Alstonia*. Two-aperturate pollen grains (63a) is a synapomorphy for the *Alstonia* group, but there is a reversal into three-aperturate pollen in the clade of *A. boonei, A. congensis, A. rostrata*, and *A. scholaris*.

The presence of H-endoapertures (64) in certain groups shows the distinction of the transformation series of this character; in this case absence of the H-shaped condition is a plesiomorphy. Two independently developed states may be recognised here: 1) H-endoapertures present and bulging along the colpi (64b) is a synapomorphy for the *Tonduzia, Monuraspermum*, and *Dissuraspermum* groups, and 2) H-endoapertures present and bulging at some distance of the colpi (64c) is a synapomorphy for the *Blaberopus* group.

The transformation series of the ornamentation type A (65) and type B (66) is rather indistinct. Although both characters possess a low consistency index, they are

quite informative in cladogram building. The presence of the ornamentation type A gives more support than type B; it is a synapomorphy for the basal species of the *Dissuraspermum* group; it then reverses in the clade of *A. costata* and *A. sphaerocapitata*, and in *A. deplanchei*, with parallel development in *A. breviloba* and *A. parvifolia* of the *Monuraspermum* group.

Intine ghosts (67) are another rather common character in *Alstonia*. This character shows a reversal at the end of the clade of the *Alstonia* group (*A. boonei* and *A. rostrata*) with a parallel occurrence in *A. penangiana* in the *Monuraspermum* group.

3.9. Systematic implications

Starting point of the present study was the monophyly of *Alstonia* and the results do not yield any evidence to dispute the status of *Alstonia* as a distinct genus. The monophyletic groups within *Alstonia* correspond to the sections commonly recognised (mostly conform Monachino, 1949), and therefore the nomenclature of each group is based on that of the sections. Following the cladogram, the genus *Tonduzia* has to be merged in *Alstonia* R. Br.

Fig. 3.2. shows that by using *Dyera costulata* as the outgroup, the genus *Alstonia* is distinguished by the presence of colleters in the leaf axils (9b), terminal inflorescences (17b), connate sepals basally (22b), without colleters on the inside of the sepals (26a), the presence of hairs surrounding the mouth of the corolla tube (36b), and the apex of the stamens below the mouth of the corolla tube (38b). These characters strongly support the monophyly of the genus *Alstonia.*

The five distinct monophyletic groups within the genus *Alstonia* are each considered a formal section in the taxonomic classification. I have refrained from raising each group to generic status. This is possible, because each section is obviously monophyletic and characterised by a set of synapomorphies. However, such a taxonomic change is more a question of personal taste than of a major improvement of the present classification and as such it would not contribute to taxonomic stability. No further formal division is made.

The relationships among the sections are not so well supported. Nevertheless, the cladogram selected implies that section *Alstonia* is sister of the other sections. The presence of minute or linear colleters in the axils (10a), indumentum on seed surfaces (60b), length of cilia on the seed margins (58a), and the absence of an admedial ramified form of the tertiary venation (16a) are the synapomorphic characters for the sections *Blaberopus, Tonduzia, Monuraspemum* and *Dissuraspermum.* At one level lower, the presence of bracteole(s) on the pedicels (21c), minute or narrow stigmoid apical part (46a) and pollen grains with H-endoapertures bulging along the colpi (64b) characterise the group comprising the sections *Tonduzia, Monuraspermum* and *Dissuraspermum.* The sistergroup relation between the last two sections is supported by the corolla lobes overlapping to the right (33a) and the shape of the central part of the pistil head which is conical (45a).

Chapter 4

WOOD ANATOMY OF *ALSTONIA*

4.1. Introduction

In order to obtain additional characters for the taxonomic classification, a wood anatomical survey of the genus *Alstonia* was undertaken. Unfortunately, two sections (section *Blaberopus*, which include only shrubs or very small trees up to 5 m high, and section *Tonduzia*) could not be studied because no wood samples could be obtained.

Wood anatomical data on *Alstonia* in the literature are mostly confined to a few economically important timber species, and usually scattered in limited papers and some books or atlases on wood anatomy for restricted geographical regions. The most important references are: Metcalfe & Chalk (1950), Gill et al. (1985), Martawijaya et al. (1986), Ilic (1987, 1991), Soerianegara & Lemmens (1993). No wood anatomical descriptions are available for the numerous non-timber species from mainland Asia and the Pacific Islands.

These earlier studies have demonstrated that among the timber producing genera of *Alstonia* there are two distinct groups: lightweight woods traded as 'Pulai' with thin-walled fibres (including *A. pneumatophora, A. scholaris*, and *A. spatulata*), and medium heavy woods traded as 'Hard Alstonia' with thick-walled fibres (including *A. macrophylla* and *A. spectabilis*).

In addition to the main systematic objective, the present wood anatomical study of *Alstonia* was also undertaken to explore relationships that might exist between wood structure and ecological preference and habit of the species. *Alstonia* lends itself well for such an analysis because some species are restricted to swampy areas, while most occur in areas on well-drained soils. Moreover the habit of the species range from shrubs and small trees to big trees up to 60 m tall.

4.2. Materials and Methods

More than 80 wood samples were obtained from various institutes (see Acknowledgements), but only 44 were selected to be studied (cited in the sectional descriptions). The selection was based on the quality of samples (mature or immature) and the possibility of verifying their botanical identity using herbarium vouchers. Some unvouchered samples had to be included because none other were available. Samples were mostly from mature trees. When possible more than one sample (up to 9 specimens in *A. costata*) per species were studied in order to cover at least part of the infraspecific variability.

Information on habit and habitat of each sample was collected for the analysis of ecological trends. In case the habit (or diameter of the sample) was not mentioned on the label, an estimate was made based on direction of rays and growth rings (if present).

Table 4.1. Variation of selected wood anatomical characters of *Alstonia*.

	GR	SOL	RAD	CL	VF	VD	VL	L/D	IP	FL	FT	FPr	PD	PR	RF	RH	USR	LT	PC	NCC
Section Alstonia																				
A. actinophylla																				
Versteegh BW 66	–	10	70	20	8	106	695	6.5	4–5	1350	vt	+	±	+	7	435	1	+	–	–
A. angustiloba																				
BZFw 8018	+	8	67	25	4	107	1010	5.6	4–7	1570	vt	+	±	+	7	525	1	+	PR	17
KEPw 63545	+	4	64	32	5	154	840	6.9	5–7	1540	vt	+	±	+	6	450	1–2	+	–	–
A. boonei																				
INEAC 664,DF	–	4	80	16	5	162	1080	5.8	4–7	1740	vt	+	±	+	7	630	1–2	+	–	–
MAD–SJRw 47430	±	9	82	9	4	144	830	4.7	4–8	1400	vt	+	±	+	8	740	1–5	+	–	–
A. congensis																				
MADw 27091	–	21	65	14	4	116	785	5.7	4–7	1240	vt	+	±	+	7	800	1–2	+	PR	3
FHOw 818	±	8	52	40	5	149	1235	?	4–6	?	vt	+	±	+	8	650	1–4	+	–	–
A. iwahigensis																				
Ridsdale 1868	+	13	55	32	8	127	860	5.0	4–8	1550	vt	+	±	+	6	480	1–3	+	P	–
Sidiyasa 1116	±	11	45	43	6	91	960	7.5	4–10	1630	vt	+	±	+	6	450	1–3	+	P	–
AA 970	+	11	45	44	6	121	810	4.6	4–8	1410	vt	+	±	+	8	610	1	+	P	–
BZFw 13585	+	16	67	17	4	146	880	4.1	4–10	1670	vt	+	±	+	6	450	1–2	+	P	–
A. pneumatophora																				
Sidiyasa 1169	±	23	62	15	6	146	625	3.0	4–6	1380	vt	+	±	+	8	525	1	+	PR	20
(BZFw) E418	–	20	54	26	3	158	910	6.6	4–6	1420	vt	+	±	+	7	440	1	+	PR	19
Sidiyasa 1383	±	16	58	27	6	152	850	5.6	4–6	1340	vt	+	±	+	5	788	1	+	P	–
Sidiyasa 1381	±	17	49	33	5	120	710	4.7	4–5	1210	vt	+	±	+	6	455	1	+	–	–
A. rostrata																				
CAFw 12013	–	16	40	44	10	78	685	8.6	4–5	1430	vt	+	±	+	9	570	1–5	+	–	–
Gamble B–6750	±	12	63	25	15	76	770	10.7	4–6	1350	vt	+	±	+	8	565	1–7	+	PR	–
A. scholaris																				
van Balgooy 4809	–	10	50	40	4	154	930	6.1	4–6	1560	vt	+	±	+	6	740	1–2	+	PR	12
BZFw 25003	±	9	53	38	3	151	810	4.1	4–7	1420	vt	+	±	+	5	750	1–4	+	PR	4
Sidiyasa 1402	±	23	50	28	6	128	790	5.3	4–8	1410	vt	+	±	+	7	580	1–5	+	P	15
MADw 45148	–	14	78	8	3	172	840	3.5	4–6	1490	vt	+	±	+	6	830	1–6	+	P	–
AA 961	–	10	47	43	6	117	500	3.5	4–7	1110	vt	+	±	+	7	400	1–3	+	PR	10
A. spatulata																				
BZFw 22312	±	16	66	19	6	111	740	4.4	4–6	1170	vt	+	±	+	6	395	–	+	–	–
BZFw 13110	±	26	67	7	7	101	720	5.4	4–6	1330	vt	+	±	+	7	520	–	+	–	–

(Table 4.1 continued)

	GR	SOL	RAD	CL	VF	VD	VL	L/D	IP	FL	FT	FPr	PD	PR	RF	RH	USR	LT	PC	NCC
Section Dissurapermum																				
A. costata																				
MADw 20623	±	30	67	3	100	46	620	9.8	3–4	1505	m–t	±	+	–	11	435	1–2	–	PR	24
MADw 29265	–	62	30	8	72	59	770	8.9	3–4	1500	m	±	+	–	11	425	1–2	–	PR	19
MAD–SJRw 24854	–	47	48	5	121	41	720	14.9	3–4	1360	m–t	±	+	–	12	415	1–5	–	–	16
MAD–SJRw 25481	–	44	49	7	110	49	870	14.8	3–4	1490	m–t	±	+	–	10	520	1–8	–	–	12
MAD–SJRw 26118	–	55	39	7	147	42	720	13.7	3–4	1300	m–t	±	+	–	13	535	1–10	+	PR	13
MAD–SJRw 28040	±	34	56	10	131	43	710	10.3	2.5–4	1430	m–t	±	+	–	12	435	1–4	–	PR	9
MAD–SJRw 28275	–	57	37	6	131	43	725	12.9	3–4	1270	m–t	±	+	–	11	400	1–4	–	PR	8
MAD–SJRw 28329	–	51	41	8	106	50	810	13.4	3–4	1500	m	±	+	–	12	400	1–3	–	PR	4
MAD–SJRw 28377	±	38	57	5	149	49	905	14.6	2.5–4	1530	m–t	±	+	–	13	660	1–12	–	PR	12
Section Monuraspermum																				
A. angustifolia																				
BZFw 6013	–	50	46	4	29	83	1000	9.8	4–5	1470	tm	±	+	–	9	315	1–11	–	P	16
BZFw 11044	–	37	58	5	30	91	890	9.7	3–5	1620	tm	±	+	–	11	320	1–11	–	P	8
BZFw 3365	–	32	56	12	34	72	940	10.7	3–5	1590	m–t	±	+	–	8	310	1–8	–	P	10
A. macrophylla																				
Ridsdale 1425A	±	39	57	5	49	88	760	10.6	3–5	1370	tm	±	+	–	10	300	1–10	–	PR	13
Ridsdale 1159	–	18	74	8	31	88	960	14.2	3–5	1480	tm	±	+	–	8	330	1–10	–	P	5
Jacobs 8668	–	57	41	2	61	51	790	11.6	4–5	1400	tm	±	+	–	14	505	1–12	–	–	–
NGF 15481	–	28	71	1	53	88	930	8.8	3–5	1590	tm	±	+	–	9	445	1–6	–	PR	13
Hoogland 8901	–	34	56	10	53	83	1320	12.5	4–5	1830	tm	±	+	–	7	455	1–8	–	P	8
A. spectabilis																				
Sidiyasa 1101	±	45	49	6	45	59	820	10.8	3–4	1480	tm	±	+	–	9	320	1–12	–	PR	13
BZFw 3331	+	44	44	12	31	77	960	10.5	3–5	1580	mt	±	+	–	12	390	1–15	–	P	13
BZFw 22100	–	13	76	11	37	88	1100	13.5	3–5	1750	mt	±	+	–	8	345	1–8	–	PR	20

GR: growth rings present and distinct (+), indistinct (±), absent (–). — **SOL:** Percentage of solitary vessels. — **RAD:** Percentage of radial vessel multiples. — **CL:** Percentage of clustered vessels. — **VF:** Vessel frequency (per sq. mm). — **VD:** Average tangential vessel diameter (μm). — **VL:** Average vessel element length (μm).— **L/D:** Ratio vessel length/vessel diameter. — **IP:** Intervessel pit diameter (μm). — **FL:** Average fibre length (μm). — **FT:** Fibre wall thickness (μm) (m: medium, tm: thin to medium, vt: very thin, m–t: medium to thick). — **FPr:** Fibre pits in radial walls common (+), very few (±). — **PD:** Axial parenchyma diffuse and diffuse-in-aggreagates predominant (+), few (±). — **PR:** Axial parenchyma reticulate predominant (+), absent (–). — **RF:** Ray frequency (per mm). — **RH:** Height of multiseriate rays (μm). — **USR:** Number of square or/and upright (marginal) cells in multiseriate rays. — **LT:** Latex tubes present (+), absent (–). — **PC:** Prismatic crystals present in axial parenchyma cells (P), in the ray cells (R), or absent (–). — **NCC:** Number of chambers per chain of prismatic crystals.

Information on habitat often had to be obtained from the collective floristic data as summarised in Chapter 5.

All selected samples were sectioned, macerated and prepared according to standard techniques described by Baas & Zhang (1986) for light microscopic analysis and scanning electron microscopic (SEM) observation on certain features of all the samples.

The sequence adopted for the general survey of wood anatomical features and the descriptions of the sections follow a standard format presented in Baas & Zhang (1986), Baas et al. (1988), and Zhang & Baas (1992). The terminology, definition, and measurements of quantitative features mainly follow the IAWA List (Wheeler et al., 1989). The ratio of vessel element length to vessel element diameter (L/D ratio) is used here according to Zhang & Baas (1992). The specimens studied are listed, and the wood collections are indicated according to Stern (1988). Xylarium accession numbers are given in brackets; herbarium vouchers are cited where known. In view of the small infrasectional variation, the wood anatomical descriptions are given per section.

4.3. Wood anatomical features in *Alstonia*

Introduction

The following description presents a general wood anatomical survey of *Alstonia* based on the three sections that have been studied. The diagnostic and systematic value of various wood anatomical characters are also discussed, especially at sectional level. Table 4.1 summarises the most important characters that were observed in the present study. Variation of mean vessel frequency, tangential vessel diameter, L/D ratio, and ray frequency of each section is illustrated in Fig. 4.40 on page 60.

Growth rings (Fig. 4.1–4.9)

Growth rings in *Alstonia* are absent or indistinct, rarely distinct. If present, they are usually marked by slightly thicker walls of radially flattened fibres in the latewood. Only in a few samples the growth rings are marked by narrower latewood fibres and vessels and a slightly higher vessel frequency in the latewood (i.e., in Fig. 4.9). In some species of section *Alstonia* (e.g., *A. scholaris* and *A. angustiloba*), the growth rings may also be indicated by the presence of marginal parenchyma bands.

Vessels

Distribution and grouping (Table 4.1 and Fig. 4.1–4.9) — Only diffuse porosity was observed in *Alstonia*. This feature is also found in the other genera of Apocynaceae (Metcalfe & Chalk, 1950; Martawijaya et al. 1986; Ilic, 1991; Lemmens et al., 1995).

The vessels are solitary and in radial multiples, more rarely in clusters. The percentage of each category is sometimes an important feature for identification. In section *Alstonia*, the pattern is usually dominated by radial multiples (sometimes also by clusters in *A. rostrata* only). In the other sections the situation is different: in *Dissuraspermum* and *Monuraspermum* solitary vessels or radial multiples may be dominant.

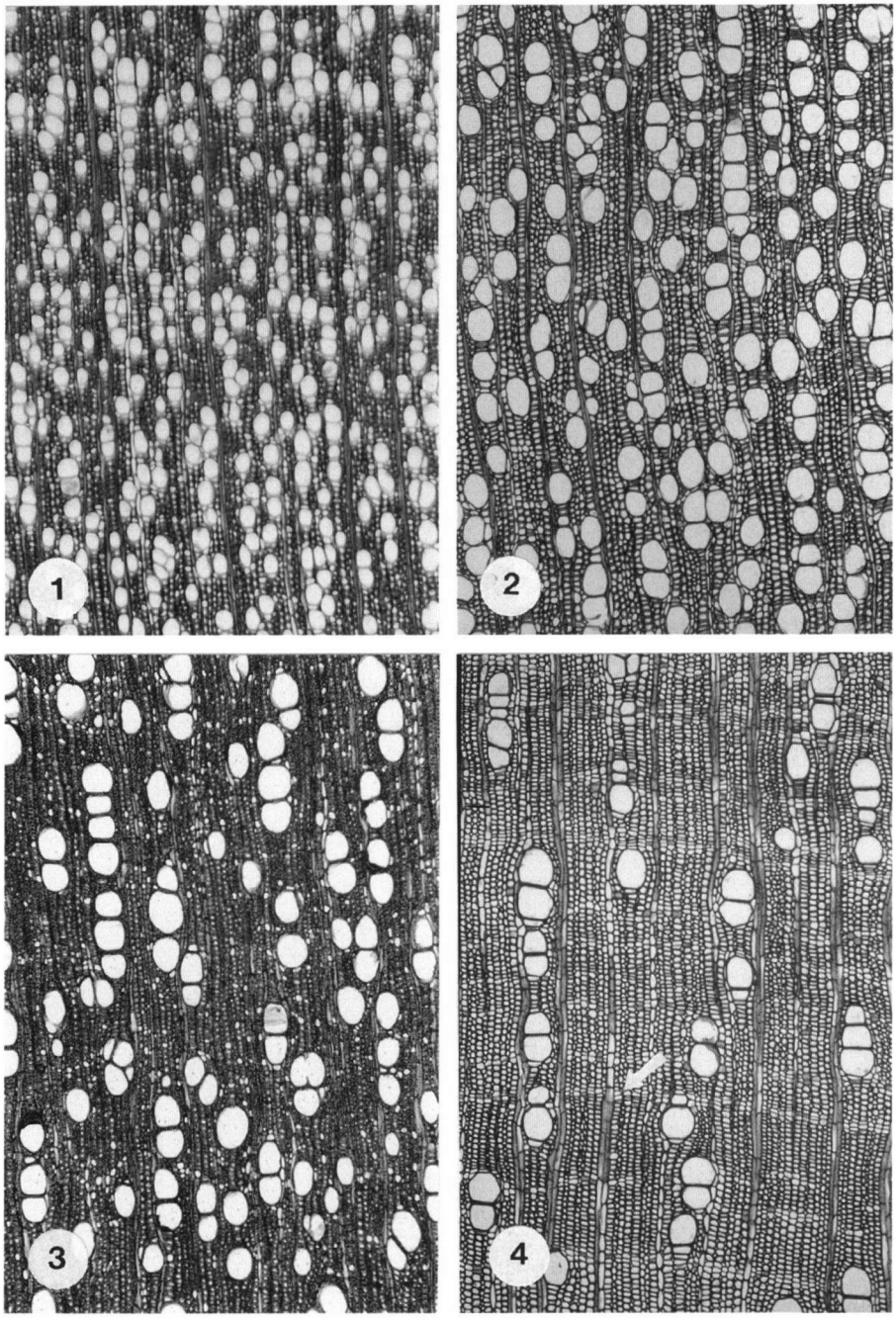


Fig. 4.1–4.4. Transverse sections (× 45) showing vessel distribution, grouping, and axial parenchyma predominantly diffuse and diffuse-in-aggregates (1–3), and axial parenchyma predominantly reticulate, showing vague ring boundaries (arrow) (4). – 1: *Alstonia costata* (MAD-SJRw 28329). – 2: *A. macrophylla* (*Hoogland 8901*). – 3: *A. angustifolia* (BZFw 11044). – 4: *A. rostrata* (CAFw 12013).

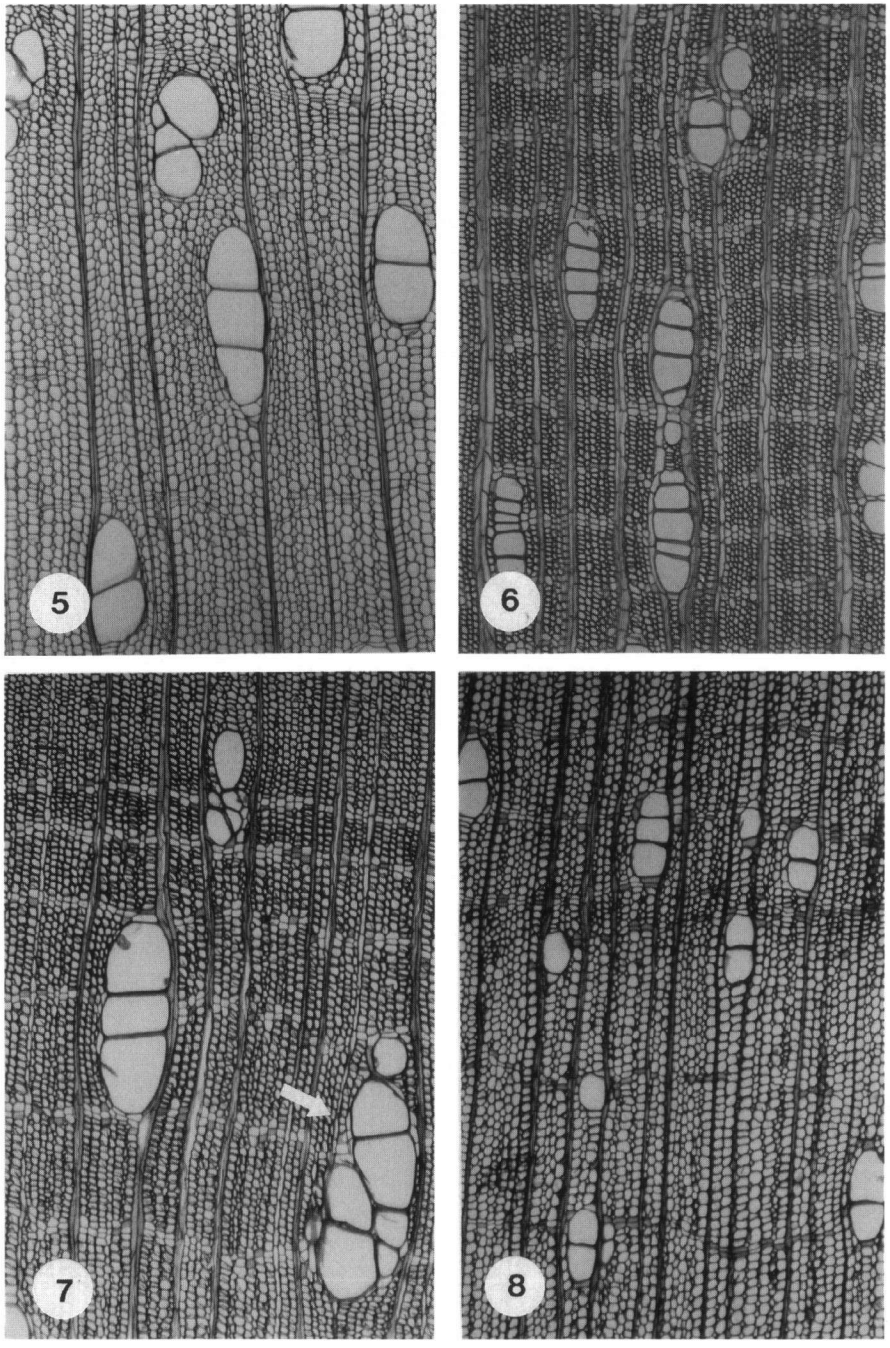


Fig. 4.5–4.8. Transverse sections (× 45), showing axial parenchyma reticulate. – 5: *A. pneumatophora* (*Sidiyasa 1383*). – 6: *A. actinophylla* (*Versteegh BW 66*). – 7: *A. boonei* (MAD-SJRw 47430), note cluster of laterally adjoining radial multiples (arrow). – 8: *A. spatulata* (BZFw 13110).

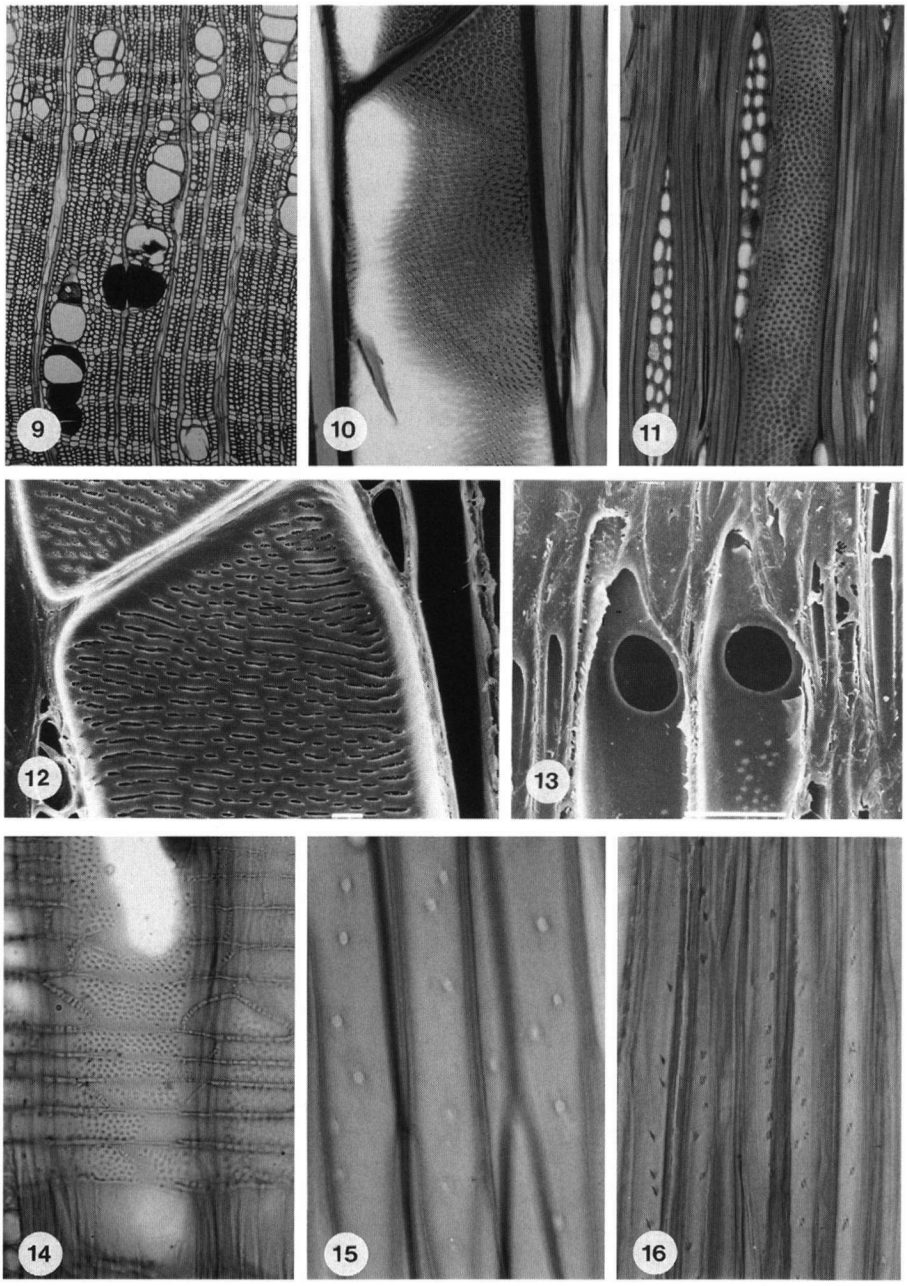


Fig. 4.9. *Alstonia scholaris* (*Sidiyasa 1402*), parenchyma reticulate, some vessels with deposits. — Fig. 4.10–4.12. Intervessel pits (10, 11, × 206; 12, × 495). – 10 & 12: *A. iwahigensis* (*Sidiyasa 1116*). – 11: *A. spectabilis* (BZFw 3331). — Fig. 4.13. Simple perforations (RLS, × 330): *A. macrophylla* (*Hoogland 8901*). — Fig. 4.14. Vessel-ray pits (RLS, × 306): *A. angustifolia* (BZFw 11044). — Fig. 4.15 & 4.16. Fibre pits (RLS, × 330). – 15: *A. rostrata* (CAFw 12013). – 16: *A. pneumatophora* (*Sidiyasa 1383*).

The radial multiples in *Alstonia* consist of 2–8(–11) vessels, and the clusters (i.e., laterally adjoining radial multiples, cf. Fig. 4.7) consist of 3–9(–10) vessels. These values are not diagnostic.

Frequency and element size (Fig. 4.40)— Vessel frequency ranges from 3/sq.mm in *A. pneumatophora* and *A. scholaris* to 149/sq.mm in *A. costata*. This feature has a high diagnostic value for identification at the sectional level: in section *Alstonia*, the vessel frequency varies from 3 to 8(–15)/sq.mm (Fig. 4.4–4.9); in section *Monuraspermum* from 29 to 53(–61)/sq.mm (Fig. 4.2 & 4.3); and in section *Dissuraspermum* it varies from (72–)100 to 149/sq.mm (Fig. 4.1). Average tangential vessel diameter ranges from 42 μm in *A. costata* to 172 μm in *A. scholaris*. There is a distinct correlation be-tween vessel frequency and vessel diameter, the species with higher vessel frequency tend to have a narrower vessel diameter, and *vice versa.*

The solitary vessels are usually round to oval, but slightly angular vessels were also found in all species, especially in section *Alstonia*.

Average vessel element length varies from 500 μm in *Ambriansyah & Arifin AA 961* (*A. scholaris*) to 1320 μm in *Hoogland 8901* (*A. macrophylla*). This feature usually varies greatly within species or sections. The longest individual vessel elements (up to 1950 μm) can also be found in *Hoogland 8901*, the shortest (only 170 μm long) found in MADw 20623 (*A. costata*). Vessel element length has no diagnostic value at the species or section level in *Alstonia*.

Vessel wall thickness varies from (1.5–)2–8 μm. The species of section *Dissuraspermum* are usually characterised by vessel walls up to 4 μm thick (up to 5 μm thick in MAD-SJRw 26118). It is a quite consistent wood anatomical feature for the section. In the other sections, vessel wall thickness varies greatly, from 2 to 8 μm.

Perforation plates (Fig. 4.13) — All species of *Alstonia* and all other tree genera of *Apocynaceae* have exclusively simple perforations (Metcalfe & Chalk, 1950). The perforations are usually round, in oblique or more rarely in horizontal end walls.

Wall pitting (Fig. 4.10–4.12 & 4.14) — Intervessel pits in *Alstonia* are alternate and vestured (Fig. 4.10–4.12). Pit shape is characteristically round to oval and/or slightly polygonal. The horizontal diameter ranges from 2.5 to 8(–10) μm. The intervessel pit diameter is diagnostic for most of the sections. The smallest pits (2.5–4 μm) are found in section *Dissurapermum*, medium-sized ones (3–5 μm) in section *Monuraspermum* (Fig. 4.11), and the largest pits (4–8(–10) μm) in section *Alstonia* (Fig. 4.10).

Pit apertures are mostly oval or narrowly elliptic, but circular apertures are also present especially in *A. rostrata*. In some species of section *Alstonia* (*A. scholaris, A. boonei,* and *A angustiloba*), coalescent apertures are sometimes present and give an impression of scalariform intervessel pit arrangement (Fig. 4.12). Coalescent apertures have not been observed in other sections of the genus *Alstonia*.

Vessel-ray (Fig. 4.14) and vessel-parenchyma pits are usually similar to the intervessel pits in arrangement, shape, size, and apertures, with the exception that they are sometimes more variable. They may be somewhat smaller or bigger and more clearly polygonal.

Helical thickenings — Helical thickenings are absent from the vessel elements in *Alstonia*.

Tyloses and deposits — Tyloses are always absent. Vessel deposits were observed in many species, but usually very few and only in some vessels. Commonly occurring deposits were observed in *Sidiyasa 1402* (*A. scholaris*) (Fig. 4.9). This sample was collected from a big tree (c. 80 cm in diameter) on limestone in Central Sulawesi, Indonesia.

Vestures — This feature is found in intervessel pits, vessel-ray pits, and in fibre pits. With SEM, some variation of vestures can be recognised, mainly in density and morphology (Fig. 4.28–4.36).

Fibres (Fig. 4.15–4.19)

The fibres are non-septate and have distinctly bordered pits. The length of fibres and diameter of pits do not provide good characters for identification. The average length of fibres varies greatly, from 1110 to 1830 μm (full range: 520–2470 μm). The diameter of the fibre pits varies from 3 to 10 μm (but is mostly less than 8 μm). Fibre wall thickness (Fig. 4.17–4.19) and distribution of pits (Fig. 4.15 & 4.16, only for section *Alstonia*) are good characters to classify the woods into two groups (light and heavy). These characters are mutually related. The woods of the light Alstonia group (section *Alstonia*) are characterised by very thin fibre walls and pits common in the radial walls; in contrast, the woods of the heavy Alstonia group (sections *Dissuraspermum* and *Monuraspermum*) have medium to very thick fibre walls and few or very few pits in both radial and tangential walls (Fig. 4.26 & 4.27, see arrows).

Axial parenchyma (Fig. 4.1–4.9)

This feature is of great diagnostic value. Two characteristic types of axial parenchyma distribution were observed in the *Alstonia* (both apotracheal): 1) predominantly reticulate in narrow bands and 2) diffuse and diffuse-in-aggregates. These characters are also correlated with those of the fibres that characterise the two groups (light and heavy) of *Alstonia*. The light Alstonia group is characterised by predominantly reticulate axial parenchyma (Fig. 4.4–4.9), while the heavy Alstonia group has predominantly diffuse and diffuse-in-aggregates parenchyma (Fig. 4.1–4.3).

The reticulate pattern is usually in bands of 1–3 cell wide (up to 4 cells in *A. rostrata* only). The bands are usually wavy; the (almost) straight ones are marginal and form the (indistinct) growth ring boundaries. The other patterns of axial parenchyma distribution are scanty paratracheal and vasicentric. The latter pattern is usually very rare.

Axial parenchyma strand length varies from 3 to 15 cells, and is not of diagnostic value. This feature also varies greatly within the species or sections. In section *Alstonia*, the strands are mostly longer than in the other sections. The longest strands (up to 15 cells) are found in *A. congensis* (FHOw 818), in the other sections they are usually up to less than 10 cells long.

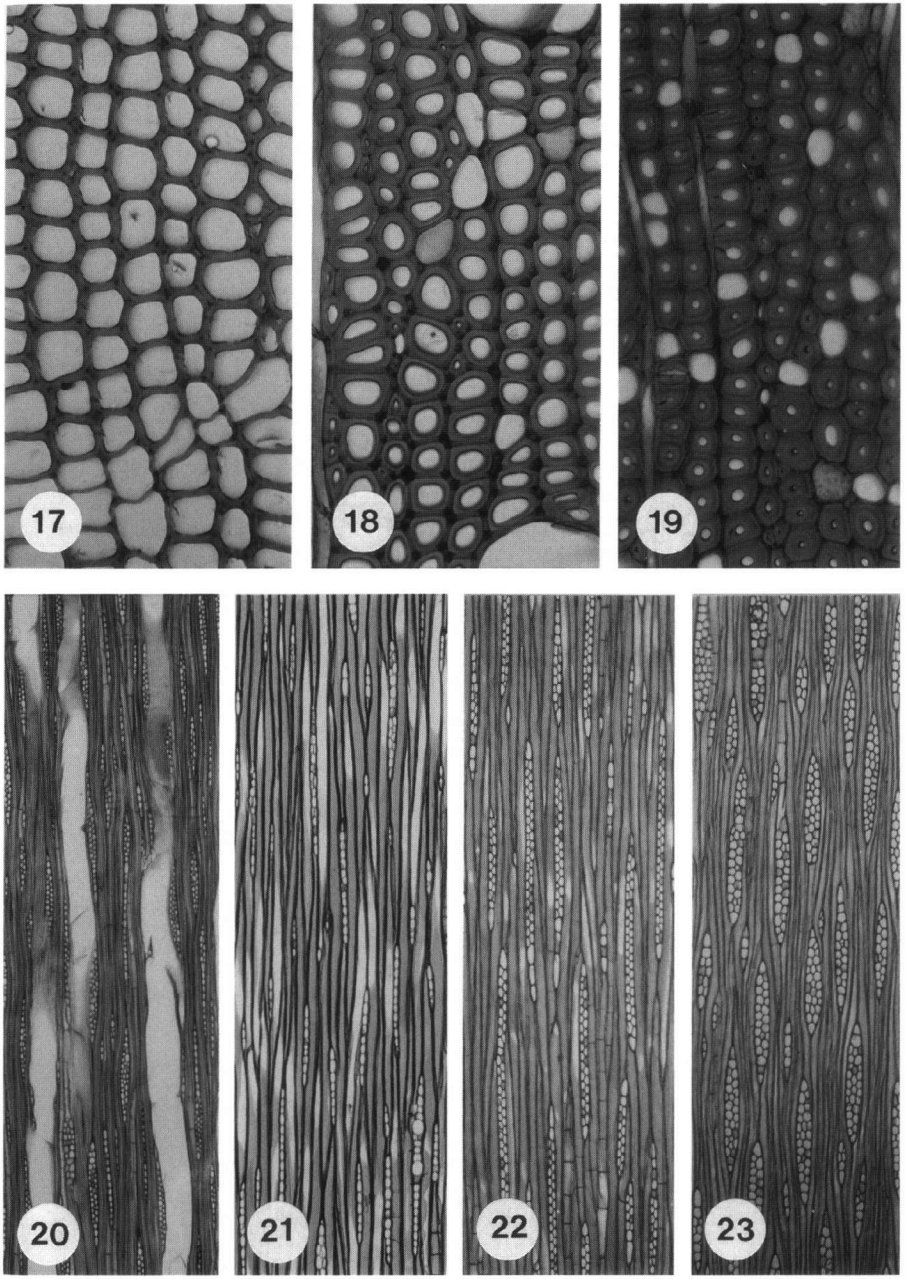


Fig. 4.17–4.19. Fibre wall thickness (× 287). – 17: Very thin walls in *Alstonia scholaris* (BZFw 25003). – 18: Very thin to medium thick walls in *A. macrophylla* (*Hoogland 8901*). – 19: Thick walls in *A. spectabilis* (BZFw 22100). — Fig. 4.20–4.23. Rays in tangential view (× 46). – 20: *A. macrophylla* (*Ridsdale 1159*). – 21: *A. pneumatophora* (BZFw = E 418). – 22: *A. boonei* (SJRw 47430). – 23: *A. actinophylla* (*Versteegh BW 66*).

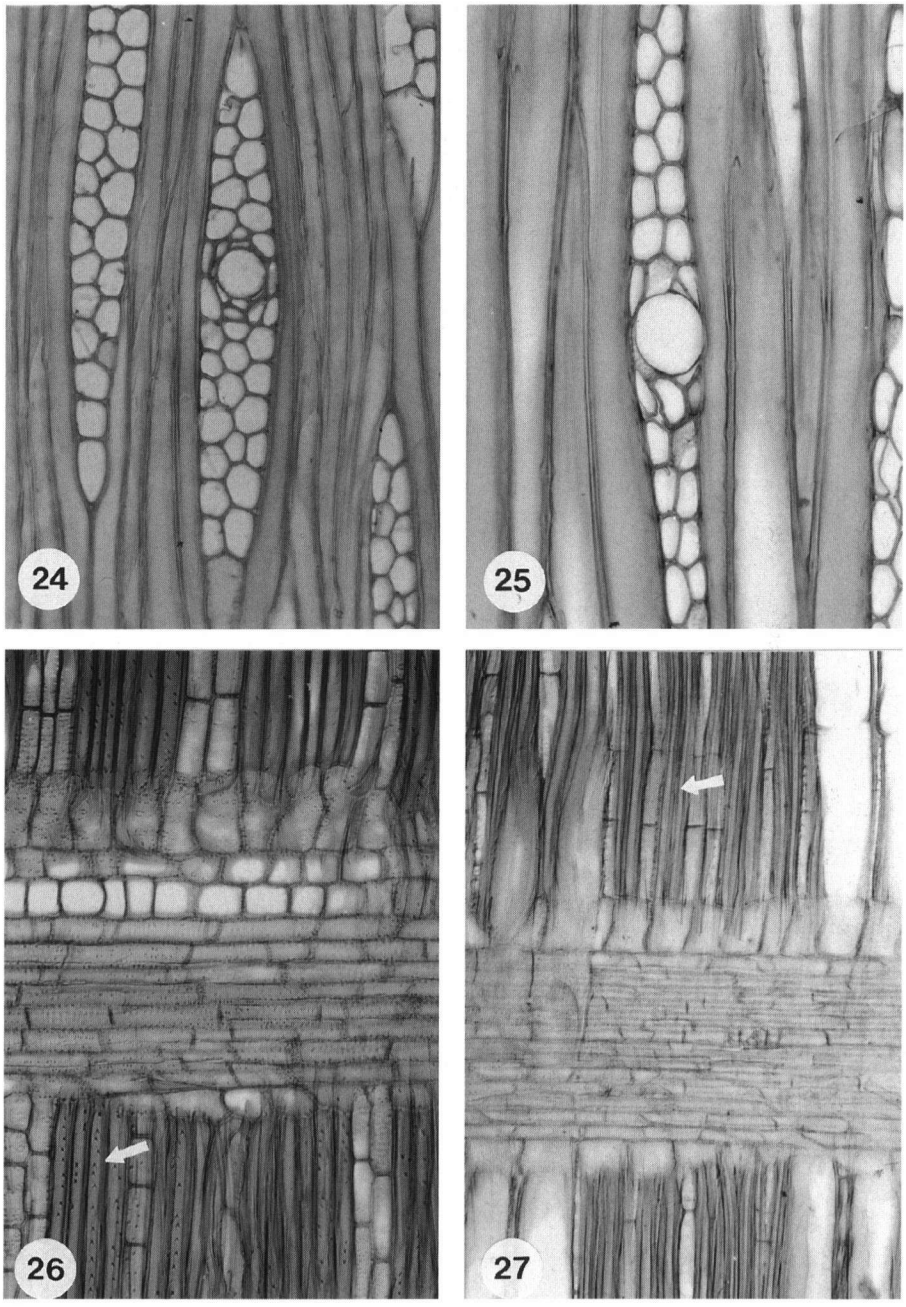


Fig. 4.24 & 4.25. Latex tubes (× 280). – 24: *Alstonia actinophylla* (*Versteegh BW 66*). – 25: *A. iwahigensis* (*Sidiyasa 1116*). — Fig. 4.26 & 4.27. Rays in radial view (× 108). – 26: Two rows of square and one row of upright marginal cells and pits in fibre walls very common (arrow) in *A. rostrata* (CAFw 12013). – 27: One row of upright marginal cells and very few pits in fibre walls (arrow) in *A. costata* (MAD-SJRw 28329).

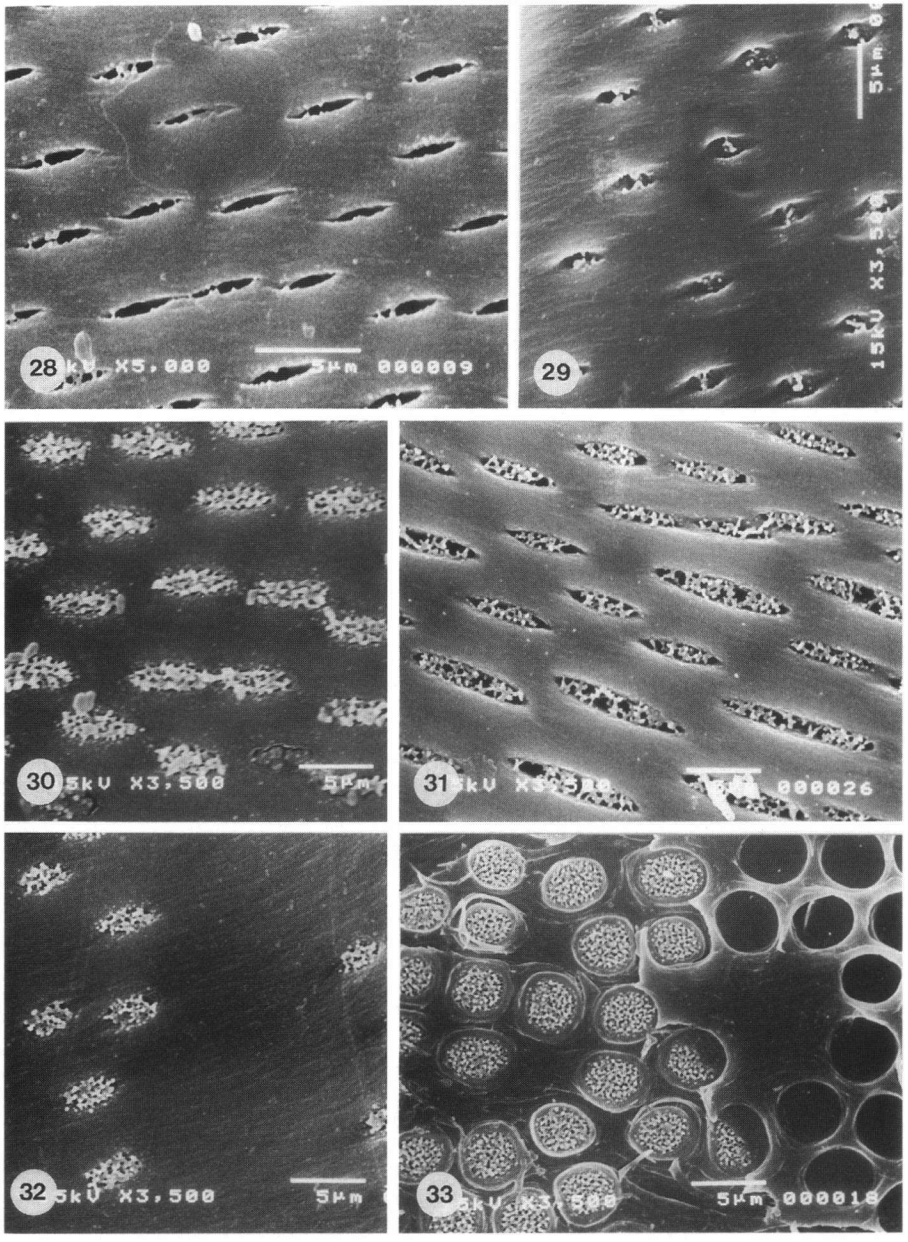


Fig. 4.28–4.33. Vestured intervessel pits (28–31, 33) and vessel-parenchyma pits (32) (28, × 3300; 29–33, × 2310). – 28: *Alstonia angustifolia* (BZFw 11044). – 29: *A. macrophylla* (*Hoogland 8901*). – 30 & 31: *A. scholaris* (*van Balgooy 4809*). – 32: *A. costata* (MAD-SJRw 28329). – 33: *A. rostrata* (CAFw 12013), split along the pit membrane (middle lamella).

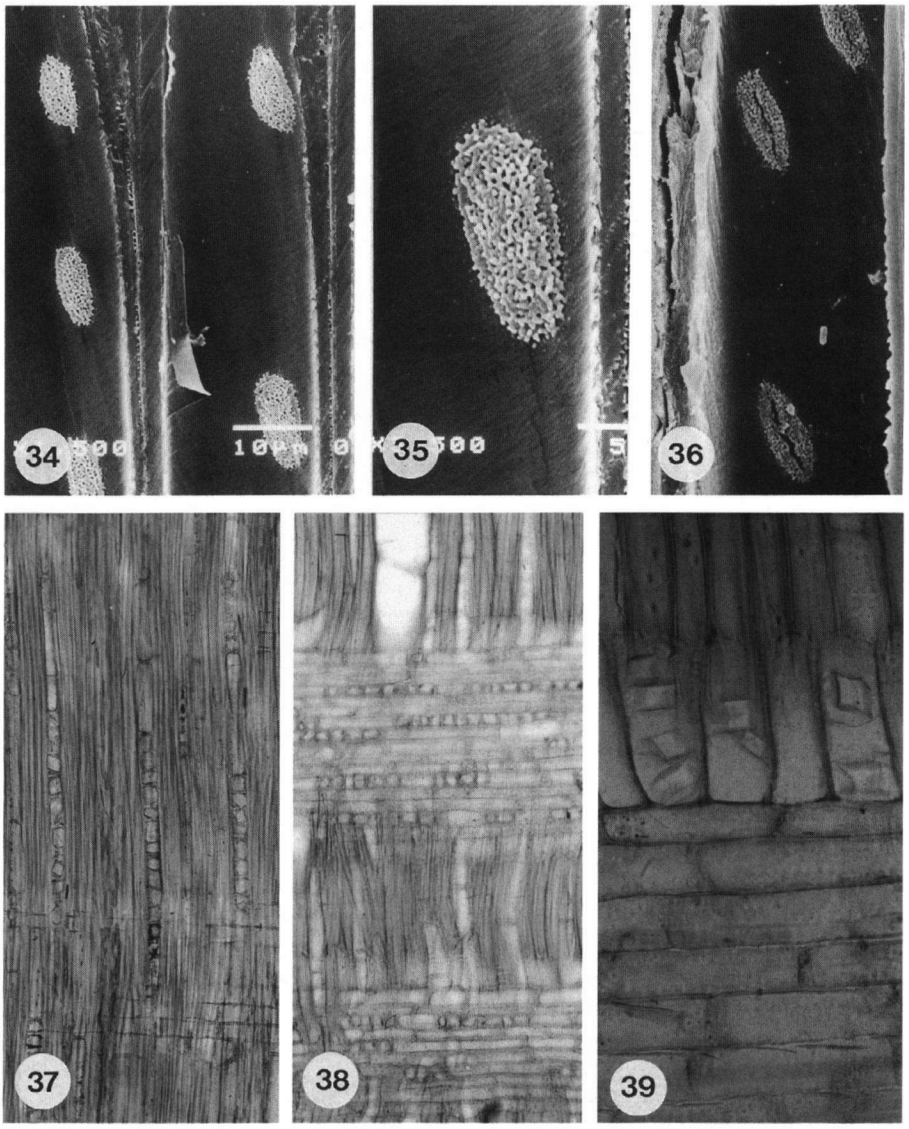


Fig. 4.34–4.36. Vestured pits in fibres (34, × 1260; 35, × 2940; 36, × 1680). – 34 & 35: *Alstonia iwahigensis* (*Sidiyasa 1116*). – 36: *A. rostrata* (CAFw 12013). — Fig. 4.37–4.39. Prismatic crystals (37 & 38, × 105; 39, × 262). – 37: In axial parenchyma cells in *A. macrophylla* (*Havel & Kairo NGF 15481*). – 38: In procumbent ray cells in *A. costata* (*Craven & Schodde 198*, MADw 29265). – 39: In upright chambered ray cells in *A. scholaris* (*Ambriansyah & Arifin AA 961*).

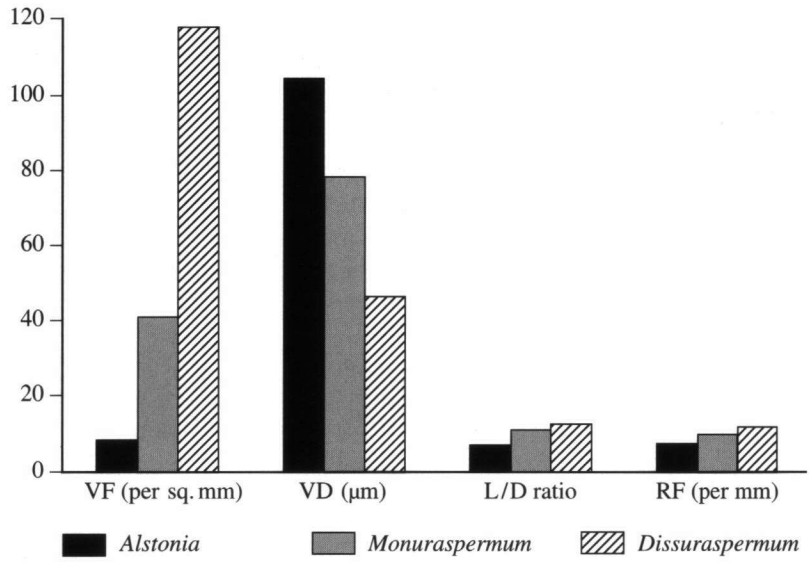


Fig. 4.40. Mean vessel frequency (VF), tangential vessel diameter (VD), L/D ratio, and ray frequency (RF) of sections *Alstonia, Monuraspermum*, and *Dissuraspermum*.

Rays (Fig. 4.20–4.23)

In general, rays in *Alstonia* are more or less similar for all species. The uniseriate and multiseriate forms (1–3(–4) cells wide) are found together, with a frequency of 5–15 (4–18)/mm. Usually, the species of section *Alstonia* have a lower frequency of rays compared with the other sections (see Table 4.1 & Fig. 4.40). Rays up to 4 cells wide are only found in *A. rostrata*.

The uniseriate rays are 1–23(–32) cells high, composed of weakly procumbent and upright or square cells. There are no distinct differences in number of cells between the species. The upright and/or square marginal cells of the multiseriate rays are more common in sections *Dissuraspermum* and *Monuraspermum* (Fig. 4.20), and less so in the other sections (cf. Fig. 4.22 & 4.23).

Multiseriate rays vary from 60–1460 µm in height and are composed of procumbent body cells and (0–)1–15 rows of upright or square marginal cells. There is a great variation in the arrangement and number of the upright or square marginal cells, and this may be useful for identification. For instance, in *A. pneumatophora* there is always only one row of upright marginal cells, and the mature wood of *A. spatulata* has procumbent cells only. In section *Monuraspermum* there are up to 6 or more rows of square to upright marginal cells (up to 15 in BZFw 3331, *A. spectabilis*). Rays over 1 mm high are usually found in section *Alstonia*, the highest one is 1.5 mm tall.

Latex tubes are mostly rounded or slightly oval and 20–55 µm in diameter (Fig. 4.24 & 4.25). This feature is always present and therefore diagnostic in section *Alstonia*. In section *Dissuraspermum*, latex tubes were observed only in one sample (MAD-SJRw 26116) of *A. costata*. This is an exception for this section, and there is a possibility that the sample was mislabelled or misidentified.

Crystals (Fig. 4.37–4.39)

The only form of crystals observed in *Alstonia* is prismatic. They are present in chambered or non-chambered axial parenchyma cells and ray cells, but are usually more common in axial parenchyma cells. The frequency and location of the prismatic crystals are variable, from very infrequent to abundant. In the abundant form, they usually form chains of up to 24 chambers. More than one crystal of about the same size or of two distinct different sizes per cell are sometimes present in square or upright marginal cells.

The prismatic crystals are absent from a number of specimens and species (mainly belonging to section *Alstonia*). Silica bodies are absent.

4.4. Wood anatomical descriptions of *Alstonia*

Section *Alstonia* R. Br.

Materials studied: *A. actinophylla* (A. Cunn.) K. Schum.: Indonesia, Irian Jaya, *Versteegh BW 66* (Lw). — *A. angustiloba* Miq.: Malaysia (KEPw 63545). Indonesia, Sumatra, *Hassanudin bb 8431* (BZFw 8018). — *A. boonei* De Wild.: Africa, s.l. (MAD-SJRw 47430). Congo (INEAC 664, DF). — *A. congensis* Engl.: Africa, s.l. (FHOw 818). Ivory Coast, *Fleury 45* (MADw 27091). — *A. iwahigensis* Merr.: Philippines, *Ridsdale 1868* (Lw). Indonesia, E Kalimantan, *Haring bb 13010* (BZFw 13585), *Sidiyasa 1116* (Lw), *Arifin AA 970* (Lw). — *A. pneumatophora* Backer ex Den Berger: Indonesia, E Kalimantan, *Sidiyasa 1169* (Lw); Sumatra, *Endert 28E ip 418* (BZFw 418); Central Sulawesi, *Sidiyasa 1381 & 1383* (Lw). — *A. rostrata* C.E.C. Fisch.: s.l., *Gamble B-6750* (DDw). China (CAFw 12013). — *A. scholaris* R. Br.: Indonesia, E Kalimantan, *Ambriansyah & Arifin AA 961* (Lw); Central Sulawesi, *Sidiyasa 1402* (Lw); Maluku, Buru, *van Balgooy 4809* (Lw); Aru, *Buwalda bb 25315* (BZFw 25003). Papua New Guinea: Bismarck Archipelago, *Sudo TWTw 11535* (MADw 45148). — *A. spatulata* Blume: Indonesia, W Kalimantan, *Deheems bb 12625* (BZFw 13110); Irian Jaya, *Matatula bb 21905* (BZFw 22312).

Growth rings absent or indistinct, rarely distinct, if present usually marked by slightly thicker fibre walls and rows of radially flattened latewood fibres, and occasionally by narrow latewood vessels. In *A. scholaris* and *A. angustiloba,* the growth rings may also be indicated by the presence of marginal parenchyma bands, or by vessels that tend to be more solitary in the latewood than in the subsequent earlywood. Wood diffuse-porous. *Vessels* 3–8(–15)/sq. mm, mostly in radial multiples of 2–7(–10) (40–82%), remainder solitary (8–26%) and in clusters of 3–8(–10) (7–44%), round to oval, sometimes slightly angular, mean tangential diameter (76–)100–160 µm (range 30–250 µm), walls 2–8 µm thick. Vessel element length 500–1240 (210–1480) µm. L/D ratio 3.0–10.7 (0.9–18(–37.4)). Perforation plates simple in mostly oblique end walls. Intervessel pits vestured, alternate (sometimes coalescence of apertures gives an impression of scalariform pitting), round, oval, or slightly polygonal, 4–8(–10) µm in horizontal diameter, with round to narrowly elliptic, occasionally coalescent apertures. Vessel-ray and vessel-parenchyma pits with distinct borders, similar to intervessel pits in shape and size (slightly wider pits sometimes found in *A. angustiloba* and *A. pneumatophora*). Helical thickenings and tyloses absent. Deposits mostly absent or very rare (quite common only in *Sidiyasa 1402* (*A. scholaris*)). *Fibres* 1110–1670 (520–2340) µm long, very thin-walled, non-septate, with distinctly bordered pits of

3–6(–8) μm in diameter, mostly in the radial walls, rarely in the tangential walls. *Axial parenchyma* predominantly apotracheal, reticulate, in bands of 1–3(–4) cells wide (usually wavy), sometimes discontinuous and tending to diffuse-in-aggregates, rarely diffuse; also in marginal bands up to 6 cells wide and scanty paratracheal, rarely vasicentric, in 3–15-celled strands. *Rays* 5–9 (4–11)/mm, 1–3(–4)-seriate. Uniseriate rays 1–23(–32) cells high, composed of weakly procumbent and upright or square cells, multiseriate rays 400–830 ((60–)100–1460) μm high, composed of procumbent body cells and (0–)1–5(–7) rows of upright or square marginal cells, with small *latex tubes* of 20–50 μm in diameter. *Prismatic crystals* usually present (absent in *A. spatulata* and *A. boonei*), few to abundant, mostly in chambered or non-chambered axial parenchyma cells, rarely in ray cells, in chains (if chambered) of 2–20 chambers; more than one crystal of about the same size or crystals in two distinct different sizes per cell sometimes present. *Silica bodies* absent.

Section Dissuraspermum (A. Gray) Benth.

Materials studied: *A. costata* (G. Forst.) R. Br.: Solomon Islands, *Craven & Schodde 198* (MADw 29265). Fiji, *A. C. Smith 1540* (MAD-SJRw 28275), *1701* (MAD-SJRw 28329), *3185* (MAD-SJRw 28040), *3521* (MAD-SJRw 28377). New Caledonia (MADw 20623). Samoa, *Christophersen 3071* (MAD-SJRw 26118). Society Islands, Raiatea (MAD-SJRw 24854). Tahiti, *MacDaniels 1252* (MAD-SJRw 25481).

Growth rings absent or indistinct, if present usually marked by rows of slightly radially flattened fibres and a higher proportion of fibres in the latewood or a latewood band of narrower vessels which occur in higher frequency than in the subsequent earlywood (in MADw 20623 the growth rings tend to be marked by discontinuous marginal parenchyma bands). *Wood* diffuse-porous. *Vessels* (72–)100–149/sq. mm, mostly solitary (30–62%) and in radial multiples of 2–7(–10) (30–67%), remainder in oblique clusters (sometimes obscure) of 3–6(–9) (3–10%), round to oval, sometimes slightly angular, mean tangential diameter 41–59 (20–85) μm, walls 2–4(–5) μm thick. Vessel element length 620–900 (170–1430) μm. L/D ratio 8.9–14.9 (2.4–29.5). Perforation plates simple in mostly oblique end walls. Intervessel pits vestured, alternate, round to slightly oval, (2.5–)3–4 μm in horizontal diameter, with round to narrowly elliptic apertures. Vessel-ray and vessel-parenchyma pits with distinct borders, similar to intervessel pits in shape and size, sometimes slightly polygonal. Helical thickenings and tyloses absent. Deposits mostly absent, sometimes very few. *Fibres* 1270–1530 (830–2470) μm long, medium to very thick-walled, non-septate, with distinctly bordered pits of 3–5(–6) μm in diameter, infrequent in both radial and tangential walls. *Axial parenchyma* predominantly apotracheal, diffuse and diffuse-in-aggregates, and scanty paratracheal, rarely vasicentric, in 4–10(–13)-celled strands. *Rays* 10–13 (8–15)/mm, 1–3-seriate. Uniseriate rays 1–16 cells high, composed of procumbent or weakly procumbent and upright or square cells, multiseriate rays 400–660 (80–1200) μm high, composed of procumbent body cells and with 1–5(–12) rows of upright and/or square marginal cells, latex tubes absent (except in MAD-SJRw 26118, where they are 25–35 μm in diameter and of common occurrence). *Prismatic crystals* abundant, mostly in chambered axial parenchyma cells and procumbent body ray cells, in chains

of 2–20(–24) chambers, rarely in upright or square ray cells; more than one crystal of about the same or different size per cell found in MADw 29265 and MAD-SJRw 28377. Obscure, smaller and more irregularly shaped crystals were observed only in MAD-SJRw 26118. These crystals occur in axial parenchyma cells and fibres. *Silica bodies* absent.

Section Monuraspermum Monach.

Materials studied: *A. angustifolia* Wall. ex A.DC.: Indonesia, W Kalimantan, *bb 6328* (BZFw 6013); Sumatra, Simalungun, *bb 2917* (BZFw 3365), Bangka, *Oetoei bb 10680* (BZFw 11044). — *A. macrophylla* Wall. ex G.Don: Philippines, Mindoro, *Ridsdale 1159* (Lw); Luzon, *Ridsdale 1425A* (Lw). Indonesia, Irian Jaya, *Hoogland 8901* (Lw), *Jacobs 8668* (Lw). Papua New Guinea, *Havel & Kairo NGF 15481* (Lw). — *A. spectabilis* R. Br.: Indonesia, Sulawesi, *bb 21603* (BZFw 22100), *Walangitang Cel/I-44* (BZFw 3331), *Sidiyasa 1101* (Lw).

Growth rings absent or indistinct, if present usually marked by rows of slightly radially flattened and thicker-walled latewood fibres, a decreased number of axial parenchyma cells in the latewood, and differences in vessel diameter between latewood and subsequent earlywood. *Wood* diffuse-porous. *Vessels* 23–54/sq. mm, mostly in radial multiples of 2–8(–11) (41–74%) and solitary ((13–)18–57%), remainder in clusters of 3–7 (1–12%), round to oval, sometimes slightly angular, mean tangential diameter 50–90 (20–140) µm, walls 2–7(–8) µm thick. Vessel element length 760–1320 (260–1950) µm. L/D ratio 8.8–14.3 (2.3–33.3). Perforation plates simple in mostly oblique end walls. Intervessel pits vestured, alternate, round to oval, sometimes slightly polygonal, 3–5 µm in horizontal diameter, with round to narrowly elliptic apertures. Vessel-ray and vessel-parenchyma pits with distinct borders, similar to the intervessel pits in shape and size, rarely wider, up to 6 µm, in horizontal diameter. Helical thickenings and tyloses absent, deposits very infrequent. *Fibres* 1370–1830 (680–2470) µm long, usually medium thick-walled, sometimes very thick-walled, non-septate, with distinctly bordered pits of 3–5(–6) µm in diameter, mostly in the radial walls, rarely in the tangential walls. *Axial parenchyma* predominantly apotracheal, diffuse and diffuse-in-aggregates, and scanty paratracheal, rarely vasicentric, in 3–10-celled strands. *Rays* 7–11 (4–18)/mm, 1–3-seriate. Uniseriate rays 1–18(–25) cells high, composed of weakly procumbent and upright or square cells, multiseriate rays 300–460 (60–850) µm high, composed of procumbent body cells and usually 1–2(–3) rows of upright and/or square marginal cells (or up to 7 rows in *Jacobs 8668*), latex tubes absent. *Prismatic crystals* mostly abundant (except in *Jacobs 8668*), in chambered axial parenchyma cells and sometimes in procumbent body ray-cells, in chains of 2–16(–20) chambers; more than one crystal of about the same or different size per cell found only in *Ridsdale 1425* (*A. macrophylla*). *Silica bodies* absent.

Note — The smallest vessel diameters are found in *Jacobs 8668* (*A. macrophylla*), 51 (20–70) µm, and in *Sidiyasa 1101* (*A. spectabilis*), 59 (20–90) µm. The small vessel diameters, the absence of prismatic crystals, and the much higher number of upright and/or square marginal cells in the ray cells in *Jacobs 8668*, may be due to the source of the sample, which was assumedly collected from a branch. *Sidiyasa 1101* was collected from a young lateral stem.

Table 4.2. Selected wood anatomical characters in the two groups of *Alstonia* species with information on habitat and habit or stem diameter classification.

	A	B	C	D	E	F	G	H
LIGHT ALSTONIA GROUP								
Section Alstonia								
A. actinophylla								
Versteegh BW 66	ns	ts	8	106	695	1350	7	435
A. angustiloba								
BZFw 8018	ns	ts	4	107	1010	1570	7	525
KEPw 63545	ns	ts	5	154	840	1540	6	450
A. boonei								
INEAC 664, DF	ns	ts	5	162	1080	1740	7	630
MAD-SJRw 47430	ns	ts	4	144	830	1400	8	740
A. congensis								
MADw 27091	ns	ts	4	116	785	1240	7	800
FHOw 818	ns	ts	5	149	1235	?	8	650
A. iwahigensis								
Ridsdale 1868	ns	ts	8	127	860	1550	6	480
Sidiyasa 1116	ns	ts	6	91	960	1630	6	450
AA 970	ns	ts	6	121	810	1410	8	610
BZFw 13585	ns	ts	4	146	880	1670	6	450
A. pneumatophora								
Sidiyasa 1169	sw	ts	6	146	625	1380	8	525
(BZFw) E 418	sw	ts	3	158	910	1420	7	440
Sidiyasa 1383	ns	ts	6	152	850	1340	5	788
Sidiyasa 1381	sw	ts	5	120	710	1210	6	455
A. rostrata								
CAFw 12013	ns	ts	10	78	685	1430	9	570
Gamble B-6750	ns	ts	15	76	770	1350	8	565
A. scholaris								
van Balgooy 4809	ns	ts	4	154	930	1560	6	740
BZFw 25003	ns	ts	3	151	810	1420	5	750
Sidiyasa 1402	ns	ts	6	128	790	1410	7	580
MADw 45148	ns	ts	3	172	840	1490	6	830
AA 961	ns	ts	6	117	500	1110	7	400
A. spatulata								
BZFw 22312	sw	ts	6	111	740	1170	6	395
BZFw 13110	sw	ts	7	101	720	1330	7	520

(Table 4.2 continued)

	A	B	C	D	E	F	G	H
HEAVY ALSTONIA GROUP								
Section Dissuraspermum								
A. costata								
MADw 20623	ns	ts	100	46	620	1505	11	435
MADw 29265	ns	ts	72	59	770	1500	11	425
MAD-SJRw 24854	ns	ss	121	41	720	1360	12	415
MAD-SJRw 25481	ns	ss	110	49	870	1490	10	520
MAD-SJRw 26118	ns	ss	147	42	720	1300	13	535
MAD-SJRw 28040	ns	ss	131	43	710	1430	12	435
MAD-SJRw 28275	ns	ss	131	43	725	1270	11	400
MAD-SJRw 28329	ns	ts	106	50	810	1500	12	400
MAD-SJRw 28377	ns	ss	149	49	905	1530	13	660
Section Monuraspermum								
A. angustifolia								
BZFw 6013	ns	ts	29	83	1000	1470	9	315
BZFw 11044	ns	ts	30	91	890	1620	11	320
BZFw 3365	ns	ts	34	72	940	1590	8	310
A. macrophylla								
Ridsdale 1425A	ns	ts	49	88	760	1370	10	300
Ridsdale 1159	ns	ts	31	88	960	1480	8	330
Jacobs 8668	ns	ss	61	51	790	1400	14	505
NGF 15481	ns	ts	53	88	930	1590	9	445
Hoogland 8901	ns	ts	53	83	1320	1830	7	455
A. spectabilis								
Sidiyasa 1101	ns	ss	45	59	820	1480	9	320
BZFw 3331	ns	ts	31	77	960	1580	12	390
BZFw 22100	ns	ts	37	88	1100	1750	8	345

A = Habitat (ns = non swamp; sw = swamp).
B = Habit or stem diameter (ss = small or thin diameter stem; ts = thick diameter stem).
C = Vessel frequency (per sq. mm).
D = Average tangential vessel diameter (μm).
E = Average vessel element length (μm).
F = Average fibre length (μm).
G = Ray frequency (per mm).
H = Height of multiseriate rays (μm).

4.5. Ecological trends of wood anatomical features in *Alstonia*

4.5.1. *Introduction*

The genus *Alstonia* is a widespread taxon and it occurs in Central America, tropical Africa, and from the Himalayas and China to New South Wales in Australia. Along with a widespread distribution its species are subjected to a large diversity of climatic and other ecological factors. Unfortunately, these ecological aspects cannot be studied completely due to lack of samples and scarcity of detailed field data. Samples from the subtropical regions and from high altitudes (above 2000 m) could not be obtained.

A number of studies on ecological trends in wood anatomy have used fundamentally different approaches, such as the study of ecological variation within species (Jenkins, 1975; Wilkins & Papassotiriou, 1989; Bosman, 1996), within genera (Baas, 1973; Van der Graaff & Baas, 1974; Van den Oever et al., 1981; Dickison et al., 1978; Bosman et al., 1994; Noshiro & Suzuki, 1996), within families (Baas & Zweypfenning, 1979; Dickison & Phend, 1985; Baas & Zhang Xinying, 1986; Baas et al., 1988; Zhang et al., 1992; Gasson, 1996; Oskolski, 1996), or in regional floras (Baas et al., 1983; Baas & Carlquist, 1985; Carlquist & Hoekman, 1985; Baas, 1986; Worbes, 1989; Wheeler & Baas, 1991). These studies, in general, showed that (physiologically) dry conditions and low temperatures as dependent on higher latitudes and altitudes are associated with high vessel frequency, narrow vessels, short vessel elements and fibres, and low rays when compared to the mesic and tropical lowlands. Spiral thickenings in vessels or fibres are largely restricted to floras of higher latitudes.

In the present study the diversity in various wood anatomical characters in relation to ecological factors (habitat) and habit (as correlated with stem diameter) will be analysed in order to: 1) search for any relation between wood anatomical characters and habitat; 2) search for any relation between wood anatomical characters and habit; 3) to assess any mutual correlation between wood anatomical characters.

The wood anatomical characters analysed are vessel frequency and diameter, vessel element length, ray frequency, and height of the multiseriate rays. The habitat factors are swamp versus non-swamp; and the habit factors are trees with a stem diameter of over 10 cm, versus small trees and shrubs with a lower stem diameter.

Swamps have water-logged soils, especially during the rainy season. This offers a less mesic environment for the trees than the non-swamp habitat because water uptake is inhibited in the anaerobic root environment. As a consequence, the wood could be expected to resemble that of xeric plants (narrower vessels, higher vessel frequency, and shorter vessel elements). The non-swamp habitats are assumed to have well-drained, well aerated soils, where there are no inhibitory factors for water uptake.

Table 4.2 gives a complete list of all wood anatomical characters and other parameters analysed. Correlation of wood parameters and habitat was analysed in mature wood samples (all from normal large trees) of the light Alstonia group (section *Alstonia*). Correlation with habit could be analysed in the heavy Alstonia group only, because of the great variation of stem sizes in sections *Dissuraspermum* and *Monuraspermum*.

Analysis of variance (ANOVA) was used to calculate the significance levels of the correlations between wood anatomical characters and habitat or habit. Partial correlation analysis was used to test the significance levels of mutual correlations between the wood anatomical characters.

4.5.2. *Wood anatomical characters of Alstonia in relation to habitat*

The only significant differences in the wood anatomy between the samples from swamps and well-drained soils in the light Alstonia group is in ray height; rays in trees growing in swamps are lower (Table 4.3). Fusiform elements (vessel elements, fibres) also tend to be shorter in the material from swamps, but this difference is not statistically.

Table 4.3. Average values ± standard deviation of quantitativewood anatomical features in the light Alstonia group in relation to habitat.

	swamp (n = 5)	non-swamp (n = 19)
Vessel frequency	5.4 ± 1.52	5.9 ± 2.84
Vessel diameter	127.2 ± 23.99	129.0 ± 28.25
Vessel element length	741.0 ± 104.18	850.5 ± 155.99
Fibre length	1302.0 ± 108.03	1456.1 ± 155.15
Ray frequency	6.8 ± 0.84	6.8 ± 1.08
Ray height*	467.0 ± 55.29	602.3 ± 139.57

Remarks:
n = number of samples
* = significant at 0.05 level.

4.5.3. *Wood anatomical characters of Alstonia in relation to habit*

Vessel frequency is significantly higher in the species with thin stems of the heavy Alstonia group (Table 4.4). This trend is illustrated more distinctly in section *Dissuraspermum* than in section *Monuraspermum*. Vessel diameter also shows a highly significant relation to plant habit (Table 4.4). The difference in tangential vessel diameter between sections *Monuraspermum* and *Dissuraspermum* is large (see also Table 4.2).

Vessel element length in the heavy Alstonia group tends to be longer in the thick stems than in the thin stems, but the differences are not significant. Carlquist & Hoekman (1985) reported that, in some cases, the vessel element length does not appear unambiguously related to habit.

Table 4.4. Average values ± standard deviation of quantitativewood anatomical features in the heavy Alstonia group in relation to habit.

	stems < 10 cm (n = 8)	stems > 10 cm (n = 12)
Vessel frequency***	111.8 ± 38.71	52.1 ± 27.09
Vessel diameter***	47.1 ± 6.11	76.1 ± 15.90
Vessel element length	782.5 ± 76.06	921.7 ± 179.28
Fibre length**	1407.5 ± 92.85	1565.4 ± 126.23
Ray frequency*	11.7 ± 1.67	9.7 ± 1.72
Ray height*	473.7 ± 103.91	372.2 ± 58.72

Remarks:
n = number of samples
*, **, and *** = significant at 0.05, 0.01, and 0.001 level, respectively.

The correlation between fibre length and habit of the heavy Alstonia group is very significant (Table 4.4). The small trees and shrubs have shorter fibres than the larger trees.

Ray frequency (Table 4.4) is higher in small diameter stems than in thick stems.

The correlation between ray height and habit is also significant (Table 4.4); small trees and shrubs have higher rays than larger trees. Moreover, variability in the ray height is also greater in the small stems.

The correlative trends of wood anatomical characters with tree size in the heavy Alstonia group conform to general trends (cf. Carlquist & Hoekman, 1985; Zhang et al., 1992).

4.5.4. *Correlations between wood anatomical characters*

According to Van den Oever et al. (1981) mutual correlations between wood anatomical characters can be calculated in different ways. Partial correlation analysis is the one chosen for the present study. Table 4.5 shows the correlation coefficient values between the wood anatomical characters concerned.

Correlations between vessel frequency and vessel diameter and between vessel frequency and ray frequency are very significant (Fig. 4.41): high vessel frequency occurs in species with narrow vessels, and *vice versa*, and high ray frequency is associated with high vessel frequency.

Vessel diameter is significantly correlated with vessel frequency, ray frequency, and ray height. Wide vessels are associated with low ray frequencies and tall multiseriate rays (Fig. 4.42). The significance level of the correlation between vessel diameter and ray height is lower than between the vessel diameter and ray frequency.

Vessel element length is significantly correlated only with fibre length (Fig. 4.43).

Ray frequency is also significantly and negatively correlated with ray height (see Fig. 4.44). Table 4.5 shows that the highest correlation coefficience index (–0.914) is found between ray frequency and ray height, and the lowest one (–0.003, not significant) is found between fibre length and ray frequency.

Table 4.5. Correlation coefficient between wood anatomical characters (n = 45).

	Vessel diameter	Vessel element length	Fibre length	Ray frequency	Ray height
Vessel frequency	–0.807*	–0.164	0.028	0.818*	–0.258
Vessel diameter	—	0.194	0.054	–0.804*	0.523*
Vessel element length		—	0.817*	–0.168	0.016
Fibre length			—	–0.003	–0.126
Ray frequency				—	–0.914*
Ray height					—

Significant level: * = significant at 0.005 level.
Critical values for significance levels: at 0.05 is 0.264; at 0.01 is 0.366; and at 0.005 is 0.402.

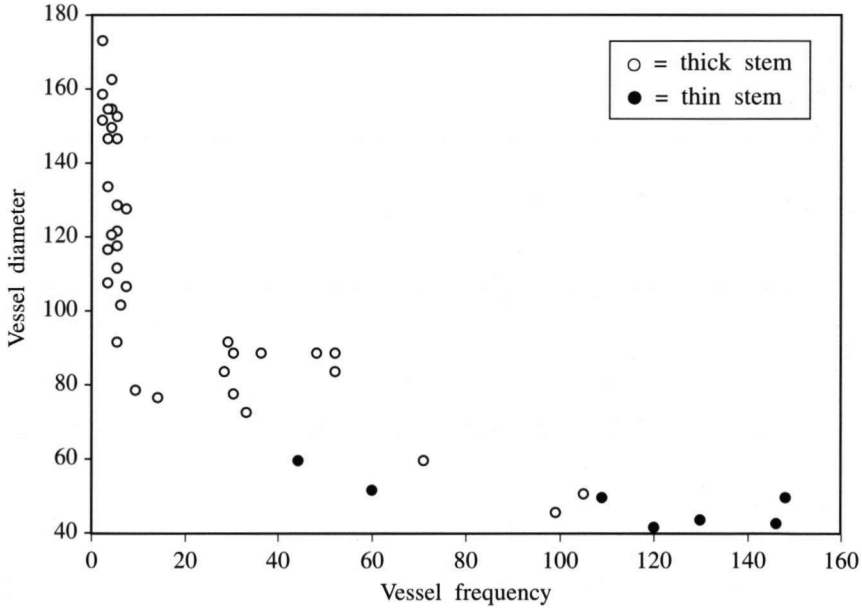


Fig. 4.41. Mutual correlation between vessel frequency and vessel diameter.

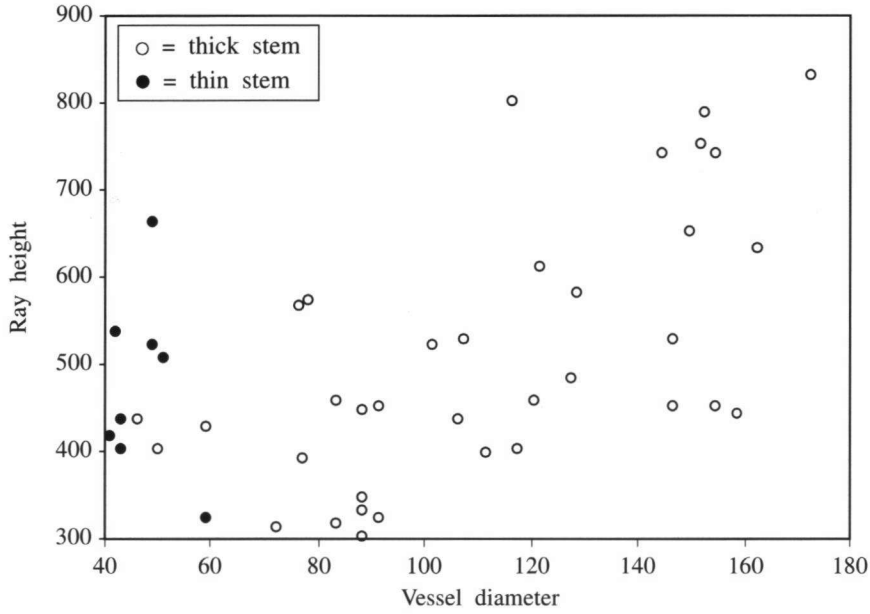


Fig. 4.42. Mutual correlation between vessel diameter and ray height.

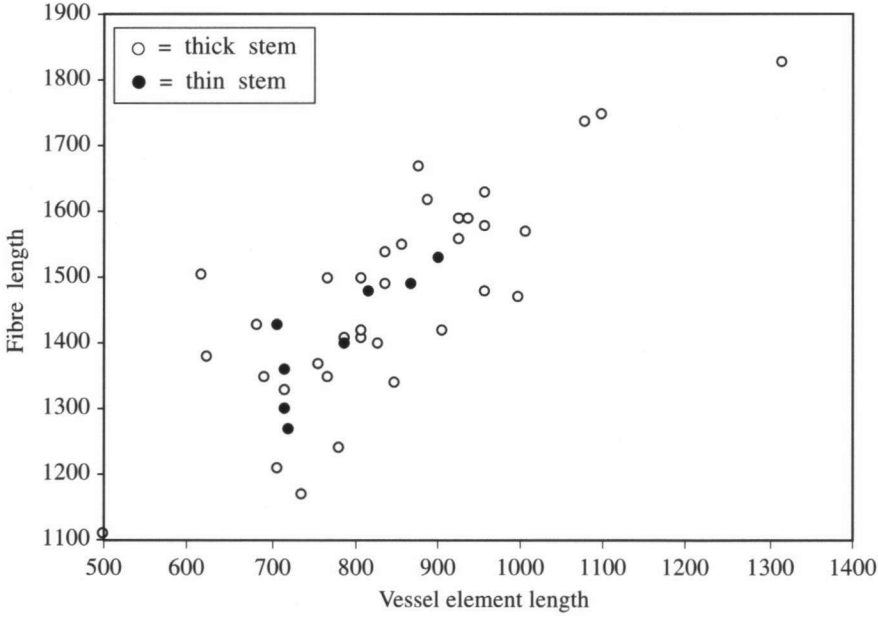


Fig. 4.43. Mutual correlation between vessel element length and fibre length.

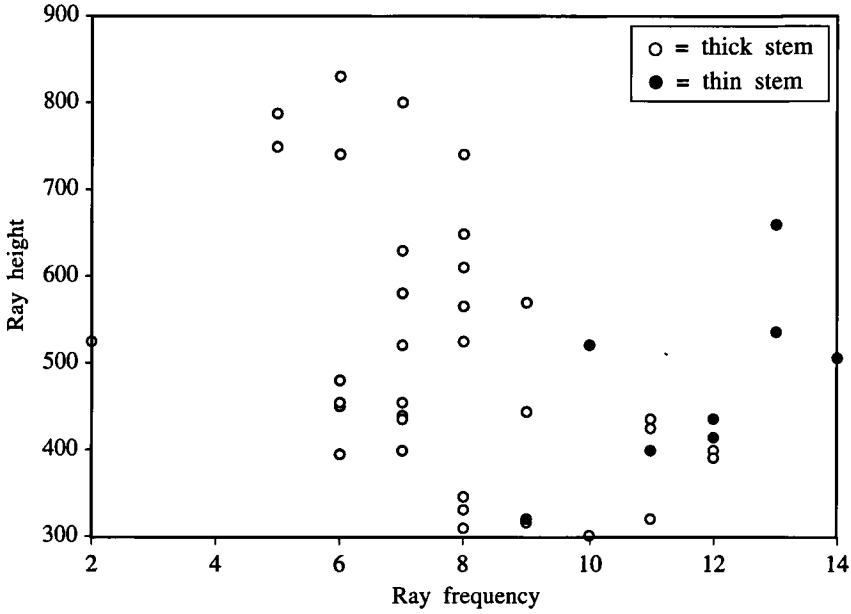


Fig. 4.44. Mutual correlation between ray frequency and ray height.

4.6. Discussion

4.6.1. *Systematic implications*

The wood anatomical characters in *Alstonia* show a considerable amount of variation of a type that is often used in systematic wood anatomy and wood identification. They support the infrageneric classification (sections) recognised on the basis of macromorphological features presented in Chapter 5. The species within a section have a similar wood anatomy, and are different from the species of the other sections. Due to the homogeneous characters within the sections, identification to the species level is impossible with wood anatomy. Fig. 4.40 & 4.45 show the wood anatomical differences between the sections. Vessel frequency is the best character to recognise the sections: it increases markedly from section *Alstonia* (with the lowest frequency) to section *Dissuraspermum* (with the highest frequency).

The timbers of *Alstonia* in Southeast Asia were classified in two groups (Soerianegara & Lemmens, 1993) mainly based on fibre wall thickness and tangential vessel diameter. If we look at only these two features as the basis (key characters) in this classification, *A. rostrata*, formerly belonging to section *Winchia*, does not fit in. This species has more or less the same vessel diameter as species of section *Monuraspermum*, but it is characterised by very thin fibre walls. Due to this and some other supporting characters, I placed *A. rostrata* in the light Alstonia group (= Pulai group according to Soerianegara & Lemmens, 1993), together with the other species of section *Alstonia*.

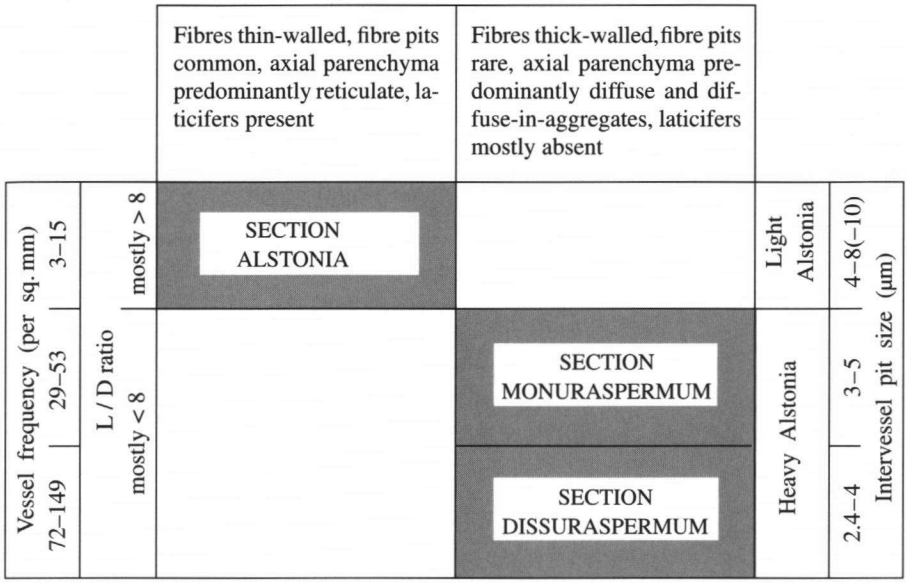


Fig. 4.45. Tentative 'block key' to the sections of the genus *Alstonia* based on wood anatomical characters.

Parenchyma distribution is another important character in *Alstonia* that can be included as a key character for sectional classification. The predominantly reticulately banded type is characteristic for the light Alstonia group, while predominantly diffuse and diffuse-in-aggregates parenchyma is typical for the heavy Alstonia group (= hard Alstonia group according to Ilic, 1991 and Soerianegara & Lemmens, 1993). Ilic (1991) includes three species in this group: *A. brassii, A. glabriflora*, and *A. spectabilis*, of which the first two now are synonyms of *A. macrophylla* (see Chapter 5).

Fig. 4.45 summarises the numerous wood anatomical differences between light and heavy Alstonia on the one hand, and between all three sections available for wood anatomical study on the other. Possibilities to differentiate between sections with relatively many quantitative wood anatomical features is quite unusual; in many woody families such differences are not even available to differentiate genera (Baas, pers. comm.).

The CSIRO's macro key for hardwood identification (Ilic, 1990) records that diffuse and diffuse-in-aggregates axial parenchyma cells is found rarely in *A. angustifolia*, while the diffuse-in-aggregates pattern is absent in *A. macrophylla*. This erroneous interpretation is understandable if these features are only studied with a hand lens. Parenchyma is often difficult to be differentiated from the thin-walled fibres in light Alstonia. A mistake has also happened in Ilic (1987). He recorded diffuse and diffuse-in-aggregates parenchyma for *A. actinophylla* but these features are never predominant in section *Alstonia* (cf. Fig. 4.6). However, most of the diagnostic characters illustrated by Ilic (1987, 1990, 1991) for *Alstonia* conform with the present results.

Soerianegara & Lemmens (1993) and Lemmens et al. (1995) noted that the light Alstonia closely resembles *Dyera*. Their wood anatomical description for *Dyera* looks very similar to *A. scholaris*. It differs mainly only in axial parenchyma distribution, which tends to be predominantly diffuse-in-aggregates or in short (discontinuous) tangential lines. In *D. costulata*, these lines are closely spaced and mostly only one cell wide and form a reticulate pattern (Martawijaya et al., 1986). A relationship between *Alstonia* section *Alstonia* and *Dyera* is also shown by the macromorphological characters (Monachino, 1949). The wood of *Alstonia* section *Alstonia* also resembles that of *Nerium, Stemmadenia, Ochrosia,* and *Tabernaemontana,* due to the latex tubes in the rays (Metcalfe & Chalk, 1950).

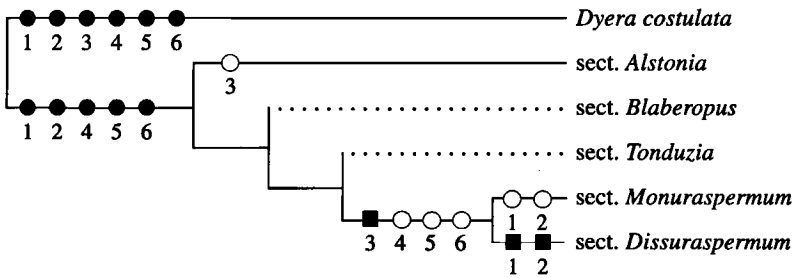


Fig. 4.46. Transformations of wood anatomical characters of the genus *Alstonia.*

1. Average vessel frequency: ● = 3–10(–15); ○ = 29–61; ■ = (72–)100–149.
2. Average vessel diameter: ● = (76–)92–162 μm; ○ = 49–91 μm; ■ = 41–59 μm.
3. Axial parenchyma: ● = densely reticulate and with short or discontinuous lines, mostly uniseriate; ○ = reticulate with mostly irregularly spaced bands, 1–3(–4) cells wide; ■ = predominantly diffuse and diffuse-in-aggregates.
4. Fibre walls: ● = thin or very thin; ○ = medium to thick.
5. Fibre pits: ● = common in both radial and tangential sections; ○ = very rare in tangential section.
6. Latex tubes or laticifers: ● = present; ○ = absent.

When the wood anatomical features are overlain on the cladogram for *Alstonia* (see Fig. 4.46), the following transformations can be hypothesised. The ancestral or the primitive characters of the genus are: thin or very thin fibre walls, wide and few vessels, the presence of laticifers, common fibre pits in both radial and tangential walls, and reticulate parenchyma. Several of these features are common characters for the family Apocynaceae (see also Metcalfe & Chalk, 1950). Only the first three of those characters show a distinct transformation in the cladogram. These characters are found only in the outgroup and in *Alstonia* section *Alstonia.* Presence of thick-walled fibres, narrow and numerous vessels, and the absence of laticifers is considered to be derived characters and are apomorphic for sections *Monuraspermum* and *Dissuraspermum.*

The irregularly spaced reticulate form of axial parenchyma cells in section *Alstonia* is an autapomorphy. This character is derived from very narrow bands (usually form

uniseriate lines) as found in *Dyera costulata,* which presumably developed into a slightly different form, predominantly diffuse and diffuse-in-aggregates, in sections *Monuraspermum* and *Dissurapsermum.* The uniseriate lines of axial parenchyma cells also occur in some species of *Cerberiopsis, Funtumia, Geissospermum, Parahancornia, Plumeria,* and *Vallaris* (Metcalfe & Chalk, 1950).

The sectional distinction by mean tangential vessel diameter is unexpected. The transformation from wide average diameters in section *Alstonia* to narrow in section *Dissuraspermum* is quite clear (see also Table 4.1). Section *Monuraspermum* is intermediate between these two sections. Ecological factors may have influenced this trend (see above).

It is impossible to state the transformation of characters and character states in sections *Blaberopus* and *Tonduzia* since no data are available. Based on the cladogram, they may be supported by the characters or character states which resemble those found in sections *Dissuraspermum* and *Monuraspermum,* because both sections are mostly comprised of shrubs and small tree.

4.6.2. *Ecological trends and functional significance*

Wood or secondary xylem provides a complex tissue for water transport, mechanical strength, and for metabolic processes such as storage and mobilisation of reserve carbohydrates and lipids (Zimmermann & Brown, 1971; Zimmermann, 1983; Baas, 1986; Carlquist, 1988). Ecological and evolutionary trends in vessel diameter, perforation plate type, vessel frequency, vessel member length, total vessel length, and fibre type have all been discussed in terms of their input to the safety and efficiency of water transport (Zimmermann & Brown, 1971; Baas, 1986). Both efficiency or maximal conductivity and safety are strongly related to vessel diameter and vessel frequency. Increased vessel diameter increases efficiency of water conduction dramatically, but at the same time it decreases safety (Zimmermann, 1983).

In *Alstonia,* these functionally significant characters vary between groups or sections, but less so in ecological categories. In section *Alstonia* (light Alstonia), the diameter of the vessels is much wider (except in *A. rostrata*) and vessel frequency is lower than in the sections of the heavy Alstonia group. However, species of both groups may grow together in the same type of habitat and in the same locality. Moreover, I did not find distinct differences within the leaf morphology (e.g., leaf size and lamina thickness) between the *Alstonia* species from different ecological niches. Field observations backed by herbarium specimens substantiated the above general observation of species with contrasting woods and similar leaf texture growing side by side: *Sidiyasa 1100* (*A. scholaris*) and *1101* (*A. spectabilis*) in Southeast Sulawesi; *Sidiyasa et al. 1385* and *1398* (*A. spectabilis*) and *Sidiyasa et al. 1386* and *1399* (*A. scholaris*) in Central Sulawesi; *Sidiyasa 1434* (*A. angustifolia*) and *1432* (*A. iwahigensis*) in Central Kalimantan. This is suggestive of alternative strategies in xylem structure and function within *Alstonia*; one emphasising efficiency in water condition (section *Alstonia,* except *A. rostrata*) and one favouring safety of conduction (the other sections). The exceptional condition in *A. rostrata* may be due to the fact that it usually occurs at higher altitudes than the other species of section *Alstonia.*

In general, habit more strongly influences wood anatomy than habitat (Table 4.3). From the characters studied, only vessel element length does not show any significant correlation with habit, while all characters lack a significant correlation to the habitat factor of water-logged versus well-drained soil. The highest significance level of correlation is found between vessel diameter and habit. More or less similar results have been reported by Noshiro and Suzuki (1996) for Nepalese *Rhododendron*.

Most of the variables analysed are directly associated with function such as water transport, mechanical strength, and storage and mobilisation of carbohydrates and other metabolites. Physiological requirements on the secondary xylem may be different (at least quantitatively so) in trees and shrubs (Zimmermann & Brown, 1971; Baas, 1986). For instance, small trees and shrubs are often characterised by slow growth rates throughout their life span (Zimmermann & Brown, 1971).

Table 4.6. Significant correlations between wood anatomical characters of *Alstonia* from the present study compared with two other families from different former studies.

Character pairs	*Alstonia*	*Symplocos*[1]	Rosaceae[2]
Vf – VD	−**	−ns	−**
Vf – Vl	−ns	−*	−**
Vf – Rf	+**	0	0
Vf – Rh	−ns	0	0
Vd – Vl	+ns	+ns	+**
Vd – Rf	−**	0	0
Vd – Rh	+**	0	−ns
Vl – Fl	+**	+**	0
Rf – Rh	−**	0	0

1) Data from Van den Oever et al. (1981) table 6 (partial correlations).
2) Data from Zhang et al. (1992) table 3.
Fl = fibre length; Rf = ray frequency; Rh = ray height; Vd = vessel diameter; Vf = vessel frequency; Vl = vessel element length.
− = negative correlation; + = positive correlation; 0 = not calculated.
* = significant at 0.05 level; ** = significant at 0.01 level; ns = non significant.

With respect to mutual correlations between characters, Table 4.6 presents a comparison of data from the present study with two former studies. As far as comparative data are available the correlations in *Alstonia* confirm results of earlier analyses in two remote woody families. Three highly significant correlations are reported here for the first time: vessel frequency and ray frequency (positive), vessel diameter and ray frequency (positive) and ray frequency and ray height (negative). These character pairs deserve further analysis in other plant groups.

It should be stressed that the existence of mutual correlations between wood anatomical features is of importance for the functional interpretation of ecological and evolutionary trends. In the present study only partial correlations are presented, but as demonstrated by Van den Oever et al. (1981) and Zhang et al. (1992), intrinsic dependencies of characters or character combinations on ecological variables require more complex correlation analyses. Such analyses were beyond the scope of the present study of *Alstonia* wood anatomy.

Chapter 5

TAXONOMIC REVISION

The descriptions are based on herbarium specimens. Measurements on flower parts (except flower buds) were taken from rehydrated materials.

5.1. Generic description

ALSTONIA

Alstonia R. Br., On Asclepiad. (1810) 64; Mem. Wern. Nat. Hist. Soc. 1 (1811) 75; nom. cons. — *Pala* A. Juss., Ann. Mus. Paris 15 (1810) 246. — Type species: *Alstonia scholaris* (L.) R. Br.

Blaberopus A. DC., Prodr. 8 (1844) 410. — Type species: *Blaberopus venenatus* (R. Br.) A. DC. (= *Alstonia venenata* R. Br.).

Winchia A. DC., Prodr. 8 (1844) 326. — Type species: *Winchia calophylla* A. DC. (= *Alstonia rostrata* C. E. C. Fisch.).

Amblyocalyx Benth. in Bentham & Hooker, Gen. Pl. 2 (1876) 689. — Type species: *Amblyocalyx beccarii* Benth. (= *Alstonia angustifolia* Wall. ex A. DC.).

Tonduzia Pittier, Contr. U. S. Natl. Herb. 12 (1908) 103. — Type species: *Tonduzia parvifolia* Pittier [= *Alstonia longifolia* (A. DC.) Pichon].

Paladelpha Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 299. — Type species: *Paladelpha angustiloba* (Miq.) Pichon (= *Alstonia angustiloba* Miq.).

Shrubs or trees. *Branches* smooth to slightly rough, lenticellate or not; branchlets terete, sometimes slightly angular or sulcate when dried, glabrous, puberulous or pubescent. *Leaves* in whorls (opposite partly in sect. *Dissuraspermum*); petiolate or sessile, colleter(s) present in the axils; blade chartaceous to thickly coriaceous when dried, ovate to obovate, narrowly so or linear, apex acuminate to retuse or emarginate, base obtuse to decurrent onto the petiole, rarely subtruncate or truncate, margin entire, undulate and/or sinuate, revolute or not, sometimes irregularly dentate; midrib flat or impressed above (raised only in *A. curtisii)*; submarginal vein mostly present; tertiary venation reticulate, scalariform or admedial ramified, conspicuous or inconspicuous. *Inflorescence* compound, cymose, terminal, pedunculate, frequently in whorls or umbellate, few- to many-flowered; pedicels very short to long, sometimes with 1 or 2 bracteole(s) just below the calyx or around the middle. *Bracts* sometimes leafy, mostly similar to bracteoles, scale- or sepal-like, ovate, triangular to narrowly so, broadly ovate, sometimes 'boomerang-like', apex acuminate to rounded, ciliate or not, sometimes with some colleters in the axils or united at the base (sect. *Blaberopus*). *Flowers* 5-merous, actinomorphic, mostly fragrant, open during the day. *Sepals* equal or subequal, ovate to narrowly ovate, sometimes broadly ovate, suborbicular or turbinate, connate at the base, apex rounded to acute, sometimes mucronulate, translucent around margin or not, ciliate or not, erect, sometimes slightly spreading when dried, without colleters in the axils. *Corolla* with various patterns of hairy belt(s) inside; corolla lobes in bud overlapping to the left or to the right; tube cylindrical or slightly widened around stamens, not twisted; lobes broadly to narrowly ovate, sometimes elliptic or narrowly so, slightly oblique or falcate, ciliate or not, auriculate at

the base at the left or the right side, spreading. *Stamens* free from the pistil; filaments short, filiform; anthers ovate or narrowly ovate, apex acute, obtuse or mucronulate, cordate at the base, locules more or less equal and with longitudinal slits, without appendages. *Pistil:* ovary superior, apocarpous (syncarpous only in *A. rostrata*), a 2-lobed disk alternating with the carpels (sect. *Blaberopus*) or a disk-like thickening at the base (distinct or sometimes obscure) (in other sections); style short to long (absent or obscure only in *A. quaternata*), mostly filiform, slightly laterally compressed and caniculate on both sides; pistil head sometimes pagoda-like, composed of a narrow membranous basal veil (which is usually united to the basal ring), a narrow basal ring, a conical or cylindrical central part (sometimes formed by two rings in sect. *Blaberopus*), and a minute, narrow or robust wide cleft stigmoid apex. *Fruit* a pair of follicles (a single 2-celled follicle only in *A. rostrata*), glabrous or pubescent, minute to roughly striate, stipitate or not, apex with or without style. *Seeds* numerous, elliptic, narrowly elliptic or oblong, ends rounded to acuminate, or caudate, glabrous or pubescent, long cilia forming a coma of simple hairs (arranged in groups of various shapes and sizes only in sect. *Tonduzia*).

Distribution — From tropical Africa to Central America, and from the Himalayas and China to New South Wales, Australia.

Habitat & Ecology — Secondary and primary forests, in swamps or dry habitats, on various soils: sandy, clay, or limestone. Altitude 0–2870 m.

5.2. Infrageneric classification

5.2.1. *Key to the sections*

1a. Colleter(s) in the leaf-axils deltoid and usually more or less as wide as the leaf-scars, or narrowly triangular and 0.3–0.7 mm wide, up to 2.5 mm high; cilia around the lateral margins of the seeds less than 1 mm long or absent; leaves always in whorls ..... **Section Alstonia**

b. Colleters minute or shortly lingulate to linear, 0.1–0.15 wide, if wider (up to 0.5 mm) then more than 2.5 mm high; cilia around the lateral margins of the seeds more than 1 mm long; leaves opposite or in whorls 2

2a. Corolla lobes overlapping to the left; follicles rostrate; seed ends rounded, if elongate, then plants of tropical New World; leaf apex pointed 3

b. Corolla lobes overlapping to the right; follicles not rostrate; seed end(s) acuminate or caudate; leaf apex blunt to retuse, rarely pointed 4

3a. Corolla tube up to 8 mm long; disk-like thickening annular; sepals glabrous outside; leaves glabrous on both sides (tropical New World) .. **Section Tonduzia**

b. Corolla tube more than 9 mm long; disk with two conspicuous deltoid to narrowly triangular lobes; sepals glabrous or pubescent outside; leaves glabrous or pubescent (Old World) ..... **Section Blaberopus**

4a. Leaves in whorls of 3 or 4; seeds acuminate or caudate at one end; cilia more than 3 mm long ..... **Section Monuraspermum**

b. Leaves opposite, sometimes in whorls of 3, seeds elongate or caudate on both ends; cilia uniform, up to 2 mm long ..... **Section Dissuraspermum**

5.2.2. *Sectional descriptions*

Section Alstonia

Section *Alstonia* R. Br., On Asclepiad. (1810) 64; Mem. Wern. Nat. Hist. Soc. 1 (1811) 75; nom. cons.; Kochummen & Wong, Blumea 29 (1984) 515. — Section *Pala* (A. Juss.) Benth. in Bentham & Hooker, Gen. Pl. 2 (1876) 705; Monachino, Pacific Sci. 3 (1949) 139; Markgraf, Blumea 22 (1974) 21. — Section *Pala* series *Pilosae* Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 296. — Type species: *Alstonia scholaris* R. Br.

Section *Pala* series *Glabrae* Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 296. — Lectotype species: *Alstonia spatulata* Blume, designated here.

Section *Winchia* (A. DC.) Monach., Pacific Sci. 3 (1949) 139. — *Winchia* A. DC., Prodr. 8 (1844) 326. — Type species: *Alstonia glaucescens* (K. Schum.) Monach. (= *Alstonia rostrata* C. E. C. Fisch.).

Trees up 60(–70) m high, and up to 200 cm in diameter, mostly buttressed, with copious white latex from the trunk bark. *Leaves* in whorls of (3–)4–9; blade glabrous on both sides (except sometimes velutinous beneath in *A. scholaris*). *Colleters* in the leaf axils deltoid and usually more or less as wide as the leaf-scars, or narrowly triangular and 0.3–0.7 mm wide, up to 2.5 mm high. *Fruit* a pair of follicles (united in *A. rostrata* only), glabrous or pubescent, minutely striate. *Seeds* rounded at both ends, glabrous on both sides, coma 8–22 mm long, cilia around the lateral margins absent or very short (less than 1 mm long).

Species: *Alstonia actinophylla* (A. Cunn.) K. Schum., *A. angustiloba* Miq., *A. boonei* De Wild., *A. congensis* Engl., *A. iwahigensis* Elmer, *A. pneumatophora* Backer ex Den Berger, *A. rostrata* C. E. C. Fisch., *A. spatulata* Blume, *A. scholaris* R. Br.

Section Blaberopus

Section *Blaberopus* (A. DC.) Benth. in Bentham & Hooker, Gen. Pl. 2 (1876) 705; Monachino, Pacific Sci. 3 (1949) 140. — *Blaberopus* A. DC., Prodr. 8 (1844) 410. — Subgenus *Blaberopus* (A. DC.) King & Gamble, J. Asiat. Soc. Bengal 74, 2 (1907) 435. — Lectotype species: *Blaberopus venenatus* (R. Br.) A. DC. (= *Alstonia venenata* R. Br.), designated by Monachino (1949).

Shrubs or small trees up to 5 m high. *Leaves* in whorls of 3–6, with pointed apex. *Colleters* in the leaf axils narrow to linear, up to 5 mm long, up to 0.5 mm wide. *Sepals* glabrous or minutely hairy outside, glabrous inside, ciliate or not. *Corolla* in the mature buds (9–)10–40 mm long. *Fruit* in pairs of follicles, smooth or very minutely striate, stipitate or not, rostrate. *Seeds* rounded at both ends, glabrous or puberulous and with long sparse hairs towards (around near) the margin, margin wavy or irregularly dentate, cilia (2.5–)4–13 mm long, cilia around the lateral margins about similar in length to the cilia of both ends.

Species: *Alstonia curtisii* King & Gamble, *A. guangxiensis* D. Fang & X. X. Chen, *A. mairei* H. Lév., *A. neriifolia* D. Don, *A. rupestris* Kerr, *A. sebusi* van Heurck & Müll. Arg., *A. venenata* R. Br., *A. yunnanensis* Diels.

Section Dissuraspermum

Section *Dissuraspermum* (A. Gray) Benth. in Bentham & Hooker, Gen. Pl. 2 (1876) 705; Monachino, Pacific Sci. 3 (1949) 142. — Subgenus *Dissuraspermum* A. Gray, Proc. Amer. Acad. 5 (1862) 334. — Section *Dissuraspermum* series *Orientales* Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 298. — Lectotype species: *Alstonia costata* (G. Forst.) R. Br., designated by Monachino (1949).

Shrubs or small trees, rarely medium-sized tree, up to 20 m high. *Leaves* opposite or in whorls of 3. *Colleters* in the leaf axils minute, shortly lingulate or narrow. *Sepals* glabrous and not ciliate (except in *A. constricta*). *Corolla* glabrous or minutely hairy outside. *Fruit* in pairs of follicles. *Seeds* elongate at both ends, pubescent, rarely glabrescent, cilia up to 2 mm long.

Species: *Alstonia balansae* Guillaumin, *A. boulindaensis* Boiteau, *A. constricta* F. Muell., *A. coriacea* Panch. ex S. Moore, *A. costata* (G. Forst.) R. Br., *A. deplanchei* van Heurck & Müll. Arg., *A. lanceolata* van Heurck & Müll. Arg., *A. lanceolifera* S. Moore, *A. legouixiae* van Heurck & Müll. Arg., *A. lenormandii* van Heurck & Müll. Arg., *A. odontophora* Boiteau, *A. quaternata* van Heurck & Müll. Arg., *A. stenophylla* Guillaumin, *A. sphaerocapitata* Boiteau, *A. vieillardii* van Heurck & Müll. Arg.

Section Monuraspermum

Section *Monuraspermum* Monach., Pacific Sci. 3 (1949) 141. — Section *Dissuraspermum* series *Occidentales* Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 297. — Type species: *Alstonia spectabilis* R. Br., designated by Monachino (1949).

Small or big trees, up to 40(–50) m high, and up to 100 cm in diameter, without latex from the inner bark. *Leaves* in whorls of 3 or 4. *Colleters* in the leaf axils minute, shortly lingulate or narrow. *Sepals* glabrous or densely pubescent, ciliate. *Corolla* in the mature bud up to 14 mm long, glabrous or densely pubescent outside. *Fruit* in pairs of follicles, glabrous. *Seeds* acuminate at one end, pubescent, coma 3–13 mm long, cilia around the lateral margins more than 2 mm long.

Species: *Alstonia angustifolia* Wall. ex A. DC., *A. annamensis* (Monach.) Sidiyasa, *A. beatricis* Sidiyasa, *A. breviloba* Sidiyasa, *A. macrophylla* Wall. ex G. Don, *A. muelleriana* Domin, *A. parvifolia* Merr., *A. penangiana* Sidiyasa, *A. rubiginosa* Sidiyasa, *A. spectabilis* R. Br.

Section Tonduzia

Section *Tonduzia* (Pittier) Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 296. — *Tonduzia* Pittier, Contr. U. S. Natl. Herb. 12 (1904) 103. — Type species: *Tonduzia parvifolia* Pittier [= *Alstonia longifolia* (A. DC.) Pichon].

Shrubs or trees up to 20 m high, up to 40 cm in diameter. *Leaves* in whorls of 3 (or 4), petiolate, blade narrowly ovate to narrowly obovate, apex pointed. *Colleters* in the leaf axils minute. *Corolla* in the mature bud 6–14 mm long, glabrous outside. *Fruit* in pairs of follicles, rostrate, stipitate or obscurely stipitate. *Seeds* with various shape of ends, rounded or acuminate, cilia arranged in groups of various shapes and sizes that seem to be branching, up to 3.5 mm long.

Species: *Alstonia longifolia* (A. DC.) Pichon.

5.3. Keys to the species

5.3.1. *General key to the species*

1a. Leaves in whorls 22
b. Leaves opposite or sometimes in whorls of 3 as well as opposite 32
2a. Colleter(s) in the leaf axils deltoid and usually more or less as wide as the leaf-scars, or narrowly triangular, 0.3–0.7 mm wide, up to 2.5 mm high, mostly glued together by resin; leaves in whorls of (3–)4–9 3
b. Colleters minute or shortly lingulate to linear, 0.1–0.15 mm wide, if wider (up to 0.5 mm) then more than 2.5 mm high, usually not glued together by resin; leaves consistently in whorls of 3 or 4, if in whorls of 3–6 then the leaf apex narrow or long-acuminate and with a pointed tip 11
3a. Branches or branchlets usually with a distinctly shorter internode at the end; leaves long-acuminate; ovary syncarpous; follicles solitary ..... **32. A. rostrata**
b. Branches or branchlets without a distinctly shorter internode at the end; leaf apex retuse to shortly acuminate; ovary apocarpous; follicles in pairs 4
4a. Leaves with the tertiary venation more or less conspicuous above; colleters narrowly triangular; corolla (sometimes partly) pubescent outside 5
b. Leaves with the tertiary venation mostly inconspicuous or obscure above; colleters deltoid; corolla glabrous outside 7
5a. Leaves petiolate with the petioles 5–22 mm long; sepals densely pubescent outside; ovary densely pubescent; follicles glabrous or pubescent 6
b. Leaves sessile or rarely petiolate with the petioles up to 7 mm long; sepals glabrous or rarely laxly puberulous outside; ovary glabrous or sparsely hairy; follicles glabrous (Africa) ..... **10. A. congensis**
6a. Petioles with a distinct narrow intrapetiolar stipule at the base; flowers usually very densely clustered; corolla lobes glabrous inside except at the extreme base where moustache-like hairs surround the mouth of the corolla tube; follicles glabrous (widespread from India and China to Solomon Islands and Australia) ..... **35. A. scholaris**
b. Petioles without intrapetiolar stipule at the base; flowers not densely clustered; corolla lobes pubescent inside; follicles pubescent (Africa) ..... **7. A. boonei**
7a. Leaves elliptic or narrowly so, rarely slightly obovate, apex usually obtuse or shortly acuminate 8
b. Leaves strongly obovate or spathulate, apex rounded or retuse 10
8a. Sepals pubescent outside; leaves 1.5–7 cm wide (Thailand and Western Malesia) 9
b. Sepals glabrous outside; leaves 0.7–2.2 cm wide (Papua New Guinea and Australia) ..... **1. A. actinophylla**
9a. Flowers very densely clustered; corolla tube 1.8–2.8 × as long as the lobes which are 2.6–4 mm long; follicles glabrous ..... **17. A. iwahigensis**
b. Flowers rather lax; corolla tube 1–1.7 × as long as the lobes which are 4–6.5 mm long; follicles pubescent ..... **3. A. angustiloba**

10a. Leaves usually sessile, rarely petiolate; flowers many and densely clustered together, usually into two clusters; sepals pubescent outside; corolla lobes 3–4.3 (–5) × 2–3.2 mm; follicles pubescent ..... **30. A. pneumatophora**
b. Leaves petiolate; inflorescences few-flowered, lax; sepals glabrous outside; corolla lobes 6.7–11 × 3.5–6 mm, follicles glabrous ..... **37. A. spatulata**
11a. (2). Leaf apex acute or acuminate with a pointed tip; corolla lobes overlapping to the left; seeds rounded at both ends; follicles rostrate 12
b. Leaf apex rounded, obtuse or acuminate with a blunt tip; corolla lobes overlapping to the right; seeds acuminate or caudate; follicles not rostrate 20
12a. Corolla tube up to 8 mm long; disk-like thickening annular; sepals glabrous outside; leaves glabrous on both sides (tropical New World) ... **22. A. longifolia**
b. Corolla tube more than 9 mm long; disk with two conspicuous deltoid to narrowly triangular lobes; sepals glabrous or pubescent outside; leaves glabrous or pubescent (Old World)..... 13
13a. Leaves sessile or subsessile; follicles not stipitate 14
b. Leaves petiolate; petioles often winged; follicles stipitate or not 16
14a. Corolla tube 6–12 mm long; corolla lobes up to 5 mm long 15
b. Corolla tube c. 20 mm long; corolla lobes 8–10 mm long **16. A. guangxiensis**
15a. Leaves glabrous on both sides; secondary veins 60–80 pairs; sepals glabrous outside, not ciliate; corolla lobes c. 3 mm long ..... **34. A. rupestris**
b. Leaves puberulous or pubescent beneath, sometimes almost so on upper side; secondary veins 15–30 pairs; sepals glabrous or minutely hairy at the base outside, ciliate; corolla lobes 3.5–5 mm long ..... **43. A. yunnanensis**
16a. Petioles distinctly winged towards the base; sepals not ciliate..... 17
b. Petioles without distinct wings towards the base; sepals ciliate..... 18
17a. Stamens with apex 1–1.5 mm below the mouth of the corolla tube; corolla tube 14–20 mm long; corolla lobes 8–9 mm long; seeds not pitted . **24. A. mairei**
b. Stamens with apex 6–7 mm below the mouth of the corolla tube; corolla tube 24–26.5 mm long; corolla lobes 14–18 mm long; seeds pitted on the hilar side ..... **14. A. curtisii**
18a. Corolla in the mature bud 9–12 mm long; corolla tube 8.2–10.5 mm long; corolla lobes 1.6–3.5 mm long ..... **36. A. sebusi**
b. Corolla in the mature bud more than 17 mm long; corolla tube more than 14 mm long; corolla lobes more than 6 mm long 19
19a. Pubescent belt inside the corolla tube 4–4.5 mm wide, starting from 1–1.5 mm below the stamens and ending at 1–2 mm below the mouth of the corolla tube; corolla in the mature bud 18–26(–35) mm long; corolla tube 15–19.5(–22.5) mm long; follicles not stipitate, 2.5–3.5 mm in diameter; leaves in whorls of 3 or 4 ..... **26. A. neriifolia**
b. Pubescent belt inside the corolla tube 5–6 mm wide, starting from 2.3–3 mm below the stamens and ending at 0.5–0.8(–1) mm below the mouth of the corolla tube; corolla in the mature bud 26–35(–40) mm long; corolla tube (20–)23–28.5 mm long; follicles stipitate, 3.5–5 mm in diameter; leaves in whorls of 3–6 ..... **41. A. venenata**

20a. (11). Sepals not ciliate; seeds more or less elongate at both ends, cilia less than 2 mm long (New Caledonia) 21
b. Sepals ciliate; seeds elongate or acuminate only at one end, cilia more than 3 mm (Malesia and Australia)..... 23
21a. Secondary veins 40–50 pairs; inflorescences on much reduced branchlets which resemble peduncles with somewhat reduced opposite leaves; style absent or obscure; seeds 2.8–3.2 mm wide ..... **31. A. quaternata**
b. Secondary veins usually less than 40 pairs; inflorescences on normal branchlets; style distinct, up to 0.6 mm long; seeds 1.8–2.5 mm wide..... 22
22a. Corolla in the mature bud less than 3 mm long; corolla lobes suborbicular or broadly ovate, 1–1.5 × 1.1–1.5 mm; leaves chartaceous or thinly coriaceous; secondary veins mostly conspicuous ..... **40. A. stenophylla**
b. Corolla in the mature bud 4.8–9 mm long; corolla lobes ovate to very narrowly ovate, more than 2.3 mm long; leaves coriaceous or thickly coriaceous, secondary veins mostly inconspicuous 41
23a. Sepals grey- or rusty-pubescent outside 24
b. Sepals glabrous or puberulous outside 31
24a. Corolla glabrous or very sparsely hairy outside (usually around the apex), dark brown or blackish when dried..... 25
b. Corolla pubescent outside, sometimes puberulous only around the apex, usually pale or rusty brown due to the hairs 27
25a. Leaves glabrous on both sides, secondary veins 12–17 pairs; sepals pubescent (except on the fused part) inside..... 26
b. Leaves glabrous or sparsely hairy above, densely velutinous beneath, secondary veins 23–26 pairs; sepals glabrous inside ..... **33. A. rubiginosa**
26a. Sepals ovate, 2.5–3.7 mm long; corolla tube 3.8–5 mm long; corolla lobes 3.5–5.8 mm long, ciliate or not (Philippines) ..... **28. A. parvifolia**
b. Sepals turbinate, c. 1.7 mm long; corolla tube c. 2 mm long; corolla lobes c. 2 mm long, ciliate (Waigeo Island, Irian Jaya) ..... **6. A. beatricis**
27a. Corolla lobes suborbicular, ovate, or sometimes shortly lingulate, 1–2.1 × as long as wide, apex rounded or obtuse (West Malesia) 28
b. Corolla lobes narrowly ovate, rarely ovate, more than (2.6–)3.1 × as long as wide, apex acute or obtuse (New Guinea and Australia) ..... **25. A. muelleriana**
28a. Sepals pubescent inside the lobed part 29
b. Sepals glabrous or laxly puberulous only around the apex inside 30
29a. Sepals with a thick margin, usually reflexed, obovate, connate at base at least half the length; corolla tube 3–4.5 mm long; corolla lobes 1–2.3 × 1–1.8 mm; leaves usually in whorls of 3 (rarely 4); seeds 1.2–1.6 mm wide ..... **2. A. angustifolia**
b. Sepals with a thin margin, not reflexed, ovate, connate at the base less than 0.5 of the length; corolla tube 5.4–5.6 mm long; corolla lobes 3–4.5 × 1.8–2.3 mm; seeds 1.8–2 mm wide ..... **29. A. penangiana**

30a. Corolla tube 2.7–2.9 mm long; corolla lobes lingulate, 1–1.3 × 0.7–0.8 mm; follicles up to 17.5 cm long, c. 5 mm in diameter; seeds 2.8–3 mm wide; leaves narrowly elliptic or narrowly obovate, glabrous on both sides (Vietnam) ..... **4. A. annamensis**

b. Corolla tube 3–4.3 mm long; corolla lobes suborbicular or ovate, 2–3.5 × 1.2–2.8 mm; follicles (15–)20–50 cm long, 2.5–4 mm in diameter; seeds 1.5–2.7 mm wide; leaves ovate to obovate or narrowly so, sometimes linear, glabrous or densely pubescent (Philippines to Australia and Solomon Islands) ..... **38. A. spectabilis**

31a. (23). Corolla tube 2–3 × as long as the lobes which are ovate or subtriangular, 1–1.3 × as long as wide (2–3 × 2–2.3 mm), not ciliate; seeds 3–3.3 mm wide; leaves thickly coriaceous, usually abruptly acuminate ..... **9. A. breviloba**

b. Corolla tube 0.7–1.5 × as long as the lobes which are ovate, narrowly ovate or oblong, 2.2–5 × as long as wide ((2.8–)3.6–7 × 1–2.6 mm), ciliate or not; seeds 1.6–2.5 mm wide; leaves chartaceous or coriaceous .... **23. A. macrophylla**

32a. (1). Bracts, bracteoles, and sepals ciliate (Australia) ..... **11. A. constricta**

b. Bracts, bracteoles, and sepals not ciliate (Pacific Islands)..... 33

33a. Leaves glabrous on both sides, glaucous beneath; petioles with an intrapetiolar stipule at the base; stamens inserted below the middle of the corolla tube ..... **8. A. boulindaensis**

b. Leaves glabrous or hairy, not glaucous beneath; petioles with or without an intrapetiolar stipule at the base 34

34a. Corolla in bud with a subglobose or broadly ovoid head; corolla lobes suborbicular or broadly ovate, (0.9–)1–2 mm long, or ovate, up to 1.2 mm long 35

b. Corolla in bud with an ellipsoid, ovoid or narrowly ovoid; corolla lobes ovate, narrowly ovate or oblong, 2 mm long or more 36

35a. Secondary veins in (8–)10–16 pairs; leaf margin entire, slightly undulate and/or sinuate; corolla lobes 0.9–1.2 × 1–1.1 mm, minutely ciliate, pilose except around the apex, i.e., sometimes glabrous inside; follicles 18–35 cm long, 3–3.5 mm in diameter ..... **39. A. sphaerocapitata**

b. Secondary veins in 18–27(–32) pairs; leaf margin entire; corolla lobes (1–)1.5–2 × 1.8–2.2 mm, not ciliate, glabrous except inside the extreme base; follicles 4.5–15 cm long, 3.5–5.5 mm in diameter ..... **19. A. lanceolifera**

36a. Scalariform type of the tertiary venation present and distinct; if not, then leaves very narrow or linear and with a sinuate and/or an undulate margin 37

b. Leaves without scalariform tertiary venation, margin not sinuate and/or undulate 39

37a. Corolla in mature bud 4–5.2 mm long; corolla lobes 2.5–3.5 mm long; leaf margin usually sinuate and/or undulate ..... **5. A. balansae**

b. Corolla in mature bud 6–15 mm long; corolla lobes 4–14 mm long; leaf margin entire, flat, undulate and/or sinuate 38

38a. Corolla bud with ellipsoidal or cylindrical head and rounded apex, glabrous or minutely hairy around the stamens outside; stamens inserted at 0.3–0.4 of the length of the corolla tube, apex 4–6 mm below the mouth of the corolla tube ..... **42. A. vieillardii**

b. Corolla bud with an ovoid or very narrowly ovoid head and with a blunt or sometimes pointed apex, glabrous outside; stamens inserted at 0.4–0.64 of the length of the corolla tube, apex 0.4–2.8 mm below the mouth of the corolla tube ..... **13. A. costata**

39a. (36). Stamens inserted at 0.2–0.3 of the length of the corolla tube, apex (2.5–)3–5.3 mm below the mouth of the corolla tube; secondary veins forming an angle of 30–60° with the midrib ..... **15. A. deplanchei**

b. Stamens inserted at 0.4–0.65 of the length of the corolla tube, apex 0.4–2.8 mm below the mouth of the corolla tube; secondary veins forming an angle of (50–)60–90° with the midrib 40

40a. Leaves sometimes in whorls of 3 as well as opposite, coriaceous or thickly coriaceous, secondary veins usually inconspicuous 41

b. Leaves opposite (never in whorls), usually chartaceous or coriaceous; secondary veins conspicuous 42

41a. (22, 40). Petioles with a distinct intrapetiolar stipule at the base; corolla tube 2.5–3.1 mm long; corolla lobes always longer than the corolla tube; stamens inserted in the middle or above the middle of the corolla tube, apex 0.4–0.8 mm below the mouth of the corolla tube ..... **12. A. coriacea**

b. Petioles without an intrapetiolar stipule; corolla tube 3.2–5.2 mm long; corolla lobes vary from shorter to longer than the corolla tube; stamens inserted below or sometimes about the middle of the corolla tube, apex 0.9–1.8 mm below the mouth of the corolla tube ..... **20. A. legouixiae**

42a. Corolla in the mature bud 8–14 mm long 43

b. Corolla in the mature bud less than 8 mm long 44

43a. Leaf margin sometimes irregularly dentate, revolute; secondary veins usually distinctly branched (bifid) at the end, sometimes recurved; petiole with a minute intrapetiolar stipule at the base (New Caledonia) ..... **27. A. odontophora**

b. Leaf margin never dentate, revolute or not; secondary veins never recurved; petiole with or without a distinct intrapetiolar stipule at the base (widespread in the Pacific, including New Caledonia) ..... **13. A. costata**

44a. (42). Sepals 1.2–2 mm long; corolla tube 1.5–1.7 mm wide; corolla lobes sparsely ciliate; leaves mostly narrowly elliptic to linear and long-acuminate ..... **18. A. lanceolata**

b. Sepals up to 1.1 mm long, if longer then plant outside New Caledonia; corolla tube usually less than 1.5 mm wide; corolla lobes mostly not ciliate; leaves never linear, apex rounded, obtuse or retuse, rarely shortly acuminate 45

45a. Sepals (0.8–)1–1.8 mm long, connate at the base for (0.1–)0.2–0.3 mm; leaf apex rounded, obtuse, or acuminate; secondary veins never recurved; tertiary venation beneath sometimes inconspicuous ..... **13. A. costata**

b. Sepals 0.5–0.9(–1) mm long, connate at the base for 0.1–0.17 mm; leaf apex obtuse, rounded, or retuse; secondary veins sometimes recurved; tertiary venation beneath always conspicuous ..... **21. A. lenormandii**

5.3.2. *Regional keys to the species*

5.3.2.1. *Key to the species of Africa*

1a. Leaf apex retuse to acuminate with a blunt tip; corolla in the mature bud up to 15 mm long; corolla tube up to 11 mm long; disk-like thickening (if present) annular; follicles not stipitate or rostrate 2
b. Leaf apex narrowly acuminate with a pointed tip; corolla in the mature bud 26–40 mm long; corolla tube (20–)23–28.5 mm long; disk with two narrowly triangular lobes; follicles stipitate and rostrate (cultivated) ..... **41. A. venenata**
2a. Trunk with copious white latex from the inner bark; leaves in whorls of 4–6(–8), glaucous beneath; corolla densely pubescent outside; follicles glabrous or pubescent; seeds rounded at both ends 3
b. Trunk without white latex from the inner bark; leaves in whorls of 3 or 4, not glaucous beneath; corolla glabrous or minutely hairy outside; follicles glabrous; seeds rounded at one end, acuminate at the other (cultivated) ..... **23. A. macrophylla**
3a. Leaves sessile or rarely petiolate with the petioles up to 7 mm long; sepals glabrous or rarely laxly puberulous outside; ovary glabrous or sparsely hairy ..... **10. A. congensis**
b. Leaves petiolate with the petioles 5–22 mm long; sepals densely pubescent outside; ovary densely pubescent 4
4a. Petioles with a distinct narrow intrapetiolar stipule at the base; corolla lobes glabrous inside, except the extreme base where moustache-like hairs surround the mouth of the corolla tube; follicles glabrous (cultivated) ..... **35. A. scholaris**
b. Petioles without intrapetiolar stipule at the base; corolla lobes pubescent inside; follicles pubescent ..... **7. A. boonei**

5.3.2.2. *Key to the species of Asia (excluding Malesia)*

1a. Leaf apex retuse to acuminate with a blunt tip; disk-like thickening (if present) annular; follicles not stipitate or rostrate 2
b. Leaf apex acute or narrowly acuminate with a pointed tip; disk with two conspicuous deltoid to narrowly triangular lobes; follicles stipitate and/or rostrate. 7
2a. Trunk with copious white latex from the inner bark; colleter(s) in the leaf axils deltoid and usually more or less as wide as the leaf-scars, or narrowly triangular, 0.3–0.7 mm wide, mostly glued together by resin, persistent or falling off soon; corolla lobes overlap to the left; seeds rounded on both ends; leaves in whorls of (3–)4–9 3
b. Trunk without white latex from the inner bark; colleters in the leaf axils minute or narrowly lingulate, 0.1–0.15 mm wide, usually not glued together by resin; corolla lobes overlap to the right; seeds acuminate or caudate; leaves consistently in whorls of 3 or 4 6
3a. Branches or branchlets with a distinctly shorter internode at the end; leaves long-acuminate; ovary syncarpous; follicles solitary ..... **32. A. rostrata**

b. Branches or branchlets without a distinctly shorter internode at the end; leaf apex retuse to shortly acuminate; ovary apocarpous; follicles in pairs 4
4a. Petioles mostly with a distinct narrow intrapetiolar stipule at the base; tertiary venation more or less conspicuous above; colleters narrowly triangular; corolla (sometimes partly) pubescent outside ..... **35. A. scholaris**
b. Petioles without a distinct intrapetiolar stipule at the base; tertiary venation mostly inconspicuous above; colleters deltoid; corolla glabrous outside 5
5a. Leaves elliptic or narrowly so, rarely slightly obovate; inflorescences many-flowered; sepals pubescent outside; corolla lobes 4–6.5 × 1.6–3 mm; follicles pubescent ..... **3. A. angustiloba**
b. Leaves strongly obovate or spathulate; inflorescences few-flowered; sepals glabrous outside; corolla lobes 6.7–11 × 3.5–6 mm; follicles glabrous .... **37. A. spatulata**
6a. (2). Sepals and corolla glabrous or minutely hairy outside; corolla tube 4.5–6 mm long; corolla lobes 3.6–7 mm long, glabrous inside except at the extreme base; follicles 20–40 cm long, 1.5–2.5 mm in diameter; seeds 1.6–2 mm wide; leaves sometimes puberulous or pubescent beneath ..... **23. A. macrophylla**
b. Sepals and corolla densely pubescent outside; corolla tube 2.7–2.9 mm long; corolla lobes 1–1.3 mm long, partly hairy inside; follicles up to 17.5 cm long, c. 5 mm in diameter; seeds 2.8–3 mm wide ..... **4. A. annamensis**
7a. (1). Leaves sessile or subsessile; follicles not stipitate 8
b. Leaves petiolate; petioles often more or less winged; follicles stipitate or not 10
8a. Corolla tube 6–12 mm long; corolla lobes up to 5 mm long 9
b. Corolla tube c. 20 mm long; corolla lobes 8–10 mm long **16. A. guangxiensis**
9a. Leaves glabrous on both sides; secondary veins 60–80 pairs; sepals glabrous outside, not ciliate; corolla lobes c. 3 mm long ..... **34. A. rupestris**
b. Leaves puberulous or pubescent beneath, sometimes almost so on upper side; secondary veins 15–30 pairs; sepals glabrous or minutely hairy at the base outside, ciliate; corolla lobes 3.5–5 mm long ..... **43. A. yunnanensis**
10a. (7). Petioles distinctly winged towards the base; sepals not ciliate 11
b. Petioles without distinct wings towards the base; sepals ciliate 12
11a. Stamens with apex 1–1.5 mm below the mouth of the corolla tube; corolla tube 14–20 mm long; corolla lobes 8–9 mm long; seeds not pitted . **24. A. mairei**
b. Stamens with apex 6–7 mm below the mouth of the corolla tube; corolla tube 24–26.5 mm long; corolla lobes 14–18 mm long; seeds pitted on the hilar side ..... **14. A. curtisii**
12a. Corolla in the mature bud 9–12 mm long; corolla tube 8.2–10.5 mm long; corolla lobes 1.6–3.5 mm long ..... **36. A. sebusi**
b. Corolla in the mature bud more than 17 mm long; corolla tube more than 14 mm long; corolla lobes more than 6 mm long 13
13a. Pubescent belt inside the corolla tube 4–4.5 mm wide, starting from 1–1.5 mm below the stamens and ending at 1–2 mm below the mouth of the corolla tube; corolla in the mature bud very often less than 26 mm long [18–26(–35) mm long]; corolla tube 15–19.5(–22.5) mm long; follicles not stipitate, 2.5–3.5 mm in diameter; leaves in whorls of 3 (or 4), secondary veins forming an angle of 80–85° with the midrib ..... **26. A. neriifolia**

b. Pubescent belt inside corolla tube 5–6 mm wide, starting from 2.3–3 mm below the stamens and ending at 0.5–0.8(–1) mm below the mouth of the corolla tube; corolla in mature bud 26–35(–40) mm long; corolla tube (20–)23–28.5 mm long; follicles stipitate, 3.5–5 mm in diameter; leaves in whorls of 3–6, secondary veins forming an angle usually less than 80° with the midrib . **41. A. venenata**

5.3.2.3. *Key to the species of Malesia*

1a. Corolla in the mature bud up to 15 mm long; corolla tube up to 11 mm long; disk-like thickening (if present) annular; follicles not stipitate or rostrate; leaf apex retuse to acuminate with a blunt tip, if pointed then the leaf blade glaucous beneath or the secondary veins more than 2 mm apart 2
b. Corolla in the mature bud more than 17 mm long; corolla tube more than 14 mm long; disk with two narrowly triangular lobes; follicles stipitate and/or rostrate; leaf apex narrowly acuminate with a pointed tip (cultivated) 18
2a. Trunk with copious white latex from the inner bark; colleter(s) in the leaf axils deltoid and usually more or less as wide as the leaf-scars, or narrowly triangular, 0.3–0.7 mm wide, mostly glued together by resin; corolla lobes overlap to the left; seeds rounded on both ends; leaves in whorls of (3–)4–9 3
b. Trunk without white latex from the inner bark; colleters in the leaf axils minute or narrowly lingulate, 0.1–0.15 mm wide, usually not glued together by resin; corolla lobes overlap to the right; seeds acuminate or caudate; leaves consistently in whorls of 3 or 4 10
3a. Branches or branchlets usually with a distinctly shorter internode at the end; leaves long-acuminate; ovary syncarpous; follicles solitary ..... **32. A. rostrata**
b. Branches or branchlets without a distinctly shorter internode at the end; leaf apex retuse to shortly acuminate; ovary apocarpous; follicles in pairs 4
4a. Leaves with the tertiary venation more or less conspicuous above; colleters narrowly triangular; corolla (sometimes partly) pubescent outside 5
b. Leaves with the tertiary venation mostly inconspicuous or obscure above; colleters deltoid; corolla glabrous outside 6
5a. Petioles mostly with a distinct narrow intrapetiolar stipule at the base; corolla lobes glabrous inside except at the extreme base where moustache-like hairs surround the mouth of the corolla tube; follicles glabrous ..... **35. A. scholaris**
b. Petioles without intrapetiolar stipule at the base; corolla lobes pubescent inside; follicles pubescent (cultivated) ..... **7. A. boonei**
6a. Leaves elliptic or narrowly so, rarely slightly obovate, apex usually obtuse or shortly acuminate 7
b. Leaves strongly obovate or spathulate, apex rounded or retuse 9
7a. Sepals pubescent outside; leaves 1.5–7 cm wide (Thailand and W Malesia). 8
b. Sepals glabrous outside; leaves 0.7–2.2 cm wide (Papua New Guinea and Australia) ..... **1. A. actinophylla**
8a. Flowers very densely clustered, usually forming two clusters; corolla tube 1.8–2.8 × as long as the lobes which are 2.6–4 mm long; follicles glabrous ..... **17. A. iwahigensis**

b. Flowers rather lax; corolla tube 1–1.7 × as long as the lobes which are 4–6.5 mm long; follicles pubescent ..... **3. A. angustiloba**

9a. (6). Leaves usually sessile, rarely petiolate; flowers many and densely clustered, usually into two clusters; sepals pubescent outside; corolla lobes 3–4.3(–5) × 2–3.2 mm; follicles pubescent ..... **30. A. pneumatophora**

b. Leaves petiolate; inflorescences few-flowered, lax; sepals glabrous outside; corolla lobes 6.7–11 × 3.5–6 mm, follicles glabrous ..... **37. A. spatulata**

10a. (2). Sepals grey- or rusty-pubescent outside 11

b. Sepals glabrous or laxly puberulous outside 17

11a. Corolla glabrous or very sparsely hairy outside (usually around the apex), dark brown or blackish when dried 12

b. Corolla pubescent outside, sometimes puberulous only around the apex, usually pale or rusty brown due to the hairs 14

12a. Leaves glabrous on both sides, secondary veins 12–17 pairs; sepals pubescent (except on the fused part) inside 13

b. Leaves glabrous or sparsely hairy above, densely velutinous beneath, secondary veins 23–26 pairs; sepals glabrous inside ..... **33. A. rubiginosa**

13a. Sepals 2.5–3.7 mm long, usually ovate; corolla tube 3.8–5 mm long; corolla lobes 3.5–5.8 mm long, ciliate or not (Philippines) ..... **28. A. parvifolia**

b. Sepals c. 1.7 mm long, turbinate; corolla tube c. 2 mm long; corolla lobes c. 2 mm long, ciliate (Waigeo Island, Irian Jaya) ..... **6. A. beatricis**

14a. (11). Corolla lobes suborbicular, ovate, or sometimes shortly lingulate, 1–2.1 × as long as wide, apex rounded or obtuse 15

b. Corolla lobes narrowly ovate, rarely ovate, more than (2.6–)3.1 × as long as wide, apex acute or obtuse ..... **25. A. muelleriana**

15a. Sepals pubescent inside on the lobed part (Malaysia, Sumatra, Borneo) ... 16

b. Sepals glabrous or laxly puberulous only around the apex inside (Java, Sulawesi, Philippines to Australia and Solomon Islands) ..... **38. A. spectabilis**

16a. Sepals with a thick margin, usually reflexed, obovate, connate at base at least 0.5 of the length; corolla tube 3–4.5 mm long; corolla lobes 1–2.3 × 1–1.8 mm; leaves usually in whorls of 3 (rarely 4); seeds 1.2–1.6 mm wide .. **2. A. angustifolia**

b. Sepals with a thin margin, not reflexed, ovate, connate at the base less than 0.5 of the length; corolla tube 5.4–5.6 mm long; corolla lobes 3–4.5 × 1.8–2.3 mm; seeds 1.8–2 mm wide ..... **29. A. penangiana**

17a. (10). Corolla tube 2 or 3 × as long as the lobes which are ovate or subtriangular, index 1–1.3 (2–3 × 2–2.3 mm), not ciliate; seeds 7–9 × 3–3.3 mm; leaves thickly coriaceous, usually abruptly acuminate ..... **9. A. breviloba**

b. Corolla tube 0.7–1.5 × as long as the lobes which are ovate, narrowly ovate or oblong, index 2.2–5 ((2.8–)3.6–7 × 1–2.6 mm), ciliate or not; seeds 5–12 × 1.6–2.5 mm; leaves chartaceous or coriaceous ..... **23. A. macrophylla**

18a. (1). Pubescent belt inside the corolla tube 4–4.5 mm wide, starting from 1–1.5 mm below the stamens and ending at 1–2 mm below the mouth of the corolla tube; corolla in the mature bud 18–26(–35) mm long; corolla tube 15–19.5 (–22.5) mm long; follicles not stipitate, 2.5–3.5 mm in diameter; leaves in whorls of 3 or 4 ..... **26. A. neriifolia**

b. Pubescent belt inside the corolla tube 5–6 mm wide, starting from 2.3–3 mm below the stamens and ending at 0.5–0.8(–1) mm below the mouth of the corolla tube; corolla in the mature bud 26–35(–40) mm long; corolla tube (20–)23–28.5 mm long; follicles stipitate, 3.5–5 mm in diameter; leaves in whorls of 3–6 .... **41. A. venenata**

5.3.2.4. *Key to the species of Australia*

1a. Leaves in whorls; seeds with cilia up to more than 4 mm long 2
b. Leaves opposite; seeds with very short cilia, up to 2 mm long ..... **11. A. constricta**
2a. Secondary veins usually more than 2 mm apart; if less, then the leaf blade glaucous beneath; corolla in the mature bud up to 15 mm long; corolla tube up to 11 mm long; disk-like thickening (if present) annular; follicles not stipitate or rostrate; leaf apex retuse to acuminate, rarely pointed 3
b. Secondary veins very crowded, 0.6–2 mm apart; corolla in the mature bud 26–40 mm long; corolla tube (20–)23–28.5 mm long; disk with two narrowly triangular lobes; follicles stipitate and rostrate; leaf apex narrowly acuminate with a pointed tip (cultivated) ..... **41. A. venenata**
3a. Trunk with copious white latex from the inner bark; leaves glaucous beneath; corolla lobes overlapping to the left; seeds rounded at both ends; leaves in whorls of 4–9 4
b. Trunk without white latex from the inner bark; leaves not glaucous beneath; corolla lobes overlapping to the right; seeds acuminate or caudate; leaves in whorls of 3 or 4 5
4a. Petiole with a distinct narrow intrapetiolar stipule at the base; flowers mostly densely clustered; sepals and the corolla pubescent outside; corolla lobes suborbicular or broadly ovate, 3–5 × 2.5–4.5(–7) mm ..... **35. A. scholaris**
b. Petiole without intrapetiolar stipule at the base; flowers not densely clustered; sepals and corolla glabrous outside; corolla lobes ovate, 4–5.1 × 1.8–2.5 mm .. **1. A. actinophylla**
5a. Corolla lobes narrowly ovate, rarely ovate, 2.6–5 × as long as wide (2.1–5 × 0.8–1.4 mm), apex acute or obtuse; seeds c. 1.3 mm wide ..... **25. A. muelleriana**
b. Corolla lobes suborbicular or ovate, 1–2.1 × as long as wide (2–3.5 × (1.2–)1.5–2.8 mm), apex rounded; seeds 1.5–2.7 mm wide ..... **38. A. spectabilis**

5.3.2.5. *Key to the species of New Caledonia*

1a. Leaves in whorls of 3 or at least some in whorls of 3 2
b. All leaves opposite 4
2a. Secondary veins 40–50 pairs; inflorescences on much smaller branchlets which resemble peduncles with somewhat reduced opposite leaves; style absent or obscure; seeds 2.8–3.2 mm wide ..... **31. A. quaternata**
b. Secondary veins usually less than 40 pairs; inflorescences on normal branchlets; style distinct, up to 0.6 mm long; seeds 1.8–2.5 mm wide 3

3a. Corolla in the mature bud less than 3 mm long; corolla lobes suborbicular or broadly ovate, 1–1.5 × 1.1–1.5 mm; leaves chartaceous or thinly coriaceous; secondary veins mostly conspicuous ..... **40. A. stenophylla**
b. Corolla in the mature bud 4.8–9 mm long; corolla lobes ovate to very narrowly ovate, more than 2.3 mm long; leaves coriaceous or thickly coriaceous, secondary veins mostly inconspicuous 12
4a. Leaves glaucous beneath, glabrous on both sides; petioles with an intrapetiolar stipule at the base; stamens inserted below the middle of the corolla tube .... **8. A. boulindaensis**
b. Leaves not glaucous beneath, glabrous or pubescent; petioles with or without an intrapetiolar stipule at the base 5
5a. Corolla in bud with a subglobose or broadly ovoid head; corolla lobes suborbicular or broadly ovate, (0.9–)1–2 mm long, or ovate, up to 1.2 mm long..... 6
b. Corolla in bud with an ellipsoid, ovoid or narrowly ovoid head; corolla lobes ovate, narrowly ovate or oblong, 2 mm long or more..... 7
6a. Secondary veins in (8–)10–16 pairs; leaf margin entire, slightly undulate and/or sinuate; corolla lobes 0.9–1.2 × 1–1.1 mm, minutely ciliate, pilose except around the apex that is sometimes glabrous inside; follicles 18–35 cm long, 3–3.5 mm in diameter ..... **39. A. sphaerocapitata**
b. Secondary veins in 18–27(–32) pairs; leaf margin entire; corolla lobes (1–)1.5–2 × 1.8–2.2 mm, not ciliate, glabrous except on the extreme base inside; follicles 4.5–15 cm long, 3.5–5.5 mm in diameter ..... **19. A. lanceolifera**
7a. Scalariform tertiary venation present and distinct; if not, then the leaves very narrow or linear and with a sinuate and/or an undulate margin 8
b. Leaves without scalariform tertiary venation 10
8a. Corolla in mature bud 4–5.2 mm long; corolla lobes 2.5–3.5 mm long; leaf margin usually undulate and/or sinuate ..... **5. A. balansae**
b. Corolla in mature bud 6–15 mm long; corolla lobes 4–14 mm long; leaf margin entire, flat, undulate and/or sinuate 9
9a. Corolla with an ellipsoidal or cylindrical head and a rounded apex, glabrous or minutely hairy around the stamens outside; stamens inserted at 0.3–0.4 of the length of the corolla tube, apex 4–6 mm below the mouth of the corolla tube; seeds 5.5–8.5 mm long ..... **42. A. vieillardii**
b. Corolla with ovoid or narrowly ovoid head and a blunt apex, glabrous outside; stamens inserted at 0.4–0.64 of the length of the corolla tube, apex 0.4–1 mm below the mouth of the corolla tube; seeds 10–20 mm long ... **13. A. costata**
10a. (7). Stamens inserted at 0.2–0.3 of the length of the corolla tube, apex (2.5–)3–5.3 mm below the mouth of the corolla tube; secondary veins forming an angle of 30–60° with the midrib ..... **15. A. deplanchei**
b. Stamens inserted at 0.4–0.65 of the length of the corolla tube, apex 0.4–2.8 mm below the mouth of the corolla tube; secondary veins forming an angle of (50–)60–90° with the midrib 11
11a. Leaves coriaceous or thickly coriaceous, secondary veins usually inconspicuous..... 12
b. Leaves usually chartaceous or coriaceous; secondary veins conspicuous .. 13

12a. (3, 11). Petioles with a distinct intrapetiolar stipule at the base; corolla tube 2.5–3.1 mm long; corolla lobes always longer than the corolla tube; stamens inserted in the middle or above the middle of the corolla tube, apex 0.4–0.8 mm below the mouth of the corolla tube ..... **12. A. coriacea**

b. Petioles without intrapetiolar stipule; corolla tube 3.2–5.2 mm long; corolla lobes vary from shorter to longer than the corolla tube; stamens inserted below or sometimes about the middle of the corolla tube, apex 0.9–1.8 mm below the mouth of the corolla tube ..... **20. A. legouixiae**

13a. Corolla in mature bud 8–14 mm long; leaf margin sometimes irregularly dentate, revolute; secondary veins usually distinctly branched (bifid) at the end; petiole with a minute intrapetiolar stipule at the base ..... **27. A. odontophora**

b. Corolla in mature bud less than 8 mm long; leaf margin not irregularly dentate, revolute or not; secondary veins usually not bifid at the end; petiole with or without intrapetiolar stipule 14

14a. Sepals 1.2–2 mm long; corolla tube 1.5–1.7 mm wide; corolla lobes sparsely ciliate; seeds 15–30 mm long; leaf apex usually long-acuminate ..... **18. A. lanceolata**

b. Sepals 0.5–0.9(–1) mm long; corolla tube 0.9–1.2 mm wide; corolla lobes mostly not ciliate; seeds less than 15 mm long; leaf apex obtuse, rounded or retuse ..... **21. A. lenormandii**

5.3.2.6. *Key to the species of the Pacific Islands (excl. New Caledonia)*

1a. Leaves in whorls; sepals and corolla pubescent outside; corolla lobes suborbicular or ovate (Solomon Islands) 2

b. Leaves opposite; sepals and corolla glabrous outside; corolla lobes ovate to very narrowly ovate (Solomon to Marquesas Islands) ..... **13. A. costata**

2a. Leaves in whorls of 4–9, glaucous beneath, petiole with a narrow intrapetiolar stipule at the base; corolla lobes overlapping to the left; seeds rounded on both ends ..... **35. A. scholaris**

b. Leaves in whorls of 3 or 4, not glaucous beneath, petiole without intrapetiolar stipule at the base; corolla lobes overlapping to the right; seeds with one end rounded or obtuse, the other end acuminate or caudate .... **38. A. spectabilis**

5.3.3. *Synoptic key to the species*

The numbers in the key refer to the numbers of the species as given in the descriptions. Numbers printed in **bold**: the species shows more than one character state; numbers in parentheses: character state rare; numbers with a question mark: character state unknown.

Trunk and roots

1. Exudate on trunk bark (obviously only for the Malesian species)
   a = present: 1, 3, 5?, 7, 10, 11?–16?, 17, 18?–22?, 24?–27?, 30, 31?, 32, 34?, 35, 36?, 37, 39?–43?.
   b = absent: 2, 4, 5?, 6, 8, 9, 11?–16?, 18?–22?, 23, 24?–27?, 28, 29, 31?, 33, 34?, 36?, 38, 39?–43?.

2. Aerial roots
   a = present: 30, 37?.
   b = absent: 1–29, 31–36, 37?, 38–43.

Leaves

3. Leaf arrangement
   a = opposite: 5, 8, 11, **12**, 13, 15, 18, 19, **20**, 21, 27, (**31**), 39, 42.
   b = in whorls of 3 or 4: **1**, 2, **3**, 4, 6, **7**, 9, **10**, (**12**), 14, 16, **17**, **20**, 22, 23, **24**, 25, 26, 28, 29, **30**, **31**, **32**, 33, 34, **35**, 36, **37**, 38, 40, (**41**), **43**.
   d = in whorls of more than 4: **1**, **3**, **7**, **10**, **17**, (**24**), **30**, (**32**), **35**, **37**, **41**, (**43**).

4. Leaf petiolate
   a = petiolate: **1**, 2–9, **10**, 11–14, **15**, 17–23, 25–29, **30**, 31–33, 35–37, **38**, 39–42
   b = sessile or subsessile: **1**, **10**, **15**, 16, 24, **30**, 34, (**38**), 43.

5. Leaf shape
   a = linear (index 10): (**12**), **15**, **18**, **20**, (**21**), (**24**), (**38**), **40**.
   b = index 1–9: 1–11, **12**, 13, 14, **15**, 16, 17, **18**, 19, **20**, **21**, 22, 23, **24**, 25–37, **38**, 39, **40**, 41, 42, 43.

6. Leaf apex pointed
   a = present: **1**, **11**, (**13**), 14, 16, 22, 24, 26, 34, 36, (**38**), 41, 43.
   b = absent: **1**, 2–10, **11**, 12, **13**, 15, 17–21, 23, 25, 27–33, 35, 37, **38**, 39, 40, 42.

7. Leaf apex retuse
   a = present: (**5**), **7**, **10**, **15**, **21**, **30**, **35**.
   b = absent: 1–4, **5**, 6, **7**, 8, 9, **10**, 11–14, **15**, 16–20, **21**, 22–29, **30**, 31–34, **35**, 37–43.

8. Leaf base subtruncate or truncate
   a = present: **13.**
   b = absent: 1–12, **13**, 14–43.

9. Leaf margin
   a = Not undulate and/or sinuate: 1, 2, 3, 4, 6, 7, **8**, 9, 10, **11**, 12, **13**, 14, 15, 16, 17, **18**, 19, 20, **21**, **22**, 23, 24, 25, 26, **27**, 28, 29, 30, 31, **32**, 33, **34**, 35, 36, 37, 38, **39**, 40, **41**, 42, 43.
   b = undulate and/or sinuate: **5**, **8**, **11**, **13**, (**18**), **21**, (**22**), **27**, **32**, **34**, **39**, **41**.
   c = irregularfy dentate: **27**.

10. Leaf indumentum
   a = glabrous on both sides: 1, **2**, 3–8, 10, **11**, 12, **13**, 14, 15, 17–22, **23**, 24, (**26**), 27–32, 34, **35**, **36**, **37**, **38**, 39, 40, **41**, **42**.
   b = glabrous or glabrescent above, puberulous or pubescent beneath: **2**, 9, **11**, **13**, 16, **23**, **25**, **26**, 33, **35**, **36**, **37**, **41**, **42**, 43.
   c = puberulous or pubescent on both sides: **11**, **25**, **26**, **36**, (**38**), (**41**).

11. Colleters in the leaf axils
   a = minute to linear: 2, 4, 5, 6, 8, 9, 11–16, 18–29, 31, 33, 34, 36, 38–43.
   b = narrowly triangular: 7, 10, 35.
   c = deltoid: 1, 3, 17, 30, 32, 37.

12. Intrapetiolar stipule
   a = distinct: 8, 12, **13**, **19**, **21**, 35.
   b = indistinct or absent: 1–7, 9–11, **13**, 14–18, **19**, 20, **21**, 22–34, 36–43.

13. Secondary veins
    a = crowded or slightly so: 1, 3, **7**, 10, **12**, 14, **15**, 16, 17, 18, **19**, (**20**), **21**, 22, 24, 26, 30, 31, 32, 34–37, (**38**), 41, **43.**
    b = well-spaced: 2, 4–6, **7**, 8, 9, 11, **12**, 13, **15**, **19**, **20**, **21**, 23, 25, 27–29, 33, **38**, 39, 40, 42, **43**.

14. Secondary veins
    a = obscure or inconspicuous: **12**, **15**, **20**.
    b = conspicuous: 1–11, (**12**), 14, **15**, 16, 17, 18, 19, (**20**), 21–43.

15. Recurved secondary veins
    a = present: **12**, **18**, **19**, **20**, **21**.
    b = absent: 1–11, **12**, 13–17, **18**, **19**, **20**, **21**, 22–43.

16. Tertiary venation above (excl. linear leaves which are always inconspicuous)
    a = inconspicuous: 1, **2**, 3, 4, 6, 8, 11, 12, **13**, 14, **15**, 16, **17**, 18, (**19**), 20, 21, 22, **23**, 24, 26, (**27**), 28, (**29**), 30, 33, 34, **35**, 36, 37, 39, **40**, 41, 43.
    b = conspicuous: (**2**), 5, 7, 9, 10, **13**, **15**, **17**, **19**, **23**, 25, **27**, **29**, 31, 32, **35**, 38, **40**, 42.

Inflorescences and flowers

17. Flowers in bunches
    a = present: 17, 30, (**35**).
    b = absent: 1–16, 18–29, 31, 32, 33, 34, **35**, 36–43.

18. Pubescence on the inflorescences (peduncles and branches)
    a = glabrous: 1, **2**, **3**, 5, 8, **9**, 10, **11**, 12–16, **17**, 18–22, **23**, 24, **26**, 27, 28, **29**, 31, **32**, 34, **35**, **36**, 37, **38**, 39, 40, 41, **42**.
    b = puberulous or pubescent: **2**, **3**, 4, 6, 7, **9**, **11**, **17**, **23**, 25, **26**, **29**, 30, **32**, 33, **35**, **36**, **38**, **42**, 43.

19. Pubescence on the pedicels
    a = glabrous: 1, 5, 8, **9**, **10**, **11**, 12, **13**, 14, 15, 16, 18–22, **23**, 24, 26, 27, 31, **32**, 34, **36**, 37, 39, 40, 41, **42**.
    b = puberulous or pubescent: 2, 3, 4, 6, 7, **9**, **10**, **11**, (**13**), 17, **23**, 25, 28, 29, 30, **32**, 33, 35, **36**, 38, **42**, 43.

20. Colleters in the axils or united at the base of bracts or bracteoles
    a = present: 14, 16, 24, 26, 34, 36, 41, 43.
    b = absent: 1–15, 17–23, 25, 27–33, 35, 37–40, 42.

21. Sepal margin
    a = thick, sometimes reflexed: **2**, 28, 31.
    b = thin, not reflexed: 1, **2**, 3–27, 29, 30, 32–43.

22. Sepal outside (pubescence)
    a = glabrous: 1, 5, 8, **9**, **10**, 11–16, 18–22, **23**, 24, 26, 27, 31, 32, 34, **36**, 37, 39, 40, 41, 42, **43**.
    b = puberulous or minutely hairy: (**9**), (**10**), 13, **23**, **36**, **43**.
    c = densely pubescent: 2, 3, 4, 6, 7, 17, 25, 28, 29, 30, 33, 35, 38.

23. Sepal inside (pubescence on the free part)
    a = glabrous: 1, **3**, **4**, 5, 8–16, **17**, 18–24, **25**, 26, 27, 31, 32, 33, 34, **35**, 36–43.
    b = puberulous or minutely hairy: **3**, (**4**), **7**, **17**, 30, **35**.
    c = pubescent: 2, 6, **7**, **25**, 28, 29.

24. Ciliation on sepals
    a = present: 1–4, 6, 7, 9–11, 16, 17, 23, 25, 26, 28–30, 32, 33, 35, 36, 37, 38, 41, 43.
    b = absent: 5, 8, 12, 13, 14, 15, 18, 19, 20, 21, 22, 24, 27, 31, 34, 39, 40, 42.

25. Corolla outside (pubescence)
    a = glabrous: 1, 3, 5, 8, **9**, 11, 12, 13, 14, **15**, 16–22, **23**, 24, 26, 27, **28**, 30, 31, **33**, 34, **36**, 37, 39, 40, 41, **42**, **43**.
    b = puberulous: 6, **9**, **15**, **23**, (**28**), 32, **33**, **35**, (**36**), **38**, **42**, **43**.
    c = densely pubescent: 2, 4, 7, 10, 25, 29, **35**, **38**.

26. Head of the corolla bud (width)
    a = narrower than the corolla tube: **3**, 14, **17**, **24**, 34, 39, 43.
    b = about as wide as the corolla tube: 1, 2, **3**, 4–9, (**10**), 11, 12, 13, **15**, 16, **17**, 18, 20, 21, 22, 23, (**24**), 25, 26, 28, 29, 31, 32, 33, **35**, 36, 38, 39, 40, 41, **42.**
    c = wider than the corolla tube: **10**, **15**, 19, 27, 30, **35**, 37, **42**.

27. Corolla lobes (shape)
    a = broadly ovate to ovate, < 1.5 × as long as wide: **2**, **4**, 7, 9, 19, 34, 35, **36**, **38**, 39, 40.
    b = elliptic to narrowly ovate, < 1.5 × as long as wide: 1, (**2**), 3, **4**, 5, 6, 8, 10–18, 20–33, (**36**), 37, (**38**), 41, 42, 43.

28. Corolla lobes (length)
    a = shorter than the corolla tube: **1**, 2, **3**, 4, 5, **7**, 8, 9, **10**, **13**, 14–19, **20**, (**21**), **22**, **23**, 24, **25**, 26, **27**, **28**, 29–36, **37**, 38–43.
    b = as long as or longer than corolla tube: **3**, 6, **7**, **10**, 11, 12, **13**, **20**, **21**, **22**, **23**, **25**, **27**, **28**, **37**.

29. Corolla lobes (thickness)
    a = thin (papery): 1, 2, 3, 5–16, 18–30, 32–41, 43.
    b = thick (fleshy when fresh): 4, 13?, 17, 31, 42.

30. Corolla lobes inside
    a = glabrous, except around the mouth: 1, 3, **13**, 14, 16, 17, 26, (**27**), 28, 30, 34, 35, 36, 37, 40, 41, 43.
    b = pilose/hairy up to ± basal half: **4**, **5**, 6, 9, 11, 12, **13**, **15**, 19–24, **27**, 31, 33, **39**, **42**.
    c = completely hairy: 2, (**4**), **5**, 7, 8, 10, **15**, 18, 25, 29, 32, 38, **39**, **42**.

31. Corolla lobes overlapping
    a = to the right: 2, 4, 5, 6, 8, 9, 11, 12, 13, 15, 18, 19, 20, 21, 23, 25, 27, 28, 29, 31, 33, 38, 39, 40, 42.
    b = to the left: 1, 3, 7, 10, 14, 16, 17, 22, 24, 26, 30, 32, 34, 35, 36, 37, 41, 43.

32. Corolla lobes ciliation
    a = on whole margin: 1, 2, 4, 6, **18**, (**21**), **23**, 25, **28**, 29, 38, 43.
    b = only at the base or very sparsely: **11**, (13), **17**, **18**, **20**, (**27**), **36**, **39**.
    c = absent: **1**, 3, 5, (7), 8–10, **11**, 12–16, **17**, 19, **20**, **21**, 22, **23**, 24, 26, **27**, **28**, 30–35, **36**, 37, **39**, 40, 41, 42.

33. Stamens (apex) below the mouth of corolla tube
    a = up to 3 mm: 1–13, **15**, 16–21, **22**, 23–41, **42**, 43.
    b = more than 3 mm: 14, **15**, **22**, **42**.

34. Ovary
    a = syncarpous: 32.
    b = apocarpous: 1–31, 33–43.

35. Pubescence on ovary
    a = glabrous: 1, 2, **3**, 4, 5, 6, 8, 9, **10**, 11–24, **25**, 26–31, **32**, 33, 34, 36–43.
    b = sparsely hairy: (**3**), (**10**), (**25**), (**32**).
    c = densely villose: 7, 35.

36. Disk or a disk-like thickening
    a = obscure or annular: 1–13, 15, 17–23, 25, 27–33, 35, 37, 38, 39, 40, 42.
    b = distinctly 2-lobed emerged alternating with the carpels: 14, 16, 24, 26, 34, 36, 41, 43.

37. Pistil length
    a = shorter or as long as the sepals: **6**, **20**, (**25**), 28, 31.
    b = longer than the sepals: 1–5, **6**, 7–19, **20**, 21, 22, 23, 24, **25**, 26, 27, 29, 30, 32–43.

38. Style
    a = absent or obscure: 31.
    b = shorter than ovary: (**7**), 8, 11, 12, **13**, 19, 20, 21, 25, **28**, **39**, **40**.
    c = as long as or longer than ovary: 1–6, **7**, 9, 10, **13**, 14–18, 22, 23, 24, 26, 27, **28**, 29, 30, 32–38, **39**, **40**, 41, 42, 43.

39. Central part of pistil head
    a = more or less conical: **4**, 5, 6, 8, **9**, 11–15, 18–20, **21**, 23, 25, 27, 29, 31, 38–40, 42.
    b = cylindrical or ring-like (sometimes double): 1, 2, 3, **4**, 7, **9**, 10, 16, 17, **21**, 22, 24, 26, 28, 30, 32–37, 41, 43.

40. Stigmoid apical part (cleft) of pistil head
    a = narrow or pointed: 2, 4, 5, 6, 8, 9, 11, 12, 13, 15, 18, 19, 20, 21, 22, 23, 25, 27, 28, 29, 31, 33, 38, 39, 40, 42.
    b = robust and 3 mm long: 1, 3, **7**, 14, 16, 17, (**24**), **26**, 30, 34, **35**, 37, 41.
    c = robust and > 3 mm long: **7**, 10, **24**, **26**, 32, **35**, 36, 43.

Fruits and seeds

41. Follicle form
    a = single (united) follicle: 32.
    b = a pair of follicles: 1–5, 6?, 7–15, 16?, 17–31, 33–39, 40?, 41, 42, 43.

42. Follicle length
    a = up to 15 cm: **1**, **5**, 6?, 8, **11**, **12**, **13**, 14, 15, 16?, **18**, **19**, 20, 21, **22**, 24, **25**, **26**, **27**, **30**, 31, 34, 36, (**37**), 40?, 41, 43.
    b = more than 15 cm: **1**, 2, 3, 4, **5**, 6?, 7, 9, 10, **11**, **12**, **13**, 16?, 17, **18**, **19**, **22**, 23, **25**, **26**, **27**, 28, 29, **30**, 32, 33, 35, **37**, 38, 39, 40?, 42.

43. Follicle diameter
    a = up to 2.5 mm: 1, **2**, 3, 6?, **7**, **10**, **13**, **15**, 16?, 17, **23**, 24, **25**, **26**, 28, 30, 35, **37**, (**38**), 40?, **42**, **43**.
    b = 2.6–5 mm: **2**, 4, 5, 6?, **7**, 8, 9, **10**, 11, 12, **13**, 14, **15**, 16?, 18, **19**, **20**, 21, 22, **23**, **25**, **26**, 27, 29, 31, 33, 34, 36, **37**, **38**, 39, 40?, 41, **42**, **43**.
    c = 5.1–7.5 mm: 6?, 16?, (**19**), (**20**), **31**, 40?.
    d = more than 7.5 mm: 32.

44. Follicle stipitate
    a = present: 16?, **22**, **24**, 36, 41, (**43**).
    b = absent: 1–5, 6?, 7–15, 16?, 17–21, **22**, 23, **24**, 25–35, 37, 38, 39, 40?, 42, **43**.

45. Follicle rostrate
    a = present: 14, 16?, 22, 24, 26, 34, 36, 41, 43.
    b = absent: 1–5, 6?, 7–13, 15, 16?, 17–21, 23, 25, 27–33, 35, 37, 38, 39, 40?, 42.

46. Follicle pubescence
    a = glabrous or almost so: 1, 2, 4, 5, 6?, 8–15, 16?, 17–29, 31–39, 40?, 41, 42, 43.
    b = pubescent: 3, 6?, 7, 16?, 30, 40?.

47. Seeds
    a = rounded on both ends: 1, 3, 7, 10, 14, 16?, 17, 24, 26, 30, 32, 34, 35, 36, 37, 40?, 41, 43.
    b = one end rounded, other end acuminate: 2, 4, 6?, 9, 16?, 23, 25, 28, 29, 33, 38, 40?.
    c = elongate on both ends or almost so: 5, 8, 11, 12, 13, 15, 18, 19, 20, 21, 22, 27, 31, 39, 40?, 42.

48. Seeds with long hairs on surface (usually near margin)
    a = present: 14, 16?, 24, 26, 34, 36, 40, 43.
    b = absent: 1–5, 6?, 7, 10–15, 17–23, 25, 27–33, 35, 37, 38, 39, 40?, 41, 42.

49. Cilia on the side margin of seeds
    a = long or ± as long as cilia at the ends: 2, 4, 5, 6?, 8, 9, 11–15, 16?, 18–29, 31, 33, 34, 36, 38, 39, 40?, 41, 42, 43.
    b = glabrous or very short: 1, 3, 7, 10, 17, 30, 32, 35, 37.

50. Cilia (maximum length)
    a = up to 2 mm: 5, 8, 11, 12, 13, 15, 18, 19, 20, 21, **22**, 27, 31, 39, 40?, 42.
    b = 2.1–7.5 mm: 4, 6?, 9, 14, 16?, **22**, **23**, 24, **26**, 33, 34, 36, **38**, **41**, 43.
    c = 7.6–10 mm: 1, **2**, **3**, 6?, 16?, **23**, 25, **26**, 28, **29**, **30**, **32**, **35**, **38**, **41**.
    d = more than 10 mm: **2**, **3**, 6?, 7, 10, 16?, 17, **29**, **30**, **32**, **35**, 37, **38**, (**41**).

51. Seed surfaces (not long hairs)
    a = glabrous: 1, 7, 10, **14**, 16?, 17, (**26**), 30, 32, **34**, 35, 37.
    b = puberulous, pubescent: 2, 3, 4, 5, 6?, 8, 9, 11, 12, 13, **14**, 15, 16?, 18–25, **26**, 27, 28, 29, 31, 33, **34**, 36, 38, 39, 40?, 41, 42, 43.

52. Seed surfaces
    a = pitted: 14, 16?, (**26**).
    b = not pitted: 1–5, 6?, 7–13, 15, 16?, 17–25, **26**, 27–39, 40?, 41, 42, 43.

Geography

53. Area distribution (not cultivated)
    a = Central America: 22.
    b = Africa: 7, 10.
    c = Continental Asia (excl. Malesia): **3**, 4, 14, 16, **23**, 24, 26, 32, 34, **35**, 36, **37**, 41, 43.
    d = West Malesia: 2, **3**, 17, **23**, 28, 29, 30, 32, **35**, **37**, **38**.
    e = East Malesia: **1**, 6, 9, **23**, **25**, 33, **35**, **37**, **38**.
    f = Australia: **1**, 11, **25**, **35**, **38**.
    g = Solomon Islands: **13**, **35**, **38**.
    h = Vanuatu to Marquesas Islands (excl. New Caledonia): **13**.
    i = New Caledonia: 5, 8, 12, **13**, 15, 18, 19, 20, 21, 27, 31, 39, 40, 42.

5.4. Species descriptions

1. Alstonia actinophylla (A. Cunn.) K. Schum. — Fig. 5.1 & 5.2

Alstonia actinophylla (A. Cunn.) K. Schum. in Engl. & Prantl, Nat. Pflanzenfam. 4, 2 (1895) 138; Monachino, Pacific Sci. 3 (1949) 154; Markgraf, Blumea 22 (1974) 26; P.I. Forster, Austral. Syst. Bot. 5 (1992) 750; Fl. Australia 28 (1996) 119. — *Alyxia actinophylla* A. Cunn., Bot. Mag. 61 (new ser. 8) (1834) 3313. — Type: *Cunningham 205* (lecto GH, designated by Monachino, 1949; isolecto BM, K, MO), Western Australia, Montague Sound, Sept. 1820, fl.

Alstonia verticillosa F. Muell., Fragm. 6 (1868) 116. — Type: *Daemel s.n.* (holo MEL, not seen; iso K, MO, W), Australia, Queensland, Cape York, March 1868, fl.

Tree, 25–40 m high; trunk 35–60 cm in diameter. *Bark* both longitudinally and horizontally deeply fissured and peeling off in rectangular flakes, greyish; inner bark soft, granular, pale yellow or straw-coloured, with copious white latex. *Branches* smooth, without lenticels; branchlets terete, usually slightly sulcate when dried, glabrous, yellowish grey, brown or sometimes blackish. *Leaves* in whorls of (4–)5–6(–8), petiolate, sometimes sessile; petiole glabrous, 3–6(–10) × 1–15 mm, flattened above, sometimes with a minute intrapetiolar stipule (up to 0.5 mm high) at the base, colleters deltoid (rarely persistent) in the leaf axils; blade thinly coriaceous, narrowly elliptic, 3.5–11 × 0.7–2.2 cm, index 3.3–7.5, apex acute or obtuse, mostly pointed, base acute or decurrent onto the petiole, entire, glabrous on both sides; midrib impressed above; secondary veins in 23–40 pairs, very fine, rather straight and forming an angle of 80–90° with the midrib, 1–3 mm from each other, short interstitial veins present; tertiary venation reticulate, admedial ramified, sometimes conspicuous beneath. *Inflorescences* 3–10(–18) cm long, terminal, 1–4 together, many-flowered; peduncle 1–3 cm long, glabrous; pedicels (1–)2–4(–5) mm long, slender, glabrous, usually with 1 or 2 bracteoles of which one near the calyx and the other around the middle or near the base. *Bracts* and *bracteoles* sepal-like, ovate or triangular, 0.5–0.7(–1) mm long, ciliate or not, glabrous on both sides, acute or obtuse. *Flowers* fragrant. *Sepals* light green or pale yellow, connate at the base for 0.2–0.3 mm, ovate, (0.8–)1–1.5 × 0.7–1 mm, index 1–1.5, erect, obtuse, glabrous on both sides, ciliate, almost translucent especially around the apex. *Corolla* white or pale yellow, 8–12.4 mm long in the mature bud and forming an ovoid head 0.3–0.4 of the bud length, 2.5–4 × 1–1.5 mm, with a blunt apex, glabrous or minutely ciliate on the corolla lobes outside, with three hairy belts inside, the first belt pubescent, starting from 2–3 mm above the base to the insertion of the stamens (3.5–4 mm wide), the second belt around the apical part of the stamens (0.5–0.8 mm wide), and the third belt pilose, with white or yellow hairs at the extreme base of the corolla lobes (moustache-like surrounding the mouth), c. 0.3 mm wide; tube 7–8 mm long, widening around the stamens, 1.4–1.9 mm wide (at the base 1–1.5 mm wide), 5.3–8 × as long as the sepals, 1.4–2 × as long as the lobes; lobes ovate, 4–5.1 × 1.8–2.5 mm, index 2–2.8, sometimes oblique or slightly falcate, apex obtuse or rounded, spreading, mostly not ciliate in open flowers. *Stamens* with apex 0.3–1 mm below the mouth of the corolla tube, inserted at 0.7–0.8 of the length of the corolla tube (at 5.2–6.4 mm from the base); filaments (0.4–)0.5–0.9 mm long,

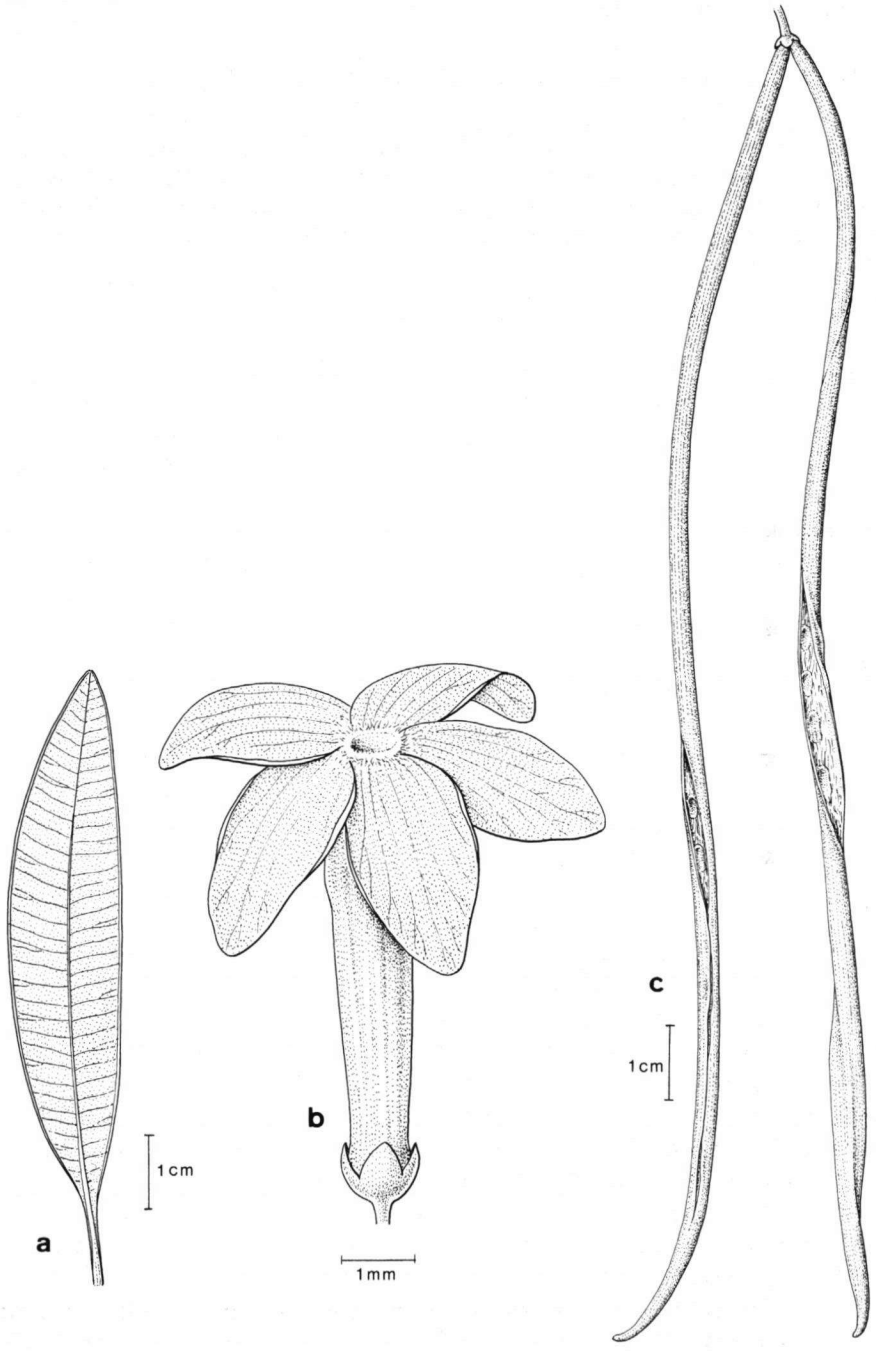


Fig. 5.1. *Alstonia actinophylla* (A. Cunn.) K. Schum. – a: Leaf; b: open flower; c: follicles (a, b: *Pullen 7196*;c: *L. S. Smith 11951*).

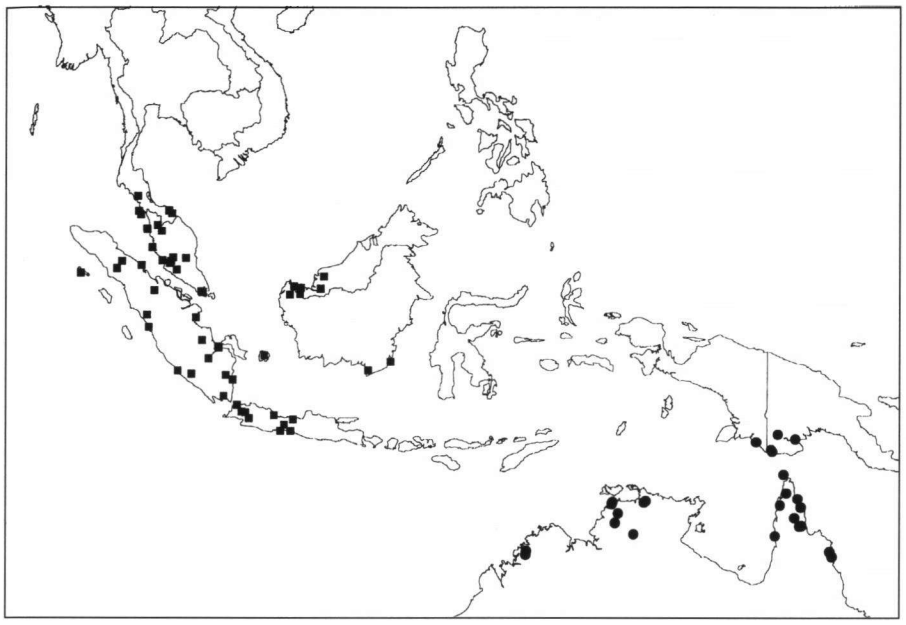


Fig. 5.2. Distribution of *Alstonia actinophylla* (A. Cunn.) K. Schum. (●) and *A. angustiloba* Miq. (■).

filiform; anthers ovate, 1–1.2 × 0.4–0.5 mm, apex obtuse. *Pistil* glabrous, 5.6–7.1 mm long; ovary ovoid, 1–1.4 × 0.8–1 mm, mostly slightly laterally compressed, composed of 2 carpels, the disk-like thickening at the base obscure; style 4–6.5 mm long, filiform; pistil head 0.6–0.8 mm high, composed of a thin basal ring c. 0.1 mm high, a cylindrical central part 0.3–0.4 × 0.2–3 mm, and a robust cleft stigmoid apical part 0.2–0.3 mm high. *Fruit* a pair of follicles, 8–20 cm long, 2–2.5 mm in diameter, striate, glabrous. *Seeds* oblong, 4–5 × 1.1–1.3 mm, ends rounded, glabrous on both sides, coma 8–10 mm long, reduced and becoming shorter, or glabrous towards the margins, hilum linear, c. 1 mm long.

Distribution — Indonesia (Irian Jaya), Papua New Guinea, Australia (Western, Northern, Queensland).

Habitat & Ecology — Woodlands with sandy or clay soils, or on rocky sandstone slopes. Altitude 2–270 m.

Vernacular names — Irian Jaya: *sendie* (Merauke) (*Anta 87*). Papua New Guinea: *sual* (Namoa language).

Uses — Exudate of this species used by local people as ingredient in making an intoxicating beverage, known as 'tuba' (*Eddowes & Kumul NGF 36056*).

Note — The lectotype was designated by Monachino, l.c., but he had misread the collection number (*205* as *206*).

Specimens studied: Indonesia: Irian Jaya, Merauke: 8 specimens. – Papua New Guinea: Western Province: 11. – Australia: Western: 3; Northern Territory: 17; Queensland: 27.

2. Alstonia angustifolia Wall. ex A. DC. — Fig. 5.3 & 5.4

Alstonia angustifolia Wall. ex A. DC., Prodr. 8 (1844) 409; Markgraf, Blumea 22 (1974) 26. — Type: *Wallich 1650* (holo G-DC; iso G, K-W), Singapore, Oct. 1822, fl.

Amblyocalyx beccarii Benth. in Hooker, Icon. Pl. 3, 2 (1876) 69, pl. 1179. — *Alstonia beccarii* (Benth.) Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 297. — Type: *Beccari 1628* (holo K; iso G, P), Malaysia, Sarawak, 1872, fl.

Alstonia angustifolia var. *elliptica* King & Gamble, J. Asiat. Soc. Bengal 74, 2 (1907) 441. — Type: *Curtis s. n.* (holo CAL, not seen), Malaysia, Penang.

Alstonia latifolia (King & Gamble) Ridl., Fl. Malay Penins. 2 (1923) 347. — *Alstonia angustifolia* var. *latifolia* King & Gamble, J. Asiat. Soc. Bengal 74, 2 (1907) 441; Monachino, Pacific Sci. 3 (1949) 160; Whitmore, Tree Flora of Malaya 2 (1973) 9. — Type: *Maingay 1070/1* (lecto L, designated by Monachino, 1949; isolecto BO, K), Malaysia, Penang, 1871, fl.

Tree, small to medium-sized, 5–35(–46) m high; trunk 8–70 cm in diameter, fluted at the base, or with small or steep buttresses. *Bark* smooth, shallowly fissured, or scaly in horizontal and longitudinal fissures, sometimes with large scattered protruding lenticels, grey or brownish; inner bark yellowish, without latex. *Branches* slightly rough, often both longitudinally and laterally fissured, usually sparsely lenticellate; branchlets terete or slightly triangular, glabrous or puberulent, brown or blackish. *Leaves* in whorls of 3 (rarely 4), petiolate; petiole glabrous or glabrescent, 8–30 × 1–2 mm, flattened or canaliculate above, without intrapetiolar stipules; colleters minute or shortly lingulate, 20–35 in the axils; blade chartaceous or thinly coriaceous, dull brown to dark red-brown when dried, obovate to narrowly obovate (rarely elliptic), 4–18 × 1.5–7 cm, index 1.9–4.7, apex acuminate, acumen c. 7(–13) mm long with a blunt point, base acute to decurrent onto the petiole, entire, glabrous above, glabrous or puberulous beneath; midrib impressed above; secondary veins in 10–20 pairs and forming an angle of 60–80° with the midrib, 4–10(–12) mm from each other, forming a thin submarginal vein; tertiary venation reticulate, sometimes conspicuous on both sides. *Inflorescence* 3–9 cm long, many-flowered; peduncle 2–6 cm long, glabrescent or puberulous; pedicels 0.5–2(–3) × 0.3–0.5 mm, pubescent. *Bracts* and *bracteoles* sepal- or scale-like, up to 0.7 mm long, acute or acuminate, ciliate. *Flowers* fragrant. *Sepals* pale green, connate at the base for 0.8–1.5 mm, obovate, 1.3–2 × 0.7–1.2 mm, index 1.1–2.5, apex acute, obtuse, or rounded, reflexed or not, rusty pubescent outside and at the lobed parts inside. *Corolla* white, cream, pale yellow, or pink, 3–5(–6) × 0.8–1.3 mm in the mature bud and forming a subglobose or ovoid head, 0.8–1.6 × 0.8–1.3 mm, rusty pubescent outside (except the basal part within the calyx or sometimes the apex glabrescent or puberulous), two distinctly hairy belts inside, the first belt pubescent starting from 1.1–2 mm above the base to the insertion of the stamens (0.7–1 mm wide), the second belt pilose over the corolla lobes (around the stamens usually very sparse); tube almost cylindrical, mostly slightly widening around the stamens, 3–4.5 mm long, 0.8–1.6 mm wide, 1.5–3.1 × as long as the sepals, 2–3.5 × as long as the lobes; lobes suborbicular or ovate, 1–2.3 × 1–1.8 mm, index 1–1.53, ciliate, spreading. *Stamens* with apex 0.4–1 mm below the mouth of the corolla tube, inserted at 0.54–0.71 of the length of the corolla tube (at 2–2.8 mm from the base); filaments short, 0.3–0.5(–0.7) mm long, filiform, glabrous; anthers ovate, 0.7–1 × 0.3–0.4 mm, apex obtuse or sometimes acute. *Pistil* 2–3 mm long; ovary ovoid or

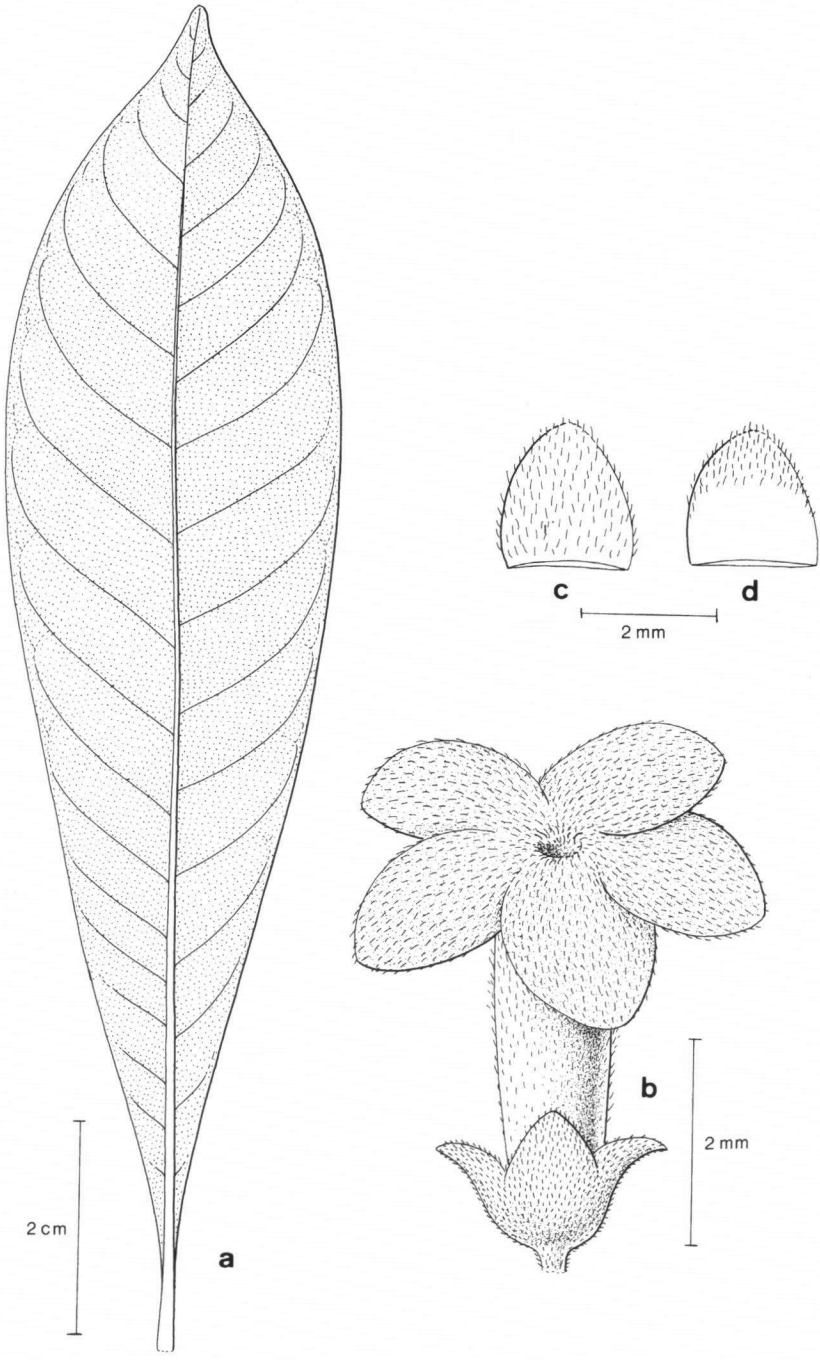


Fig. 5.3. *Alstonia angustifolia* Wall. ex A. DC. – a: Leaf; b: open flower; c: sepals, outside surface, d: sepals, inside surface (a–d: *Anta 614*).

broadly ovoid, 0.5–1 × 0.6–0.8(–1) mm, mostly slightly laterally compressed, composed of 2 carpels, glabrous, with a narrow disk-like thickening at the base, 0.1–0.3 mm high; style 1–1.8 mm long, filiform, glabrous; pistil head ovoid or funnel-shaped, 0.3–0.5 × 0.2–0.3 mm, glabrous, composed of a thin basal ring c. 0.1(–2) mm high, a cylindrical or slightly conical central part 0.2–0.4 × 0.16–0.3 mm, and a cleft stigmoid apical part up to 0.1 mm high. *Fruit* a pair of follicles, 20–53 cm long, 1.7–2.6 (–3) mm in diameter, striate, glabrous. *Seeds* dark brown, densely pubescent; elliptic to oblong, (4–)6–8.6 × 1.2–1.8(–2) mm, one end acuminate up to 4 mm long, the other end rounded; coma 5–13 mm long, reduced and becoming shorter gradually towards the side margins.

Distribution — Malaysia (Peninsular Malaysia, Sarawak and Sabah), Singapore, Indonesia (Sumatra, incl. Bangka Island, Kalimantan).

Habitat & Ecology — Primary forests, peat swamps or hillsides, on sandy or granite soils. Altitude 5–750(–1700) m.

Vernacular names — Malaysia: *itai setapoh*, *setinggi* (Peninsular Malaysia); *ply* or *plai*, *mergalang* (Iban, Sarawak).

Note — According to Monachino (1949), the specimens collected by *J. & M.S. Clemens, 28673 & 28673a,* on Mt. Kinabalu, Sabah belong to *A. parvifolia* Merr. Those specimens have a glabrous or puberulous apex of the corolla bud (the indumentum is reduced from densely pubescent on the corolla tube). My conclusion

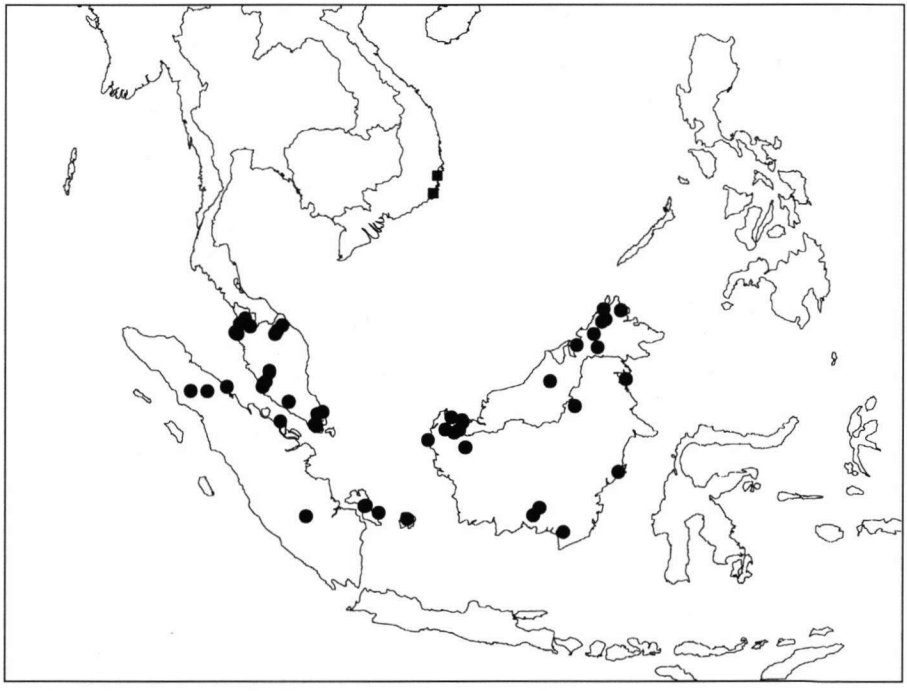


Fig. 5.4. Distribution of *Alstonia angustifolia* Wall. ex A. DC. (●) and *A. annamensis* (Monach.) Sidiyasa (■).

is that these specimens belong to *A. angustifolia*, a species widespread in Borneo, and not to *A. parvifolia* which occurs only in the Philippines. This conclusion is also based on two intermediate specimens, *J. & M.S. Clemens 50392* collected on Mt. Kinabalu, near Gurulau, above Dahobong River (alt. 1170 m) and *I.H. Sario SAN 32244* collected in Ranau District, Sosopodon, Ranau River (alt. 1700 m).

Specimens studied: Malaysia: Peninsular Malaysia: 49 specimens; Sarawak: 27; Sabah: 10. – Singapore: 22. – Indonesia: Sumatra incl. Bangka Island: 24; Kalimantan: 18.

3. Alstonia angustiloba Miq. — Fig. 5.2 & 5.5

Alstonia angustiloba Miq., Fl. Ind. Bat. 2 (1856) 438; Monachino, Pacific Sci. 3 (1949) 152 (excl. syn. *A. iwahigensis* Elmer); Markgraf, Blumea 22 (1974) 24. — *Paladelpha angustiloba* (Miq.) Pichon, Bull. Mem. Mus. Hist. Nat. Paris 2, 19 (1947) 299. — Type: *Blume 910* (holo L; iso L, 3 sh.), Indonesia, Java, fl.

Alstonia calophylla Miq., Fl. Ind. Bat. 2 (1856) 439. — Type: *Teijsmann HB 994* (holo L; iso K, U), Indonesia, Sumatra, Loeboe Aloeng (= Lubuk Alung), vegetative.

Alstonia angustiloba var. *glabra* Koord. & Valeton, Bijdr. Booms. Java 1 (1894) 120. — Type: *Koorders 4* (lecto BO, designated here), Indonesia, Java, Pekalongan, 11 Oct. 1891, fl.

Tree, up to 40 m high; trunk up to 60(–100) cm in diameter, fluted at the base and forming tall buttresses up to 8 m high. *Bark* rough, fissured and peeling off in rectangular flakes, greyish or brownish; inner bark cream, yellow, with copious white latex. *Branches* smooth or scaly, sometimes sparsely lenticellate; branchlets terete, glabrous, pale or yellowish brown to brown. *Leaves* in whorls of 4–7(–9), petiolate; petiole glabrous, (7–)10–20(–30) × 1–2 mm, flattened or canaliculate above, without distinct intrapetiolar stipule at the base, deltoid or scale-like colleters in the axils; blade greyish to reddish brown beneath, pale to dark brown or blackish above, subcoriaceous to coriaceous when dried, narrowly elliptic to obovate (rarely ovate), 4.5–22 × 2.1–7 cm, index 2.2–4.1, apex obtuse, sometimes shortly acuminate with a blunt acumen up to 0.6 cm long, base obtuse or acute, glabrous on both sides, entire; midrib impressed above; secondary veins in 30–60(–70) pairs, straight and forming an angle of 80–90° with the midrib, 1–3(–4) mm from each other; tertiary venation admedial ramified, inconspicuous or almost so. *Inflorescence* 3–9(–14) long, usually forming two umbels above each other, many-flowered; peduncle 2–5(–7) cm long, glabrous or puberulous; pedicels (0–)1–3 × 0.3–0.5 mm, pubescent. *Bracts* and *bracteoles* linear or sepal-like, up to 2(–3) mm long, acute, ciliate. *Flowers* fragrant. *Sepals* pale green, connate at the base for 0.2–0.6 mm, erect or slightly spreading when dried, ovate, 1.2–2 × 0.7–1 mm, index 1.2–2.9, obtuse, sometimes acute, pubescent or tomentose outside, glabrous or minutely pubescent around the apex inside, ciliate. *Corolla* white, yellow or cream, 8–11 × 0.7–1(–1.4) mm in the mature bud and forming a narrowly ovoid head 0.3–0.45 of the bud length, 3–5 × 1–1.4 mm, with a blunt apex; glabrous outside, three distinctly hairy belts between the glabrous parts inside, the first belt pubescent from 1.4–2.1 mm above the base to the insertion of the stamens (2–3.5 (–4.2) mm wide), the second belt around the anthers (less sparse than the first belt), and the third belt densely villose at the mouth of the corolla tube and continuing onto the very base of the lobes and forming a moustache-like portion; tube 5.6–8 mm long,

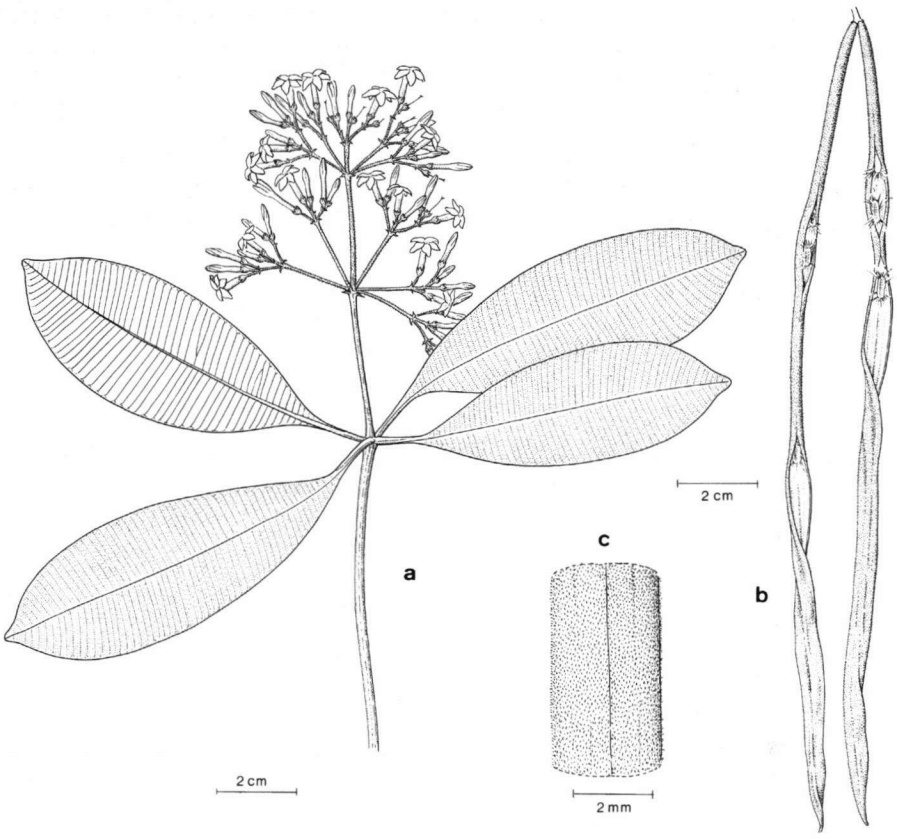


Fig. 5.5. *Alstonia angustiloba* Miq. – a: Habit; b: pair of follicles; c: surface of follicle in detail (a: *Elsener 201*; b, c: *Bojeng Sitam 8981*).

base 1–1.7 mm wide, narrowing at the middle to 0.7–1(–1.5) mm wide, then widening at the apex (around the stamens) to 1.2–1.8 mm wide, 3–6.7 × as long as the sepals, 1–1.7 × as long as the lobes; lobes oblique, ovate to narrowly ovate or oblong, 4–6.5 × 1.6–3 mm, index 1.8–3.3, spreading. *Stamens* with apex 0.6–1 mm below the mouth of the corolla tube, inserted at 0.7–0.8 of the length of the corolla tube (at 4.2–5.8 mm from the base); filaments short, 0.5–0.7 mm long, filiform; anthers ovate, 0.8–1 × 0.35–0.4 mm, apex obtuse. *Pistil* 4.8–6.3 mm long; ovary ovoid or broadly ovoid, 0.8–1.1 × 0.8–1 mm, composed of 2 carpels, mostly entirely glabrous, rarely sparsely hairy around the apex, slightly compressed, with or without a narrow disk-like thickening at the base; style 3.7–5 × 0.1–0.17 mm, filiform; pistil head 0.5–0.7 mm high, composed of (or without) a thin basal ring c. 0.07 mm high, a cylindrical central part 0.3–0.4 × 0.2 mm, and a short and robust cleft stigmoid apical part 0.2–0.3 mm high. *Fruit* a pair of follicles, (15–)20–35 cm long, 1.6–2.3 mm in diameter, brownish tomentose. *Seeds* dark brown, oblong, 5–7 × 1.3–1.5 mm, minutely undu-

late and pubescent on the hilar side (except around the hilum which is a glabrous elliptic belt), smooth and glabrous on the other side, ends rounded or obtuse, coma 10–15 mm long, hilum linear (usually whitish), 1–2 mm long.

Distribution — Thailand, Malaysia (Peninsular Malaysia and Sarawak), Singapore, Indonesia (Sumatra, Java, Kalimantan). Planted in the Bogor Botanical Garden.

Habitat & Ecology — Secondary and primary forests, on hillsides, along streams, swampy areas (usually at the edges), on loamy or sandy soils and limestone. Altitude 15–200 m.

Vernacular names — Sarawak: *pulai bukit* (common); Brunei: *pulai lilin* (Malay); Kalimantan: *hanju lutung, pantung* (Buntok, C Kalimantan), *pulantan bubur* (Pleihari, S Kalimantan).

Uses — The latex is used as a medicine to heal boils and abscesses (*J. Mamit S 35874*, Sarawak).

Specimens studied: Thailand: 7 specimens. – Malaysia: Peninsular Malaysia: 47; Sarawak: 13. – Singapore: 11. – Indonesia: Sumatra: 56; Java: 42; Kalimantan: 5.

4. **Alstonia annamensis** (Monach.) Sidiyasa, *stat. nov.* — Fig. 5.4 & 5.6

Alstonia angustifolia Wall. ex A. DC. var. *annamensis* Monach., Pacific Sci. 3 (1949) 160. — Type: *Poilane 5970* (holo A; iso K, P, US), Vietnam, Phan Rang Province, Annam, Cana, Apr. 1923, fl.

Tree, 10 m high; trunk 25 cm in diameter. *Branches* slightly rough, sometimes with sparse lenticels; branchlets terete or slightly angular, glabrous or glabrescent, blackish, or greenish brown to brown on the young parts when dried. *Leaves* in whorls of 3 or 4 (mostly 4), petiolate; petiole glabrous, 5–15 × 1–2 mm, subtriangular in cross section, flattened above, without intrapetiolar stipules, few to many minute or shortly lingulate colleters densely packed together in the axils; blade subcoriaceous, brown above and pale brown beneath when dried, narrowly elliptic or slightly narrowly obovate, sometimes elliptic or obovate, 4.5–16 × 1–5.8 cm, index 2.7–4.6, apex obtuse or shortly acuminate, acumen up to 12 mm long (sometimes obscure and gradually narrowed toward the apex) with a blunt tip, base decurrent onto the petiole giving it a winged appearance, entire or with a revolute margin when dried, glabrous on both sides; midrib impressed above; secondary veins in 12–20 pairs and forming an angle of 60–80° with the midrib, 2.5–9 mm from each other, joining and forming a thin submarginal vein, short interstitial veins sometimes present; tertiary venation reticulate, mostly conspicuous beneath, or sometimes on both sides. *Inflorescence* 3–11 cm long, terminal, 4–8 together, many-flowered; peduncle slender, 1–5.6 mm long, (0.7–)1–1.5 mm wide, puberulous or densely pubescent with curling hairs (pilose) as on the branches; pedicels rather stout, 1–2(–3.5) × 0.6–0.8 mm, pubescent. *Bracts* and *bracteoles* scale- or sepal-like, up to 1 mm long, obtuse or sometimes rounded, ciliate, pubescent outside, glabrous inside or only around the apex with short and sparse hairs. *Flowers: Sepals* connate at the base for 0.1–0.2 mm, ovate or suborbicular, 1–1.1 × 0.7–1.1 mm, index 0.9–1.4, apex obtuse or rounded, not revolute, ciliate, rusty pubescent outside, glabrous or sometimes laxly puberulous only around the apex in-

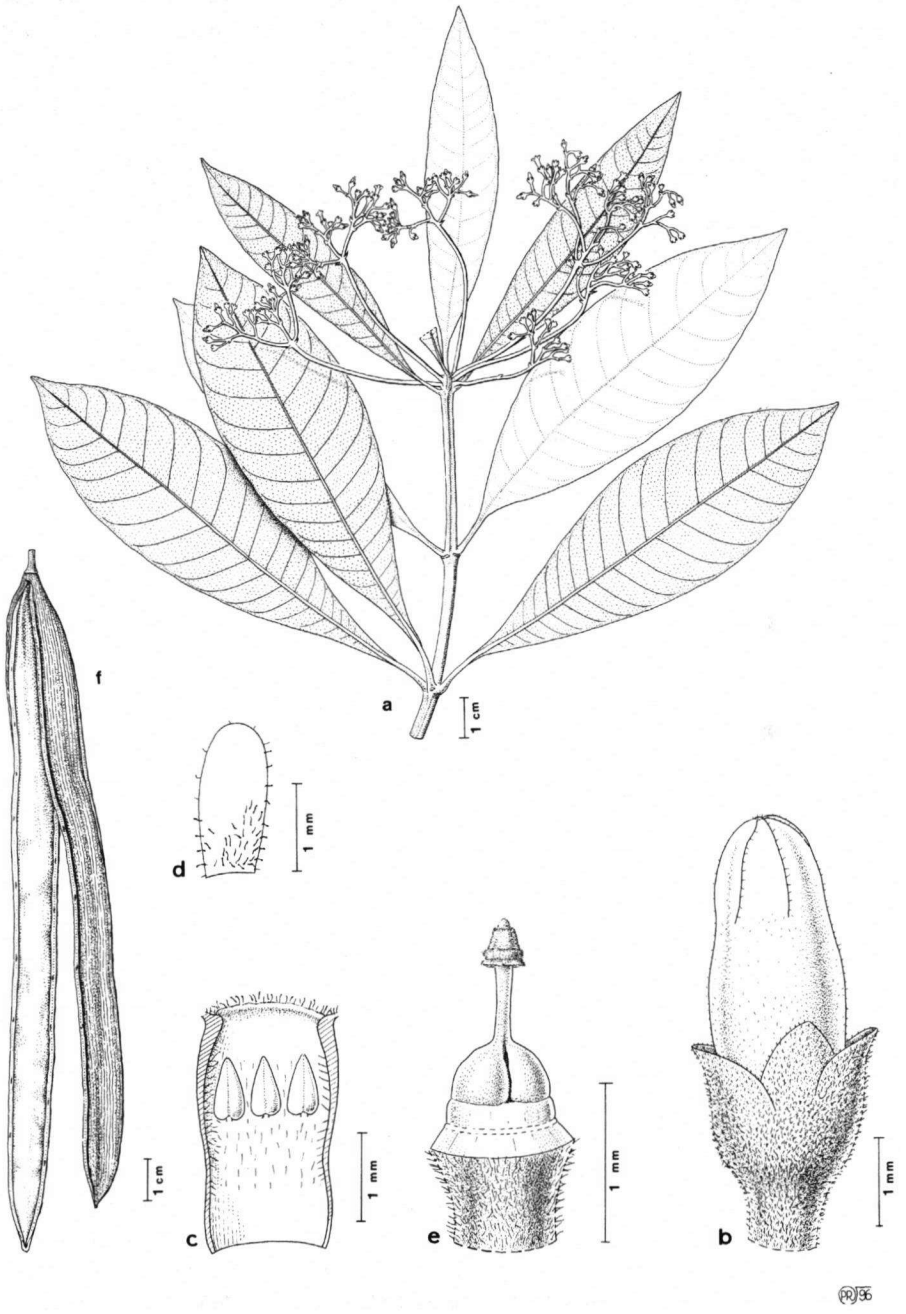


Fig. 5.6. *Alstonia annamensis* (Monach.) Sidiyasa – a: Habit; b: flower in bud; c: dissected corolla tube; d: corolla lobe; e: pistil; f: open follicles (a–e: *Poilane 10142*; f: *Poilane 6784*).

side, sometimes three of them larger than the other two. *Corolla* c. 2.9 mm long in the mature bud and forming an ovoid or a subglobose head c. 0.3 of the bud length (0.9 × 0.7–0.8 mm), rusty pubescent outside (except glabrous at the very base), with a shortly pubescent belt inside starting from 0.8–1 mm above the base and ending at the level of the stamens (c. 1.1 mm wide), and partly hairy on the right side of the corolla lobes, the throat glabrous; tube almost cylindrical or widening around the stamens, 2.7–2.9 mm long, 1.2–1.3 mm wide, 2.6–2.8 × as long as the sepals, 2.1–2.9 × as long as the lobes; lobes lingulate, 1–1.3 × 0.7–0.8 mm, index 1.4–1.6, ciliate, spreading and with a slight curve at the margin. *Stamens* with apex 0.6–0.7 mm below the mouth of the corolla tube, inserted at 0.5–0.52 of the length of the corolla tube (c. 1.5 mm from the base); filaments short, c. 0.2 mm long, filiform, glabrous; anthers ovate, 0.6–0.8 × 0.3 mm, apex obtuse or mucronulate. *Pistil* 1.3–1.6 × as long as the sepals, 1.4–1.6 mm long; ovary suborbicular, 0.45–0.6 × 0.5–0.8 mm, glabrous, composed of 2 carpels, with a narrow disk-like thickening at the base, 0.1–0.2 mm high; style 0.7–0.8 mm long, filiform, glabrous; pistil head ovoid or pagoda-shaped, c. 0.3 mm high, composed of a thin basal ring 0.06–0.1 × 0.25–0.35 mm, a cylindrical or conical central part c. 0.2 × 0.2 mm, and a cleft stigmoid apical part c. 0.05 mm high. *Fruit* a pair of follicles, 16–17.5 cm long, 3.5–4.5 mm in diameter, striate, glabrous. *Seeds* elliptic or ovate, 8–9.5 × 2.8–3 mm, dark brown, pubescent on both sides, one end rounded, the other end acute or acuminate, not clawed, sometimes bifid at the apex, coma 4–6 mm long, becoming shorter gradually towards the side margins.

Distribution — Endemic to Vietnam.

Habitat & Ecology — Forests, on rocky soils. Altitude: known only from 1700 m.

Vernacular name — Annam: *cay lae* (Nhatrang).

Uses — The leaves and roots might be used against breathing problems due to moisture conditions (*Poilane 6784*).

Specimens studied: Vietnam: Phan Rang Province: *Poilane 5970* (type), *10142* (P); Nhatrang: *Poilane 6784* (A, P).

5. **Alstonia balansae** Guillaumin — Fig. 5.7

Alstonia balansae Guillaumin, Bull. Soc. Bot. Fr. 88 (1941) 370; Boiteau et al., Adansonia sér. 2, 16 (1977) 474; Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 180. — Type: *Balansa 2424* (holo P; iso K, L, MO, UC, Z), New Caledonia, Nakety, Sept. 1869, fl. & fr.

Alstonia undulata Guillaumin, Bull. Soc. Bot. Fr. 88 (1941) 372; Boiteau et al., Adansonia sér. 2, 16 (1977) 472; syn. nov. — Type: *Franc 1386* (lecto P, designated here; isolecto G, Z), New Caledonia, Dumbea River, June 1909, fr.

Small tree, 3–10 m high; trunk up to 30 cm in diameter. *Bark* rather rough, grey to dark brown. *Branches* rough, sometimes minutely longitudinally and transversally fissured, mostly lenticellate; branchlets terete, wrinkled or slightly sulcate when dried, glabrous, grey to dark brown. *Leaves* opposite, petiolate; petiole glabrous, (20–)30–70 × 1–3(–4) mm, slightly laterally compressed, shallowly caniculate above, widening and forming an intrapetiolar stipule at the base, many minute colleters densely packed together in the axils; blade dark green above and light green beneath, dull

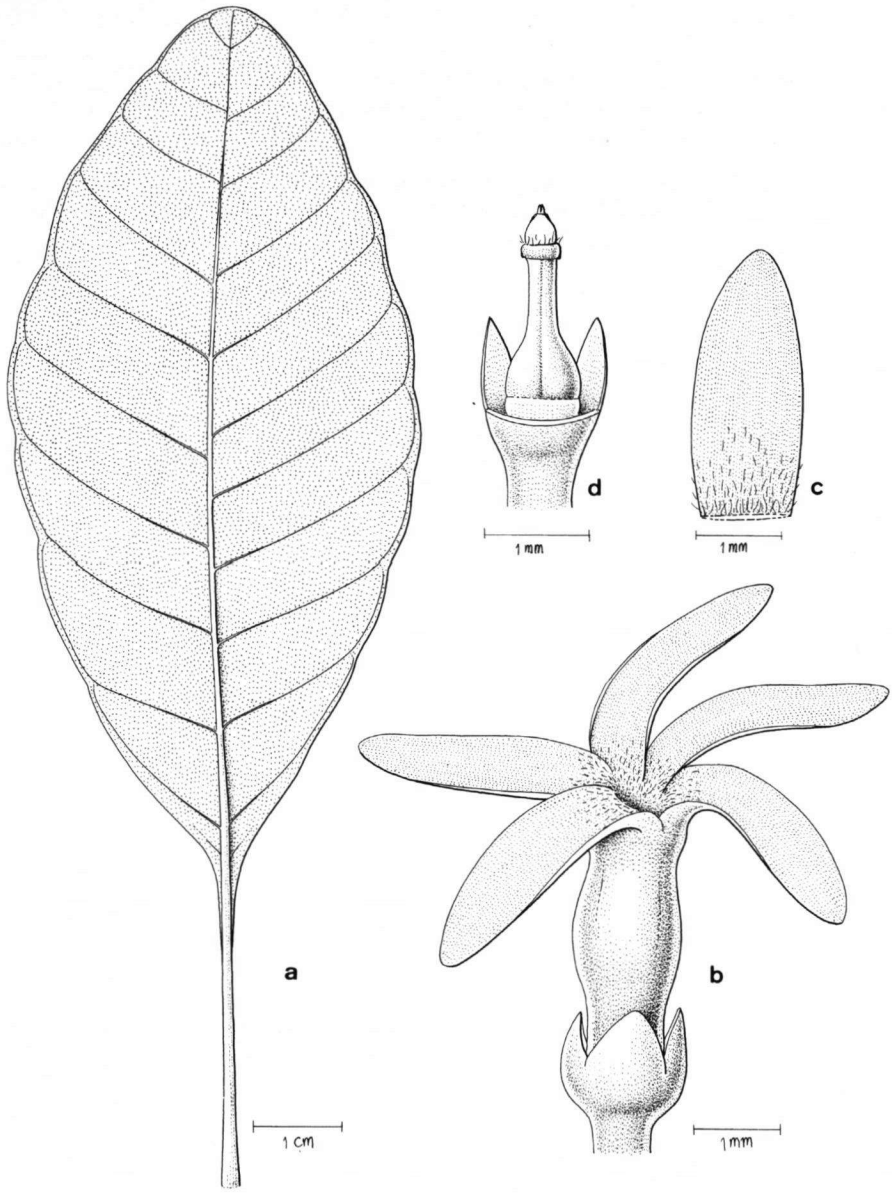


Fig. 5.7. *Alstonia balansae* Guillaumin – a: Leaf; b: open flower; c: corolla lobe; d: pistil, showing only two sepals (a–d: *MacKee 17146*).

grey green to dark brown and chartaceous when dried, elliptic to narrowly elliptic or ovate, 5–20(–30) × (1.5–)2.5–15(–20) cm, index 1.3–3.5, glabrous on both sides, apex obtuse or rounded, sometimes retuse, base obtuse to subtruncate, rarely acute, sometimes slightly oblique, margin sinuate and/or undulate; midrib impressed above;

secondary veins rather straight, in 7–12(–14) pairs and forming an angle of (55–)60–80° with the midrib, (6–)8–20(–33) mm from each other, usually joining and forming a thin submarginal vein; tertiary venation reticulate, sometimes also scalariform, conspicuous. *Inflorescence* 4–22 cm long, many-flowered; peduncle 1–11 cm long, glabrous as on the branches; pedicels 1–3 × 0.3 mm, glabrous (very often with one bracteole below the calyx). *Bracts* and *bracteoles* scale- or sepal-like, ovate to suborbicular, up to 1 mm high (usually shorter), glabrous, with an almost translucent margin, obtuse or rounded, rarely acuminate, not ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.1–0.2 mm, ovate, sometimes broadly ovate, (0.8–)1–1.4 × (0.5–)0.7–1.2 mm, index (0.8–)1–1.6, erect, glabrous on both sides, obtuse or rounded, with an almost translucent margin, not ciliate, mostly the two outer ones larger than the three inner ones. *Corolla* white, 4–5.2 mm long in the mature bud and forming an ovoid or narrowly ovoid head 0.38–0.5 of the bud length, 1.7–2.5 × 0.7–1 mm, with a blunt apex, glabrous outside or laxly puberulous only on lobes, two distinct hairy belts inside, the first belt shortly pubescent from 0.8–1 mm above the base to the insertion of the stamens (0.5–0.8 mm wide), the second belt sparsely villose starting from 0–0.4 mm below the mouth to the base of the lobes and from there gradually becoming glabrous or minutely hairy towards the apex (around stamens usually glabrous, or sometimes with very sparse and short hairs); tube almost cylindrical, 2.8–3.2 mm long, 0.8–1.2 mm wide, 2–3.8 × as long as the sepals, 0.8–1.2 × as long as the lobes; lobes ovate or narrowly ovate, 2.5–3.5 × 0.8–1.2 mm, index 2.5–4, sometimes slightly oblique or slightly falcate, not ciliate, minutely auriculate at the base on the right side, spreading. *Stamens* with apex 0.7–1 mm below the mouth of the corolla tube, inserted 0.47–0.57 of the length of the corolla tube (at 1.5–1.8 mm from the base); filaments short, 0.2–0.3 mm long, filiform; anthers ovate, 0.7–1 × 0.25–0.35 mm, apex obtuse or acute. *Pistil* 1.4–2 mm long; ovary ovoid, 0.5–0.7(–0.9) × 0.5–0.7(–0.8) mm, glabrous, usually slightly laterally compressed, composed of 2 carpels, a disk-like thickening at the base c. 0.1 mm high; style 0.5–1 mm long, filiform; pistil head 0.3–0.5 mm high, without or with minute hairs at the apex, composed of a basal ring c. 0.1 × 0.3–0.4 mm, a conical central part 0.1–0.3 × c. 0.2 mm, and a cleft stigmoid apical part c. 0.1 mm high. *Fruit* a pair of follicles, 12–43 cm long, (2.7–)3–4 mm in diameter, glabrous, striate. *Seeds* 9.5–14 mm long, main part elliptic 3.5–5 × 1.7–2.3 mm, one end long-caudate up to 5 mm and mostly irregularly dentate at the margin, the other end usually bifid or sometimes unequally lobed, densely pubescent on both sides, cilia up to 1.5–2 mm long, reduced and becoming shorter towards the middle of the margin, hilum circular, c. 0.15 mm in diameter, or elliptic, c. 0.2 × 0.1 mm.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Riverside forests, on plane with alluvial or steep slopes with serpentinic soils. Altitude 5–360(–500) m.

Notes — Two species, *Alstonia balansae* Guillaumin and *A. undulata* Guillaumin are combined here. The latter species was distinguished solely by its broad leaves which are truncate at the base. The leaves of *A. balansae* are elliptic and acute at the base. Within the specimens studied the characters used to distinguish these two species showed a continuous variation and, therefore, are unreliable. The flower characters are similar in all specimens. Because of this intergradation and the lack of any

other distinguishing features, *A. undulata* is not maintained. Some intermediate specimens are *Däniker 412, 1501, Guillaumin & Baumann-Bodenheim 12244, Jaffré 332, MacKee 17146, 23818, 25310, McPherson 3583, Sevenet & Boiteau 1089, Thorne 28405.*

From the sterile specimens, especially when they have small leaves, *A. balansae* can be confused with *A. sphaerocapitata* Boiteau, but the latter species has brown to dark brown branchlets and leaves, and the leaf apex is usually acute or obtuse.

Specimens studied: New Caledonia: 45 specimens.

6. Alstonia beatricis Sidiyasa — Fig. 5.8 & 5.9

Alstonia beatricis Sidiyasa, Blumea 41 (1996) 30. — Type: *van Royen 5535* (holo L; iso A, BO, K, WAG), Indonesia, Irian Jaya, Waigeo Island, path from Poean to Tofak Bay, 16 Feb. 1955, fl.

Small tree, 5 m high; trunk 3 cm in diameter. *Branches* smooth or slightly rough from the leaf-scars, blackish, without lenticels; branchlets terete, triangular or slightly sulcate when dried, glabrous, pale brown. *Leaves* in whorls of 3, petiolate; petiole glabrous, 10–20 × 1–2 mm, flattened or shallowly canaliculate above, colleters minute or linear and densely packed together in the axils, without intrapetiolar stipules; blade grey or grey-green above, brown or reddish brown beneath and coriaceous when dried, narrowly obovate (sometimes elliptic), 6.2–16 × 1.5–5.2 cm, index (2.6–)3.1–4.1, apex shortly acuminate, acumen up to 10 mm long with a blunt point, base acute to decurrent onto the petiole, entire, glabrous on both sides; midrib impressed above; secondary veins in 12–16 pairs (short interstitial veins present), parallel and slightly arched, forming an angle of 70–80° with the midrib, 3–12 mm from each other, joining near the margin and forming a thin submarginal vein; tertiary venation reticulate, usually inconspicuous on both sides. *Inflorescence* 3–6.5 cm long, many-flowered; peduncle 1.4–4.3 cm long, 0.7–1.5 mm in diameter, puberulous as on branches; pedicels 1–2 × 0.5–0.7 mm, softly pubescent (with very short glaucous hairs). *Bracts* and *bracteoles* sepal- or scale-like, ovate to broadly ovate or triangular, 0.4–0.9 mm long, obtuse or acute, ciliate, softly pubescent outside, glabrous inside. *Flowers: Sepals* connate at the base for 0.75 mm, turbinate, c. 1.7 × 1 mm, index c. 1.7, apex rounded, ciliate, softly pubescent except at the fused part inside, erect, glaucous when dried. *Corolla* white, c. 3 × 1 mm in the mature bud and forming an ovoid head c. 0.5 of the bud length (c. 1.5 × 1 mm), with a blunt apex, partly puberulous on the tube and on the lobe margins outside, blackish when dried, two hairy belts inside, the first belt sparsely pubescent starting from c. 0.8 mm above the base to the insertion of the stamens (c. 0.5 mm wide), the second belt pilose with white hairs on the basal half of the corolla lobes (around the stamens glabrous); tube almost cylindrical or slightly widening around the stamens, c. 2 mm long, c. 1.2 mm wide (at the base 0.9 mm wide), c. 1.2 × as long as the sepals, c. 1 × as long as the lobes; lobes ovate, c. 2 × 1.1–1.2 mm, index 1.6–1.8, ciliate, apex rounded, auriculate at the base on the right side. *Stamens* with apex 0–0.2 mm below the mouth of the corolla tube, inserted at c. 0.65 of the length of the corolla tube (at c. 1.3 mm from the base); filaments c. 0.4 mm long;

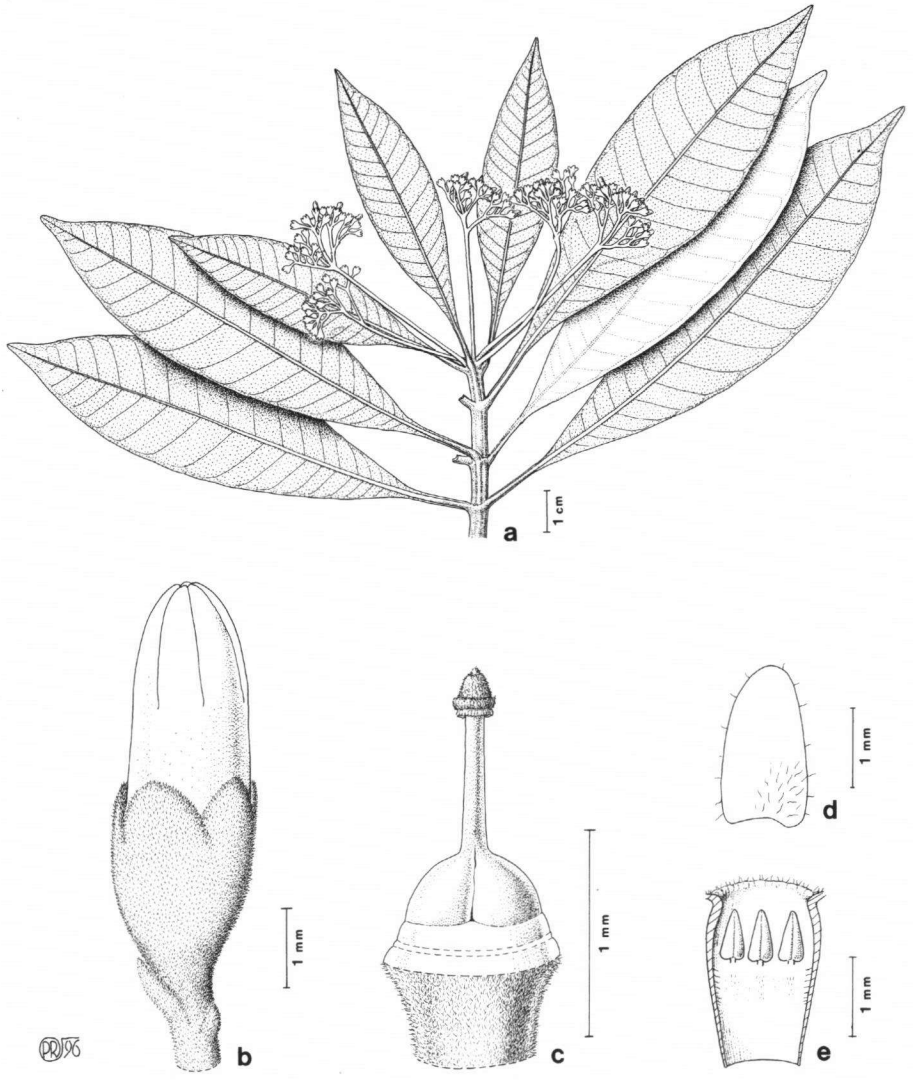


Fig. 5.8. *Alstonia beatricis* Sidiyasa – a: Habit; b: flower in bud; c: pistil surrounded by annular disk-like thickening (corolla and calyx removed); d: corolla lobe from inside; e: corolla tube, dissected slightly stretched to show 3 anthers inserted in the glabrous zone (a–e: *van Royen 5535*).

anthers ovate, c. 0.7 × 0.3 mm, apex acute. *Pistil* glabrous, 0.9 × as long as the longest sepals, 1.5 mm long; ovary broadly ovoid, 0.4 × 0.6 mm, composed of 2 carpels, with an annular disk-like thickening at the base 0.15 mm high; style 0.7 mm long; pistil head ovoid, 0.4 × 0.25 mm, composed of a thin basal ring 0.15 mm high, a conical central part, 0.2 × 0.2 mm, and a minute cleft stigmoid apical part c. 0.05 mm high. *Fruits* unknown.

Distribution — So far only known from the type specimen, reported (on label) as a common small tree species.

Habitat & Ecology — Low vegetation (open woodland) dominated by *Decaspermum*. Altitude 70 m.

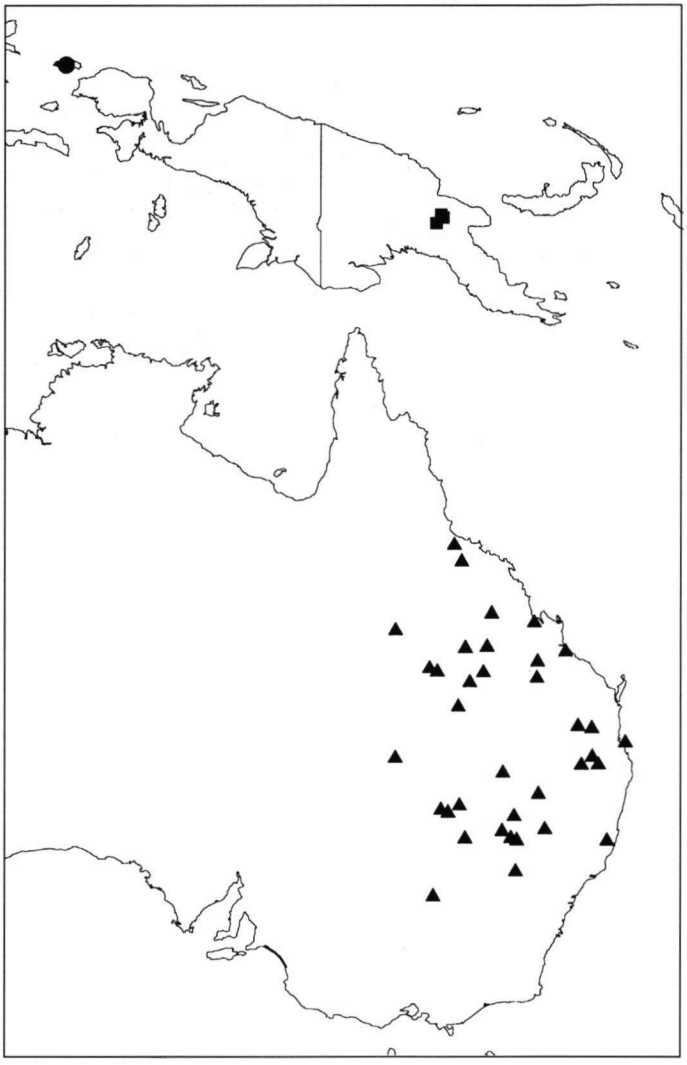


Fig. 5.9. Distribution of *Alstonia beatricis* Sidiyasa (●), *A. breviloba* Sidiyasa (■), and *A. constricta* F. Muell. (▲).

7. Alstonia boonei De Wild. — Fig. 5.10 & 5.11

Alstonia boonei De Wild., Feddes Repert. 13 (1914) 382; Monachino, Pacific Sci. 3 (1949) 150; De Jong, Meded. Landbouwhogeschool 79-13 (1979) 5. — Type: *Boone 2* (holo BR, photo HBG), Congo (Kinshasa), Nala, Uele, Jan. 1911, fl.

Big tree, up to 40 m high; trunk 50–100 cm in diameter, fluted at the base or forming tall and steep buttresses up to 4 m high. *Bark* smooth or rough, very often with large lenticels, greyish or pale brown; inner bark cream or pale yellow, with copious white

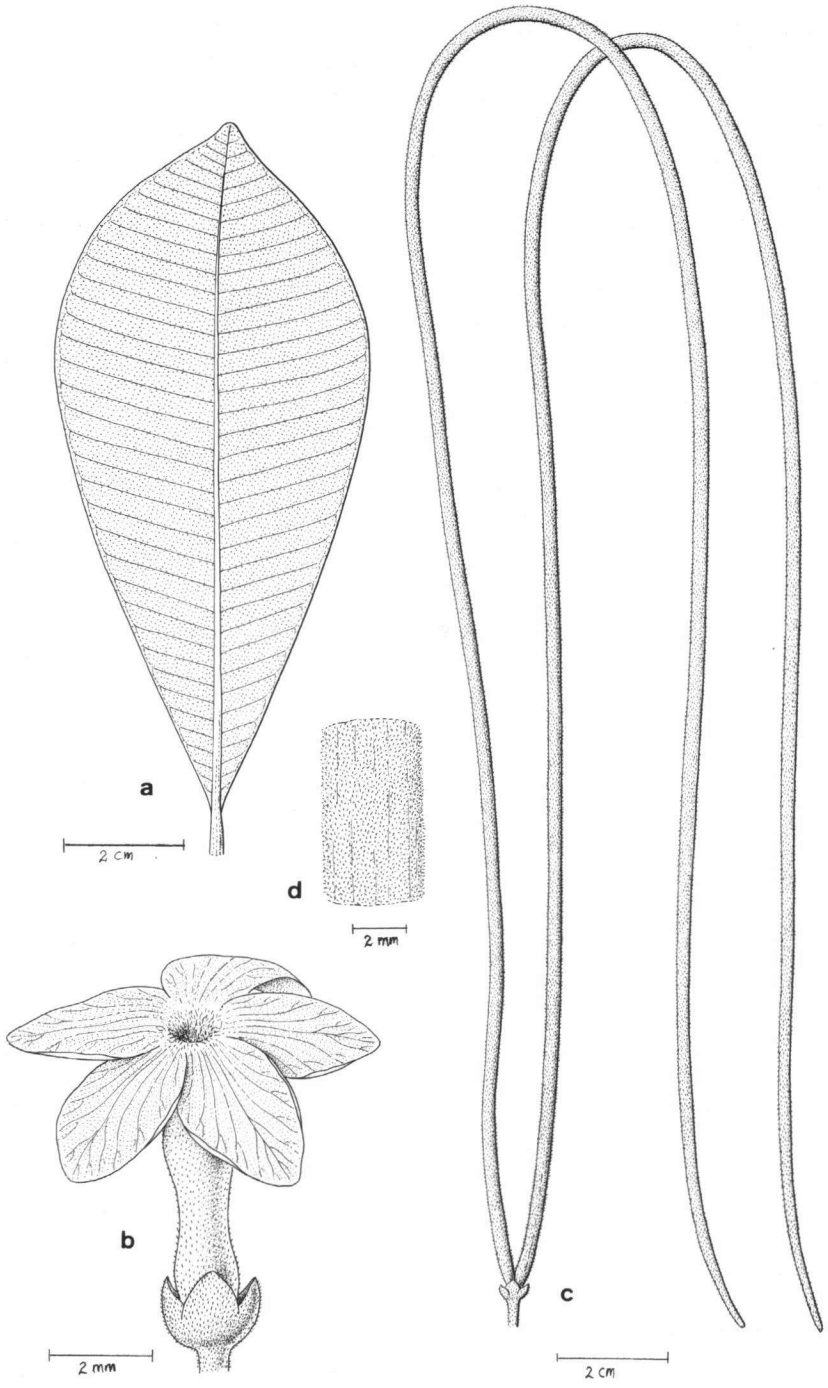


Fig. 5.10. *Alstonia boonei* De Wild. – a: Leaf; b: open flower; c: follicles; d: surface of follicle in detail (a–d: *Chevalier 2690*).

latex. *Branches* smooth, sparsely lenticellate, grey or dark brown; branchlets terete or slightly sulcate when dried, very often lenticellate, glabrous, dark brown or blackish. *Leaves* in whorls of 4–8, petiolate; petiole glabrous, (5–)10–22 × 1.5–3 mm, flattened and longitudinally canaliculate above, more or less winged, colleters narrowly triangular, densely packed in the axils (usually sticking together by resin); blade glossy and dark green above, pale or grey-green beneath, coriaceous when dried, obovate or narrowly obovate, 6–20(–25) × 2.5–7.5 cm, index 1.5–3.3(–4.3), apex obtuse or rounded, sometimes retuse or shortly acuminate, acumen c. 5 mm long with a blunt point, base obtuse to decurrent onto the petiole, entire, glabrous on both sides; midrib impressed above; secondary veins in 22–50 pairs, rather straight, or slightly arched near the apex, sometimes bifid, forming an angle of 80–90° with the midrib, 2–7 mm from each other, joining near the margin and forming a submarginal vein; tertiary venation reticulate, admedial ramified, more or less conspicuous above. *Inflorescence* 7–22 cm long, many-flowered; peduncle 2–6(–13) cm long, puberulous, stout; pedicel 2–5(–7) × 0.4–0.7 mm, pubescent. *Bracts* and *bracteoles* scale- or sepal-like, ovate or triangular, up to 2.5 mm long (mostly shorter), acute or obtuse, ciliate, glabrescent or puberulous outside, pubescent inside, sometimes with some colleters in the axils. *Flowers* fragrant. *Sepals* connate at the base for 0.4–0.6 mm, ovate, 1.5–2.2(–2.6) × 1–2(–2.8) mm, index 0.8–1.6, obtuse or rounded, sometimes turbinate or mucronulate, pubescent on both sides except on the fused part inside, ciliate, erect or slightly spreading when dried. *Corolla* cream or pale yellow, 6.5–13(–15) mm long in the mature bud and forming an ovoid head (0.16–)0.2–0.33 of the bud length, 1.5–3(–4) × 1.5–2.3 mm, with a blunt apex; pubescent outside except at the base within the calyx, hairy inside except at the base (in a belt (1.5–)2.5–4.5 mm wide) and at the throat (in a belt (0.3–)0.5–1 mm wide) which are glabrous, around the stamens usually very sparsely hairy, and with a very densely pilose belt (moustache-like) surrounding the mouth; tube 5–11 mm long, (1–)1.5–2 mm wide at the base, mostly narrowing above (around the middle) and 1–1.5 mm wide, then widening around the stamens, 1.7–2.5 mm wide, (2.3–)4.5–6.1 × as long as the sepals, 1–2.8 × as long as the lobes; lobes oblique, (2.5–)4–6 × (2–)3.5–5 mm, index 1–1.4, apex rounded, clawed at the base or more or less broadly auriculate on the left side, spreading. *Stamens* with apex 0–0.6 mm below the mouth of the corolla tube, inserted at (0.64–)0.7–0.9 of the length of the corolla tube (at (3.2–)6–9.5 mm from the base); filaments short, 0.4–0.9 mm long, filiform, glabrous; anthers ovate, 1–1.6 × 0.5–0.7 mm, obtuse. *Pistil* (4.5–)6.7–10.7 mm long; ovary ovoid, 1.3–2.4 × 0.9–1.6 mm, densely pubescent except at the base where there is a glabrous disk-like thickening, composed of 2 carpels (appear as united); style (1.3–)4.3–7.5 mm long, filiform, mostly slightly laterally compressed and longitudinally canaliculate, glabrous; pistil head 1–1.5 mm high, glabrous, composed of a membranous basal ring 0.2–0.4 × 0.5–0.8 mm, a cylindrical central part 0.2–0.4 × 0.3–0.6 mm, and a robust elongate cleft stigmoid apical part 0.6–1 × 0.2–0.35 mm. *Fruit* a pair of follicles, 30–52 cm long, 2–3 mm in diameter, soft and densely pubescent. *Seeds* oblong, 4.5–6 × 1.5–1.8 mm, ends rounded, glabrous and with a minute reticulate structure and ridged on both surfaces, slightly thickened at the margin, coma up to 12–20 mm long, hilum linear 1–2 mm long.

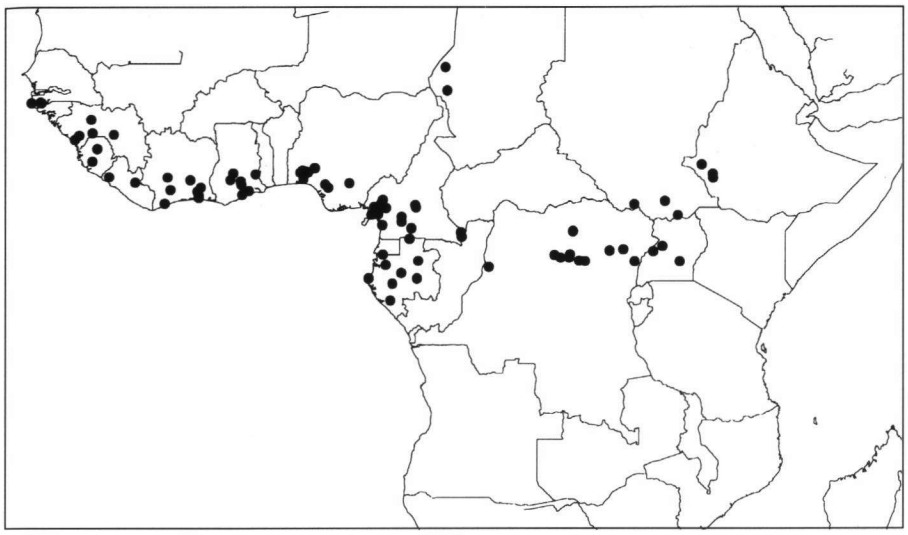


Fig. 5.11. Distribution of *Alstonia boonei* De Wild.

Distribution — Very common, from Senegal to Ethiopia. Planted in the Bogor Botanical Garden (Indonesia).

Habitat & Ecology — Secondary and primary forests. Altitude (50–)100–1200 m. De Jong (1979), from his personal communication with Hall and Leeuwenberg, mentioned that the species also grows in swamps. This information is not available from the herbarium specimens.

Vernacular names — Cameroon: *Ekouk* (Bobili and Yaounde); Central Africa: *guka* (Bambidjere); Congo (Kinshasa): *babua* (Guga), *(b)okuka* (Turumbu), *ekima* (Epulu).

Uses — The bark is used against stomach-ache (*Harris & Fay 1522*).

Specimens studied: Senegal: 9 specimens. – Gambia: 1 (*Dawe 37*). – Guinea Bissau: 3. – Guinée: 4. – Sierra Leone: 7. – Liberia: 3. – Ivory Coast: 21. – Ghana: 16. – Nigeria: 25. – Cameroon: 24. – Equatorial Guinea: 3. – Gabon: 12. – Congo (Brazzaville): 3. – Central Africa: 11. – Congo (Kinshasa): 31. – Angola: 2. – Sudan: 4. – Uganda: 12. – Ethiopia: 5.

8. Alstonia boulindaensis Boiteau

Alstonia boulindaensis Boiteau, Adansonia sér. 2, 16 (1977) 474; Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 189. — Type: *Balansa 1417* (holo P), New Caledonia, Bourail, 'forêts au-dessus de Daoui de Ero', Apr. 1869, fl. & fr.

Shrub or small tree, 2–7 m high. *Branches* smooth, without lenticels; branchlets terete, mostly slightly quadrangular when dried, glabrous, yellowish to dark brown or blackish. *Leaves* opposite, petiolate; petiole glabrous, slender, 10–30 × 0.8–1.5 mm, canaliculate above, with a distinct ocrea and forming an intrapetiolar stipule at the base, slightly widening and more or less clasping the branchlet, few to many minute colleters densely packed together in the axils; blade yellowish to dark brown above,

slightly glaucous beneath and coriaceous when dried, elliptic or narrowly elliptic, sometimes slightly narrowly ovate or narrowly obovate, 4.5–13 × 1.3–3.6 cm, index 2.7–4.6, glabrous on both sides, apex narrowly acuminate with a blunt point, base acute to decurrent onto the petiole, margin entire, slightly undulate and/or sinuate; midrib impressed above; secondary veins parallel or sometimes not, rather straight, in 10–16 pairs and forming an angle of 60–80° with the midrib, 2–8.5 mm from each other, an inconspicuous submarginal vein present; tertiary venation reticulate, inconspicuous. *Inflorescence* 2.5–6.5 cm long, many-flowered; peduncle 0.5–4 cm long, slender, 0.7–1 mm wide, glabrous as on the branches; pedicel slender, 3–7 × 0.3–0.4 mm, mostly slightly laterally compressed, glabrous, sometimes with 1 (or 2) bracteoles around the middle. *Bracts* and *bracteoles* scale- or sepal-like, ovate to broadly ovate, 0.2–0.8 mm high, more or less clasping the inflorescence branch or branchlet, glabrous, almost translucent except at the base, obtuse or rounded, sometimes acute, not ciliate. *Flowers: Sepals* connate at the base for c. 0.1 mm, ovate or broadly ovate, 0.7–1 × 0.6–1 mm, index 0.8–1.5, erect, glabrous on both sides, obtuse or rounded, with an almost translucent margin, not ciliate, mostly two of them larger than the other three. *Corolla* pinkish, 3–5(–5.5) mm long in the mature bud and forming an ovoid head 0.36–0.45 of the bud length, 1.4–2.3 × 0.8–1 mm when dried, with a blunt apex, glabrous outside, with two hairy belts inside, the first belt shortly pubescent from c. 0.6 mm above the base to the insertion of the stamens (c. 0.4 mm wide; around the stamens glabrous or very sparsely hairy), the second belt sparsely pilose and covering somewhat more than the basal half of the corolla lobes except around the margin; tube almost cylindrical or slightly widening around the stamens, 2.5–2.7 mm long, c. 1 mm wide, 2.7–3.4 × as long as the sepals, 1.1–1.35 × as long as lobes; lobes ovate, 2–2.5 × 1–1.2 mm, index 1.7–2.5, not ciliate, auriculate at the base on the right side, spreading. *Stamens* with apex 0.8–1 mm below the mouth of the corolla tube, inserted at 0.37–0.4 of the length of the corolla tube (at c. 1 mm from the base); filaments short, 0.2–0.3 mm long, filiform; anthers ovate, 0.7–0.8 × 0.25–0.3 mm, apex obtuse. *Pistil* c. 1.3 × as long as the longest sepals, 1.1–1.3 mm long; ovary ovoid, 0.5–0.7 × 0.5–0.7 mm, glabrous, composed of 2 carpels, without or with an obscure disk-like thickening at the base; style 0.1–0.2 mm long; pistil head ovoid or pagoda-shaped, c. 0.4 mm high, minutely hairy at the apex, composed of a basal ring c. 0.15 × 0.3–0.4 mm, a cylindrical or slightly conical central part 0.1–0.2 × c. 0.2 mm, and a cleft stigmoid apical part c. 0.1 mm long. *Fruit* a pair of follicles, 5–10.5 cm long, 3–3.5 mm in diameter, glabrous, striate, with a narrow pointed apex, spreading or reflexed. *Seeds* 4.8–5 × 2–2.5 mm (main part elliptic, 3–4 × 2–2.3 mm), one end obtuse, sometimes oblique, other end elongate with a tail up to 2 mm long, usually bifid or sometimes unequally lobed at the apex, pubescent or glabrescent on both surfaces, cilia up to 0.5–0.8 mm long and gradually becoming shorter towards the middle (side) of the margin, hilum more or less circular, c. 0.2 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Alluvial serpentinic soils. Altitude 300–850 m.

Specimens studied: New Caledonia: Bourail: *Balansa 1417* (type); Mt. Boulinda: *Sevenet 207* (P) and *979* (P).

9. Alstonia breviloba Sidiyasa, *spec. nov.* — Fig. 5.9 & 5.12

Arbor grandis ramulis glabris. Folia ternata petiolata crasse coriacea obovata apice breviter acuminata vel interdum rotundata basi plerumque cuneata integra supra glabra subtus sparse pilosa. Inflorescentia cymosa. Sepala subaequalia basi connata ovata apice obtusa vel rotundata ciliata extus glabra vel basi minute pilosa intus glabra. Corolla alba extus pro parte pilosa tubo lobis ovatis multo longiore. Stamina paulo inclusa filamentis potius robustis antherisque ovalis apice obtusis basi cordatis. Pistillum glabrum ovario ovoideo. Fructus folliculis duabis separatis longis glabris. Semina elliptica utroque latere pubescentia. — Typus: *Hartley TGH 11952* (holo L; iso A, ECON, K), Papua New Guinea, Eastern Highlands District, 3 km north of Omaura, 3 July 1963, fl.

Tree, 17–28 m high; trunk 30–60 cm in diameter, without buttresses. *Bark* scaly or both shallowly longitudinally and horizontally fissured (sometimes corky areas present), grey; inner bark cream, straw, or pink-brown with scattered dark fibres, paler towards the cambium, without white latex; softwood straw. *Branches* smooth or minutely lenticellate, dark brown or blackish; branchlets glabrous, smooth or slightly rough through the leaf-scars, triangular or slightly sulcate when dried, dark red-brown or blackish. *Leaves* in whorls of 3, petiolate; petiole glabrous, 10–15 × 1.5–2 mm, canaliculate or impressed above, with many minute colleters densely packed together in the axils, without intrapetiolar stipules; blade dark green above, light green beneath, or yellowish brown (usually paler beneath) and thickly coriaceous when dried, obovate, 6.5–14 × (2.7–)3.2–7.5 cm, index 1.8–2.8, apex abruptly shortly acuminate (sometimes rounded), acumen up to 12 mm long with a blunt point, base acute, sometimes obtuse, or decurrent onto the petiole, entire, glabrous above, sparsely hairy beneath (at least on the midrib); midrib impressed above; secondary veins in 10–16 pairs (short interstitial veins sometimes present), parallel and slightly arching, forming an angle of 70–80° with the midrib, 5–12 mm from each other, hardly prominent beneath, submarginal vein inconspicuous; tertiary venation reticulate, mostly conspicuous on both sides. *Inflorescence* 4–5 cm long, many-flowered; peduncle 2–3 cm long, stout, 1.2–1.8 mm in diameter, puberulous or glabrescent, first branches puberulous or softly pubescent; pedicels stout 1–3 × 0.6–0.8 mm, puberulous or pubescent. *Bracts* and *bracteoles* sepal- or scale-like, ovate to narrowly ovate, triangular, or sometimes irregularly shaped, 0.6–2 mm long, obtuse, acute, acuminate, or irregularly lobed at the apex, ciliate, puberulous outside, glabrous inside. *Flowers: Sepals* connate at the base for c. 0.9 mm, ovate, 2.2–2.6 × 1.2–2 mm, index 1.2–1.9, apex obtuse or rounded, ciliate, glabrous or minutely hairy at the base outside, glabrous inside, erect. *Corolla* white, 7–8 × 1.7–2 mm in the mature bud and forming an ovoid head 0.2–0.3 of the bud length, 1.5–2 × 1.5–2 mm, with a blunt apex, glabrous or minutely hairy around the stamens outside, two hairy belts inside, the first belt pubescent starting from c. 2 mm above the base and ending at the insertion of the stamens (1.2–1.8 mm wide), the second belt pilose on the basal half of the corolla lobes (around anthers very sparsely hairy); tube almost cylindrical or slightly widening around the stamens, c. 6 mm long, c. 2 mm wide, 2.3–2.6 × as long as the sepals, 2–3 × as long as the lobes; lobes ovate, 2–3 × 2–2.3 mm, index 1–1.3, not ciliate, apex rounded, auriculate at the base on the right side. *Stamens* with apex 0.5–0.6 mm below the mouth of the corolla tube, inserted at 0.52–0.63 of the length of the corolla

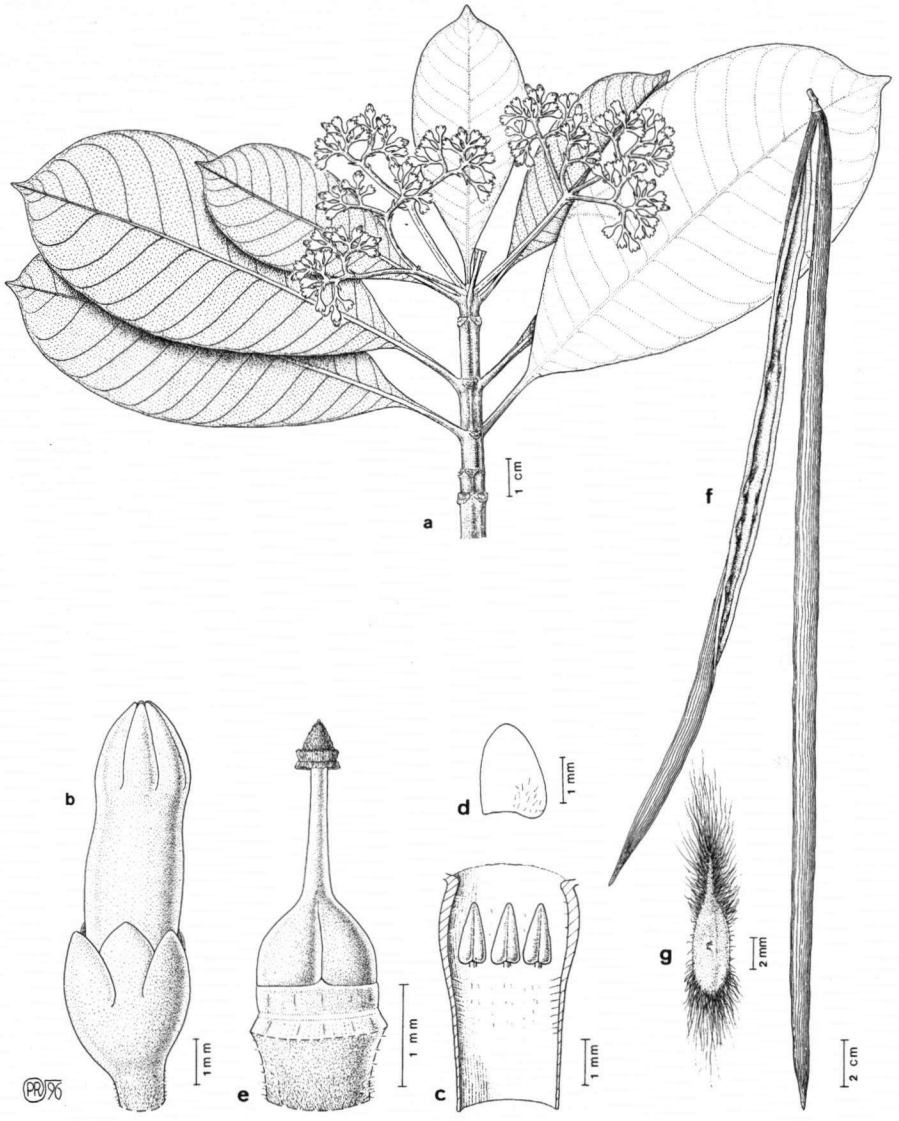


Fig. 5.12. *Alstonia breviloba* Sidiyasa – a: Habit; b: flower in bud; c: dissected corolla tube, showing 3 anthers; d: corolla lobe; e: pistil, showing an annular disk-like thickening at the base; f: follicles; g: seed (a–e: *Hartley TGH 11952*; f, g: *Coode & Lelean NGF 29940*).

tube (at 3.1–3.8 mm from the base); filaments rather stout, 0.7–0.8 × c. 0.15 mm; anthers ovate, 1.1–1.3 × 0.4–0.6 mm, apex obtuse. *Pistil* glabrous, 1.5–1.6 × as long as the longest sepals, 4–4.1 mm long; ovary ovoid, c. 1.2 × 1.2 mm, composed of 2 carpels, with an annular disk-like thickening at the base c. 0.4 mm high; style 1.9–2.1 mm long, filiform, canaliculate on both sides, slightly laterally compressed; pistil

head ovoid, 0.8–1 mm long, composed of a partly transparent basal ring c. 0.2 mm high, a conical or cylindrical central part, 0.4–0.6 × 0.3–0.4 mm, and a cleft stigmoid apical part up to 0.35 mm high. *Fruit* a pair of follicles, 20–45 cm long, 4–5 mm in diameter, glabrous, roughly striate. *Seeds* dark brown, elliptic, 7–9 × 3–3.3 mm, pubescent on both sides, one end acuminate with an acumen 1–2.6 mm long, the other end rounded (sometimes obtuse); coma 5–7 mm long, becoming gradually shorter towards the side margins; hilum (on ridge) circular, c. 0.15 mm diameter, or elliptic, c. 0.25 × 0.1 mm.

Distribution — Endemic to Papua New Guinea.

Habitat & Ecology — Primary and secondary forests, in the broad-leaved *Araucaria* community. Altitude 1400–1800 m.

Note — *Alstonia breviloba* Sidiyasa is closely related to *A. macrophylla* Wall. ex G. Don; in both species the sepals and the outside of the corolla are glabrous or very sparsely and minutely hairy. The present species differs mainly in having thickly coriaceous leaves, shorter corolla lobes (2–3 mm versus 3.6–7 mm), a wider diameter of the corolla tube (c. 2 mm versus 1–1.8 mm wide), differently shaped corolla lobes (index 1–1.3 versus 2.2–5), and wider seeds (3–3.3 mm versus 1.6–2.5 mm wide).

Specimens studied: Papua New Guinea. Eastern Highlands District: *Hartley TGH 11952* (type); Okapa Subdistrict, near Okasa, alt. 1400 m, *Coode & Lelean NGF 29940* (A, L); Okapa road about 15 miles SW of Kainantu, alt. 1800 m, *Hartley TGH 12954* (A).

10. Alstonia congensis Engl. — Fig. 5.13

Alstonia congensis Engl., Bot. Jahrb. Syst. 8 (1886) 64; Monachino, Pacific Sci. 3 (1949) 151; De Jong, Meded. Landbouwhogeschool 79-13 (1979) 9. — Type: *Naumann s.n.* (holo B †; lecto K (De Jong, 1979); photo C, HBG, M (taken from the K sheet)), Congo (Kinshasa), Boma District, Ponta da Lenha, 4 Sept. 1874, vegetative.

Alstonia gilletii De Wild., Miss. E. Laurent 1 (1907) 537; Bull. Jard. Bot. Etat. Brux. 5 (1919) 406. — Type: *Gillet 3532* (holo BR; photo HBG), Congo (Kinshasa), Kisantu, fl.

Alstonia gilletii var. *laurentii* De Wild., Miss. E. Laurent 1 (1907) 537. — Type: *Laurent s.n.* (holo BR; photo HBG), Congo (Kinshasa), Bolombo, 3 Jan. 1904, vegetative.

Alstonia congensis var. *glabrata* Hutch. & Dalziel, Fl. W. Trop. Africa 2 (1931) 42. — Type: *Dalziel 1256* (holo K; iso C, HBG photo), Nigeria, 3 Oct. 1917, fl.

Small to medium-sized tree, 6–15 m high; trunk 10–30 cm in diameter, fluted at the base. *Bark* smooth or longitudinally and transversally fissured, pale brown or grey-brown; inner bark cream or pale yellow, with copious white latex. *Branches* shallowly longitudinally fissured and sparsely lenticellate, grey to dark brown; branchlets terete or sulcate when dried, very often with sparse lenticels, glabrous, dark-brown or blackish. *Leaves* in whorls of 4–6, sessile or shortly petiolate; petiole glabrous, 0–7 mm long, flattened and longitudinally canaliculate above, up to 4 mm wide, more or less winged, some narrowly triangular colleters usually sticking together by resin in the axils; blade glossy and dark green above, dull glaucous and with pale green midrib beneath, coriaceous when dried, obovate or spathulate, 8–26 × 3.3–11.5 cm, index 1.5–2.7, apex rounded, sometimes retuse or shortly acuminate, acumen up to 7 mm long with a blunt point, base acute or decurrent onto the petiole, entire, glabrous on

both sides; midrib impressed above; secondary veins in 35–60 pairs, rather straight, parallel and forming an angle of 80–90° with the midrib, 1.5–5 mm from each other, joining near the margin and forming a submarginal vein; tertiary venation reticulate, sometimes admedial ramified, mostly conspicuous above. *Inflorescence* 10–22(–25) cm long, many-flowered; peduncle (1–)3.5–12 cm long, glabrous; pedicel (2–)3–5 (–8) × 0.3–0.5 mm, puberulous or glabrescent. *Bracts* and *bracteoles* scale- or sepal-like, ovate to broadly ovate or triangular, up to 2.2 mm long (mostly shorter), acute or obtuse, glabrous on both sides, minutely ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.3–0.4 mm, ovate, 1.9–2.5 × 1–2 mm, index 1.3–2.2, obtuse, rarely rounded, glabrous on both sides, less often laxly puberulous outside, ciliate, erect or slightly spreading when dried. *Corolla* white, 7–11.5 mm long in the mature bud and forming an ovoid head 0.39–0.43 of the bud length, 3.5–5 × 1.8–2.5 mm, with a blunt apex; pubescent outside except at the base within the calyx, hairy inside except at the base (in a belt 1.2–2.5 mm wide) and at the throat (in a belt 0.3–0.7 mm wide) which are glabrous, densely pilose at the base of the corolla lobes and moustache-like surrounding the mouth; tube 5–7 mm long, 1–1.5 mm wide at the base, widening around the stamens and 1.6–2.1 mm wide, 2–3.4 × as long as the sepals, 0.7–1.3 × as long as the lobes; lobes oblique, 5–7 × 3–4.3 mm, index 1.5–2.3, apex rounded, clawed at the base, not ciliate, spreading. *Stamens* with apex 0.1–0.7 mm below the mouth of the corolla tube, inserted at 0.66–0.75 of the length of the corolla tube (at 3.5–5 mm from the base); filaments short, 0.4–0.6 mm long, filiform, glabrous; anthers ovate or narrowly ovate, 1–1.4 × 0.3–0.5 mm, apex rounded or obtuse. *Pistil* 4–6.2 mm long; ovary ovoid, (0.8–)1–1.5 × 0.7–1.2 mm, glabrous or sometimes sparsely hairy, without or with a disk-like thickening at the base (usually darker), composed of 2 carpels; style 2.1–3.6 mm long, filiform, mostly slightly laterally compressed and longitudinally canaliculate, glabrous; pistil head 1–1.4 mm high, glabrous, composed of a

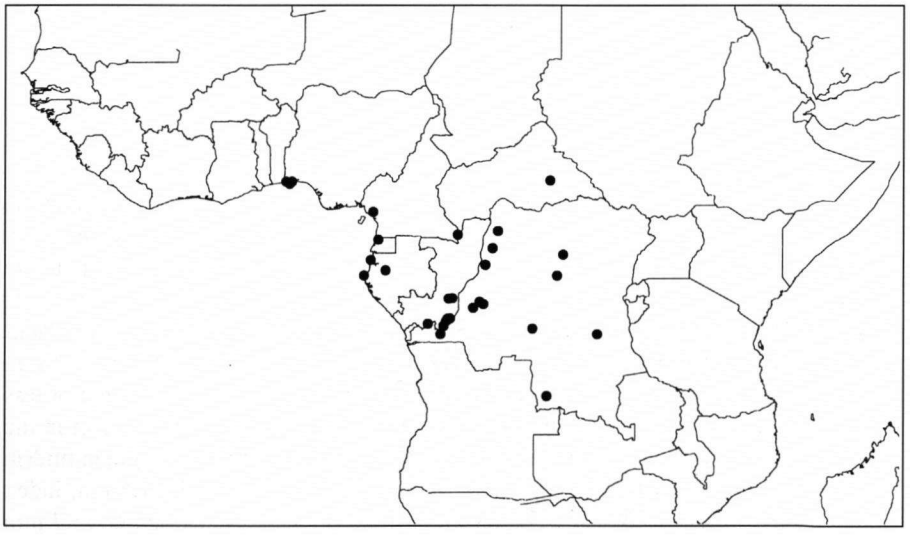


Fig. 5.13. Distribution of *Alstonia congensis* Engl.

membranous basal ring c. 0.2 × 0.3–0.6 mm, a cylindrical central part 0.15–0.3 × 0.3–0.4 mm, and a robust elongate cleft stigmoid apical part 0.6–1 × 0.15–0.25 mm. *Fruit* a pair of follicles, 30–45 cm long, 2.5–3 mm in diameter, glabrous, minutely striate. *Seeds* oblong, 7–9 × 1.8–2.5 mm, ends rounded, glabrous and with a minute reticulate structure and ridged on both surfaces, slightly thickened at the margin, coma up to 11–18 mm long, hilum linear, 1–2 mm long.

Distribution — Nigeria, Cameroon, Central Africa, Equatorial Guinea, Gabon, Congo (Brazzaville), and Congo (Kinshasa).

Habitat & Ecology — Secondary and primary forests, swampy areas or in dry habitats. Altitude 10–470 m.

Vernacular names — Nigeria: *awun* (Yoruba); Congo (Kinshasa): *dioko dioko* (Kindibu), *okuka bo lowe* (Turumbu).

Specimens studied: Nigeria: 9 specimens. – Cameroon: 1 (*Leeuwenberg 10573*). – Central Africa: 7. – Equatorial Guinea: 2. – Gabon: 4. – Congo (Brazzaville): 7. – Congo (Kinshasa): 37.

11. Alstonia constricta F. Muell. — Fig. 5.9

Alstonia constricta F. Muell., Fragm. 1 (1858) 57; Bentham, Fl. Australiensis 4 (1869) 314; Monachino, Pacific Sci. 3 (1949) 168; P.I. Forster, Austral. Syst. Bot. 5 (1992) 746; Fl. Australia 28 (1996) 118. — Type: *T.L. Mitchell 261* (lecto K, designated by Monachino, 1949), Queensland, Mt. Pluto, 30 Sept. 1846, fl.

Alstonia mollis Benth., Fl. Australiensis 4 (1869) 315. — *Alstonia constricta* var. *mollis* F.M. Bailey, Synopsis Queensland (1883) 308. — Type: *T.L. Mitchell 368* (lecto K, designated by Monachino, 1949), Queensland, Barcoo River, near Mt. Northampton, fl.

Alstonia constricta var. *montmariensis* F.M. Bailey, Queensland Agric. J. 26 (1911) 198, t. 19, f. 3. — Type: *F.M. Bailey s.n.* (lecto [AQ332792] BRI, designated here; isolecto K), Queensland, Warrego District, Mt. Maria, 1876, fl.

Shrub or small tree, 3–17 m high; trunk 3–35 cm in diameter. *Bark* corky or deeply longitudinally fissured, pale grey; inner bark brown outwards, yellowish inwards, without white latex. *Branches* smooth or rather rough, not lenticellate; branchlets terete or slightly laterally compressed, glabrous or pubescent, grey-green, yellowish brown, sometimes blackish. *Leaves* opposite, petiolate; petiole slender, 10–35 × 0.5–1 mm, shallowly canaliculate above, glabrous or pubescent, many minute or linear colleters densely packed together in the axils, without ocrea; blade dark green above, paler below, grey-green or yellowish brown and subcoriaceous or coriaceous when dried, narrowly ovate or narrowly elliptic, 4.5–14 × 0.8–2.3(–4) cm, index (2.7–)3.5–8.2, glabrous or velutinous, apex acute, obtuse, or narrowly acute with a pointed apex, base rounded, acute or decurrent onto the petiole, sometimes oblique, entire or very often with an undulate margin; midrib impressed above; secondary veins in 10–30 pairs, mostly inconspicuous, very often not parallel and forming an angle of (30–)40–60(–70)° with the midrib, 2–10 mm from each other; tertiary venation reticulate, mostly inconspicuous. *Inflorescence* 3–5 × 3–7(–10) cm, compound, terminal, many-flowered; peduncle 1–2.5 cm long, glabrous or pubescent as on the branches; pedicels slender, 1–3(–4) mm long, glabrous or puberulous. *Bracts* and *bracteoles* scale- or sepal-like, ovate or broadly triangular, up to 1 mm long, almost translucent around

the margin, ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.1–0.3(–0.4) mm, erect, ovate, 1–1.5 × 0.8–1.2 mm, index 1–1.5, glabrous on both sides, apex obtuse, almost translucent around the apex and margin, ciliate. *Corolla* white, cream or yellow, 5.5–11 mm long in the mature bud and forming an ovoid or a narrowly ovoid head 0.5–0.7 of the bud length, 2.6–7.5 × 1–1.5 mm, with a blunt apex, glabrous outside, sometimes ciliate around the lobes, with two pubescent belts inside, the first belt starting at 0.7–1 mm above the base to the insertion of the stamens (0.8–1 mm wide), the second belt on the basal half of the corolla lobes (sometimes continuous and reduced gradually towards the apex); tube almost cylindrical, 2.8–3.5 mm long, 1.2–1.7(–2) mm wide, 2.7–3.1 × as long as the sepals, 0.3–0.7 × as long as the lobes; lobes oblong or narrowly ovate, 4.4–9(–12.5) × 1.3–2 mm, index 3.1–4.5(–8.9), auriculate at the base on the right side, spreading. *Stamens* with apex 0.3–0.6 mm below the mouth of the corolla tube, inserted at 0.5–0.6 of the length of the corolla tube (at 1.5–1.8 mm from the base); filaments short, c. 0.4 mm long, filiform; anthers ovate, 0.9–1(–1.3) × 0.3–0.5 mm, obtuse and very often with a pointed apex. *Pistil* longer than the sepals, 1.5–2.1 mm long; ovary glabrous, ovoid or sometimes broadly ovoid, 0.6–1(–1.4) × 0.6–1.1 mm, mostly slightly laterally compressed, composed of 2 carpels, a disk-like thickening at the base 0.1–0.2 mm high; style short, (0.1–)0.2–0.4 mm long; pistil head 0.5–0.9 mm high, sparsely hairy around the apex or sometimes entirely glabrous, composed of a basal ring 0.1–0.2(–0.3) mm high, a sparsely hairy conical central part 0.2–0.4 × 0.3–0.4 mm, and a minute or narrow cleft stigmoid apical part 0.1–0.2(–0.35) mm high. *Fruit* a pair of follicles, 9–26 cm long, 3–3.4 mm in diameter, striate, glabrous. *Seeds* ovate or oblong, 7–11 × 1.8–3 mm, one end bifid with mostly unequal lobes, the other end blunt or truncate, pubescent on both sides, main part elliptic, 4.2–4.5 × 1.5–1.7 mm, coma 1–2 mm long, reduced and gradually becoming shorter towards the margins, hilum elliptic, c. 0.2 × 0.07 mm.

Distribution — Endemic to Australia (Queensland, New South Wales).

Habitat & Ecology — Locally common in open areas, on rocky mountains, with sandy or sandy-loamy soils. Altitude 130–470 m.

Note — About *Travers 35* (HBG), said to be collected in Wellington, New Zealand: this locality is almost certainly wrong. The locality and plant description on the label do not fit either the known distribution of the species (much too far south) or the habit (it is a tree, not a climber). Therefore it cannot be cited.

Specimens studied: Australia: 78 specimens.

12. **Alstonia coriacea** Pancher ex S. Moore — Fig. 5.14

Alstonia coriacea Pancher ex S. Moore, J. Linn. Soc. Bot. 45 (1921) 362; Boiteau et al., Adansonia sér. 2, 16 (1977) 480; Fl. Nouv. Caléd. et Dépend. 10 (1981) 194. — *Alstonia lenormandii* var. *coriacea* (Pancher ex S. Moore) Monach., Pacific Sci. 3 (1949) 176. — Type: *Vieillard 2956* (holo BM; iso P), New Caledonia, fl.

Shrub or small tree, 1–5 m high. *Branches* rough from the large leaf-scars, rarely lenticellate, sometimes both longitudinally and transversally fissured, dark grey or blackish; branchlets terete, slightly quadrangular or wrinkled when dried, glabrous,

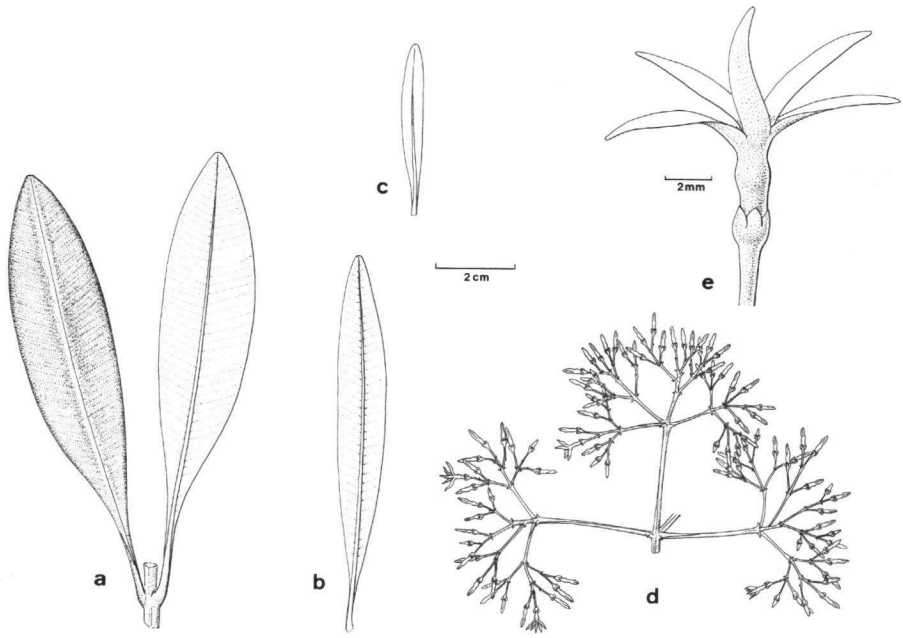


Fig. 5.14. *Alstonia coriacea* Pancher ex S. Moore – a–c: Leaves; d: inflorescence; e: open flower (a: *Suprin 546*; b–e: *McPherson 2459*).

grey-green or brown. *Leaves* opposite (rarely in whorls of 3), petiolate; petiole glabrous, (3–)5–20(–25) × 1–2 mm, slightly laterally compressed, shallowly canaliculate above, widening and forming a distinct intrapetiolar stipule at the base, more or less clasping the branchlet, few to many minute colleters densely packed together in the axils; blade dark glossy green above and light green beneath, or shiny grey-green to brown above, paler beneath and coriaceous when dried, narrowly elliptic or narrowly obovate (rarely elliptic), 5–17 × 1–4 cm, index (3–)3.2–10, glabrous on both sides, apex obtuse or rounded, sometimes shortly acuminate, acumen up to 0.8 cm long, base decurrent onto the petiole, margin entire, reflexed, sometimes undulate and/or irregularly dentate; midrib impressed above; secondary veins parallel or sometimes not, mostly inconspicuous, somewhat recurved, in (20–)25–40 pairs and forming an angle of 70–80(–90)° with the midrib, (1–)2–5 mm from each other; tertiary venation inconspicuous. *Inflorescence* 4.5–13 cm long, many-flowered; peduncle 1–8.5 cm long, slender 0.7–1.5(–2) mm wide, glabrous as on the branches; pedicels 4–8 × 0.3–0.4 mm, laterally compressed, glabrous, sometimes with 1 or 2 bracteoles around the middle. *Bracts* and *bracteoles* scale- or sepal-like, ovate to broadly ovate, 0.2–1.2 mm high, more or less clasping the inflorescence branch or branchlet, glabrous, with an almost translucent margin, obtuse or rounded, not ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.1–0.3 mm, ovate, suborbicular, or broadly ovate, 0.8–1.1 × 0.7–1.1 mm, index 0.8–1.1, erect, sometimes slightly spreading when dried, glabrous

on both sides, obtuse or rounded, with an almost translucent margin, not ciliate, mostly the three outer ones larger than the inner two. *Corolla* white, 4.8–8 mm long in the mature bud and forming an ovoid or narrowly ovoid head 0.53–0.75 of the bud length, 2.7–6 × 0.7–1 mm, with a blunt apex, glabrous outside, two hairy belts inside, the first belt shortly pubescent from 0.8–1 mm above the base to the insertion of the stamens (0.5–0.8 mm wide) (around the stamens usually glabrous, or sometimes with very sparse hairs), the second belt sparsely villose at the base of the corolla lobes and 0.5–1.3 mm wide; tube almost cylindrical or mostly widening around the stamens, 2.5–3.1 mm long, 1–1.2 mm wide (at the base 0.9–1 mm wide), 2.5–3 × as long as the sepals, 0.4–0.8 × as long as the lobes; lobes ovate to very narrowly ovate, 3–7 × 0.9–1.5 mm, index 2.7–5.8, mostly slightly falcate, not ciliate, minutely auriculate at the base on the right side, spreading. *Stamens* with apex 0.4–0.8 mm below the mouth of the corolla tube, inserted at 0.5–0.63 of the length of the corolla tube (at 1.4–1.9 mm from the base); filaments short, c. 0.2 mm long, filiform; anthers ovate, 0.6–0.9 × 0.25–0.35 mm, apex obtuse. *Pistil* 1.4–1.8 × as long as the longest sepals, 1.4–2 mm long; ovary ovoid, 0.6–0.9 × 0.5–0.7 mm, composed of 2 carpels, glabrous, disk-like thickening at the base indistinct; style 0.4–0.6 mm long; pistil head ovoid or triangular, 0.4–0.5 mm high, minutely hairy at the apex, composed of a basal ring 0.1–0.2 × 0.3–0.4 mm, a conical central part 0.1–0.2 × c. 0.2 mm, and a cleft stigmoid apical part c. 0.1 mm high. *Fruit* a pair of follicles, 5–17 cm long, 3.5–4.5 mm in diameter, glabrous, striate, abruptly pointed or obtuse at the apex. *Seeds* 6–10.5 mm long (main part elliptic, 3.7–4.2 × 1.8–2.4 mm), one end narrowly acuminate with acumen 1.5–3.5 mm long, sometimes irregularly dentate or lobed at the margin, the other end usually bifid or sometimes unequally lobed, sparsely to densely pubescent (rarely glabrescent) on both sides, cilia up to 1–1.5 mm long and gradually becoming shorter and sparser towards the side margins, hilum circular, c. 0.25 mm in diameter or elliptic c. 0.3 × 0.15 mm.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Secondary vegetation, in forests dominated by *Dacrydium araucarioides*, on slopes with serpentinic soils. Altitude 70–900 m.

Note — Moore (1921) mentioned that the type of the species is *Vieillard 2956* to which is appended the note "Arbrisseau de 3 mètres. Plaines ferrugineuses arides". There are three specimens under this number, but only the specimen in BM carries Moore's annotation. Therefore, I consider the BM specimen to be the holotype of *Alstonia coriacea*. The P sheets are isotypes, and neither of them is the holotype as was supposed by Boiteau (1976, 1981).

Specimens studied: New Caledonia: 84 specimens.

13. Alstonia costata (G. Forst.) R. Br.

Alstonia costata (G. Forst.) R. Br., On Asclepiad. (1810) 66; Mem. Wern. Nat. Hist. Soc. 1 (1811) 77; G. Don, Gen. Syst. 4 (1837) 87; De Candolle, Prodr. 8 (1844) 409; Monachino, Pacific Sci. 3 (1949) 174. — *Echites costata* G. Forst., Pl. Ins. Austr., Prodr. (1786) 20 (no. 123) [partly, excl. *Kametti-valli* Rheede, Hort. Malab. 9 (1689) 23–24, t. 14. = *Kamettia*

caryophyllata (Roxb.) Nicol. & Suresh in Taxon 35 (1986) 354]. — Type: *Forster 43* (lecto BM; isolecto K, W), Society Islands, Tahiti, fl. & fr.

Alstonia plumosa Labill., Sert. Austr.-Caled. (1824) 28, t. 32; G. Don, Gen. Syst. 4 (1837) 87. — Type: *Labillardière s.n.* (holo FI, not seen), New Caledonia.

Alstonia roeperi Van Heurck & Müll. Arg., Observ. Bot. (1871) 201; Monachino, Pacific Sci. 3 (1949) 170. — Type: *Vieillard 922* (holo AWH; iso P), New Caledonia, Wagap, fl.

Alstonia vitiensis Seem., Fl. Vitiensis (1873) 430; Monachino, Pacific Sci. 3 (1949) 171; syn. nov. — *Alstonia villosa* Seem., Fl. Vitiensis (1866) 161 (non Blume). — Type: *Seemann 318* (holo K; iso GH), Fiji, Viti Levu, 1860, fl. & fr.

Alstonia godeffroyi Reinecke in Engler, Bot. Jahrb. Syst. 25 (1898) 667; syn. nov. — Type: *Reinecke 483* (lecto G, designated here), Samoa, Upolu, Letogo-Siuma-Kamm, Apr. 1895, fl. & fr.

Alstonia reineckeana Lauterb. in Engler, Bot. Jahrb. Syst. 41 (1908) 233. — Type: *Vaupel 353* (holo B †; lecto MO, designated here; isolecto BISH, HBG, K, M, US, W), Samoa, 19 July 1906, fl.

Alstonia montana Turrill, J. Linn. Soc. Bot. 43 (1915) 32; A.C. Smith, Fl. Vitiensis Nov. 4 (1988) 71; syn. nov. — Type: *Thurn 58* (holo K; iso BM), Fiji, Viti Levu, Nandarivatu, 31 Jan. 1906, fl. & fr.

Alstonia elliptica J.W. Moore, Bernice P. Bishop Mus. Bull. 102 (1933) 39. — Type: *J.W. Moore 746* (holo BISH; iso P, UC), Society Islands, Raiatea, Tamehani, 16 Apr. 1927, fl. & fr.

Alstonia fragrans J.W. Moore, Bernice P. Bishop Mus. Bull. 102 (1933) 39. — *Alstonia costata* var. *fragrans* (J.W. Moore) M.L. Grant, Smithsonian Contr. Bot. 17 (1974) 43; syn. nov. — Type: *J.W. Moore 84* (holo BISH; iso L, US), Society Islands, Raiatea, East path to Mt. Tamehani, 16 Sept. 1926, fl. & fr.

Alstonia setchelliana Christoph., Bernice P. Bishop Mus. Bull. 128 (1935) 178, f. 27. — Type: *Christophersen 1265* (holo BISH; iso A, K, UC), Samoa, Tutuila Island, Pago Pago, 14 Nov. 1929, fr.

Alstonia smithii Markgr., Bernice P. Bishop Mus. Bull. 141 (1936) 125, f. 65a. — Type: *Smith 697* (holo BISH; iso BO, GH, K, P, UC, US), Fiji, Vanua Levu, Thakaundrove, summit of Mt. Mbatini, Nov. 1933, fl.

Alstonia vitiensis var. *novo-ebudica* Monach., Pacific Sci. 3 (1949) 171. — Type: *Kajewski 292* (holo K; iso A, P), New Hebrides (= Vanuatu), Eromanga Island, Dillon Bay, 23 May 1928, fl. & fr.

Alstonia montana var. *filiformis* Monach., Pacific Sci. 3 (1949) 173. — Type: *Horne 1043* (holo K; iso GH), Fiji, Viti Levu, Suva, Navesi (= Na Vasi), fl.

Alstonia vitiensis var. *whitmorei* Markgr., Gard. Bull. Sing. 22 (1967) 24. — Type: *Whitmore BSIP 605* (holo BISH, not seen; iso K, L), Solomon Islands, Guadalcanal, Gold Ridge, 13 Oct. 1962, fl.

Alstonia marquisensis M.L. Grant, Micronesica 8 (1972) 46. — *Alstonia costata* F. Br. (misapplied name), Bernice P. Bishop Mus. Bull. 130 (1935) 233 (non R. Br. 1811); syn. nov. — Type: *F.B.H. Brown 879* (holo BISH), Marquesas Islands, Hava Oa, alt. 900 m, 21 Dec. 1921, fl. & fr.

Alstonia plumosa Labill. var. *communis* Boiteau, Adansonia sér. 2, 16 (1977) 470; syn. nov. — Type: *Le Rat 506* (holo P), New Caledonia, Paita, 9 Oct. 1909.

Alstonia plumosa var. *communis* forma *glabra* Boiteau, Adansonia sér. 2, 16 (1977) 472; Fl. Nouv. Caléd. et Dépend. 10 (1981) 174; syn. nov. — Type: *Sevenet 4* (holo P), New Caledonia.

Alstonia vitiensis forma *glabra* A.C. Smith, Fl. Vitiensis Nov. 4 (1988) 76; syn. nov. — Type: *A.C. Smith 5474* (holo BISH; iso A, K, L), Fiji, Viti Levu, northern part of Rairaimatuku Plateau, between Nandrau and Nanga, Aug. 1947, fl.

Shrub or small to medium–sized tree, (1–)3–19 m high; trunk up to 30 cm in diameter, sometimes a large spreading tree with a trunk up to 100 cm in diameter. *Bark* smooth or shallowly fissured, grey or light brown; inner bark soft, granular, yellowish brown, cream, vivid sulphurous yellow cambium, usually paler outwards, with fawn flecks. *Branches* smooth or rough caused by the leaf-scars, lenticellate or not; branchlets terete, sometimes angled, slightly sulcate or wrinkled when dried, grey-green to dark brown, sometimes glaucous. *Leaves* opposite, petiolate; petiole slender or rather stout, 5–95 × 0.8–6 mm, glabrous to pubescent, canaliculate above, with or without a distinct intrapetiolar stipule (up to 2(–4) mm high) on the distal part at the base, slightly widened and more or less clasping the branchlet, many minute or linear colleters densely packed together in the axils; blade dark green above, light green beneath, or in various colours from dull yellowish green to dark brown and chartaceous to subcoriaceous when dried, narrowly elliptic to obovate, 3–46 × 1.2–28 cm, index 1.4–6.8(–9.6), glabrous on both sides, or glabrous above and sparsely (at least on the midrib) to densely velutinous beneath, apex rounded to acuminate or subapiculate, acumen up to 1.5(–2) cm long and with an acute or a blunt point, base rounded to decurrent onto the petiole, sometimes truncate, sometimes slightly oblique, margin entire, undulate and/or sinuate, revolute or not; midrib impressed above; secondary veins rather straight or slightly curved, in 8–24(–26) pairs and forming an angle of (45–)50–80(–90)° with the midrib, 2–30(–38) mm from each other, conspicuous submarginal vein present at least towards the apex; tertiary venation reticulate or scalariform, conspicuous or inconspicuous on both sides. *Inflorescence* 2.5–35 cm long, few or many-flowered; peduncle 0.5–21 cm long, slender or rather stout, 0.6–3.5 mm wide, glabrous; pedicel 2–10(–13) × (0.2–)0.3–0.8 mm, mostly slightly laterally compressed, glabrous, sometimes with 1 or 2 bracteoles just below the calyx or around the middle. *Bracts* and *bracteoles* scale- or sepal-like, ovate to broadly ovate, up to 1(–1.5) × 2 mm, more or less clasping the inflorescence branches or branchlets, almost translucent around the margin, obtuse or rounded, sometimes acute, mucronulate, or acuminate, glabrous on both sides, not ciliate, leafy bracts sometimes present. *Flowers* fragrant. *Sepals* connate at the base for (0.1–)0.2–0.35(–5) mm, ovate, subtriangular, or broadly ovate, (0.8–)1–2.5(–3.2) × 0.8–2 mm, index 0.8–2.5(–2.8), erect, or sometimes slightly spreading when dried, glabrous on both sides, obtuse, sometimes rounded, acute or mucronulate, with an almost translucent margin, not ciliate, mostly three of them larger than the other two. *Corolla* white, cream, yellow, or orange (usually greenish on the tube when fresh), 4.2–14 mm long in the mature bud and forming a narrowly ovoid head (rarely ovoid) 0.38–0.77 of the bud length, (1.6–)2.2–9 × 0.8–2 mm when dried, with a blunt apex, glabrous outside, with two densely hairy belts inside, the first belt pubescent from 0.7–2(–2.5) mm above the base to the insertion of the stamens (0.5–1.4(–2) mm wide) (around the stamens glabrous or very sparsely hairy), the second belt pilose, starting with sparse hairs from 0–1.6 mm below the mouth of the corolla tube and then usually densely surrounding the mouth, again reduced to sparsely hairy or glabrous towards the apex of the corolla lobes; the tube almost cylindrical or slightly widening around the stamens, 3–8 mm long, 1–2(–2.5) mm wide (at the base 1–1.7 mm wide), (1.7–)2–4.6 × as long as the sepals, 0.26–1.1 × as long as the lobes; lobes ovate to very narrowly ovate, sometimes

slightly falcate, (2.5–)3.5–14 × 1.1–2.7 mm, index 2–5.8(–6.3), without or, rarely, with very sparse cilia, auriculate at the base on the right side, spreading. *Stamens* with apex 0.5–2.2(–2.5) mm below the mouth of the corolla tube, inserted at 0.4–0.6 of the length of the corolla tube (at 1.3–4.5 mm from the base); filaments 0.3–0.5 mm long, filiform; anthers ovate or narrowly ovate, 0.9–2 × 0.3–0.5 mm, apex obtuse, sometimes acute or mucronulate. *Pistil* 1.3–4.5 mm long, 1.2–2.5 × as long as the longest sepals; ovary ovoid to broadly ovoid, 0.4–1(–1.2) × 0.5–1 mm, composed of 2 carpels, glabrous, a disk-like thickening at the base (mostly indistinct) up to 0.3 mm high; style 0.3–1.9(–2.8) mm long; pistil head ovoid, 0.4–1 mm high, minutely hairy at the apex, composed of a basal ring 0.07–0.3 × 0.3–0.5 mm, a conical central part 0.15–0.55 × 0.2–0.5 mm, and a small to narrow cleft stigmoid apical part 0.1–0.4 mm long. *Fruit* a pair of follicles, (5–)10–56 cm long, (2–)2.5–4.4 mm in diameter, glabrous, striate, with a narrow (sometimes abruptly) and blunt apex, pendulous or spreading. *Seeds* (2.5–)4–24 × 1–2.3(–2.5) mm (grain elliptic (1.5–)2–4.2 × 1–2(–2.3) mm), with the ends varying from shortly acuminate (rarely unequally lobed) to long tailed, 1–11 mm long, usually bifid only at one end, puberulous or pubescent on both sides, sometimes glabrescent, coma up to 0.5–1.5 mm long and gradually becoming shorter towards the middle of the margin, hilum circular, 0.1–0.2 mm in diameter, or elliptic, 0.2–0.3 × 0.1–0.2 mm.

Distribution — Solomons, Vanuatu, New Caledonia, Fiji, Samoa, Tonga, Society, and Marquesas Islands. Planted in the Waihawa Botanical Garden, Hawaii (*Lau 2304*).

Habitat & Ecology — Open or dense forests, on ridges, slopes, and hillside thickets, sometimes in river valleys. In the Solomons Islands this species is also found on ultrabasic hills near the coast in a forest dominated by *Casuarina* (*Whitmore BSIP 4015*) or in *Agathis* forests (*Chew Wee-Lek RSNH 113*; *Schmid 3146*). In the Society Islands this species very often occurs in forests dominated by *Metrosideros* (*Florence 2319, 4962, 4975, 4992, 7806, 7808, 7890*; *Florence et al. 9656*; *Carlquist 652*). Altitude 0–1400 m.

Vernacular names — Solomons: *dadaoasi, malmalsilio, malunga, seliu, si-ilio, si-iliu,* or *siliu'u* (all in Kwara'ae language); *gaiala* (Ysabel Island). Vanuatu: *gaitataweti* (Maewo); *neyevri* or *ney-everie* (Sie, Erromango). Fiji: *dregadrega* or *rerese* (Suva); *mbulei* or *mbuleki* (Ovalau, Serua); *ndranga nggurunguru* (Vanua Levu); *(n)drenga(n)drenga* (Sabatu); *nggatu* or *soroua* (Viti Levu); *sorua, sorouia,* or *drega* (Fiji).

Uses — The latex is used as chewing gum and as an eye lotion (remedy) (*Degener 1701, 14022, 14124, 15062, 15266; St. John 18301*; *A.C. Smith 1795, 6651*). For the eyes the local people usually use an extract from the bark rather than the latex (*Degener 15040*; *Kajewski 2575*).

Notes — The holotype is in BM and not in K as was supposed by Monachino (1949).

This species is complex as it has great variation in the leaves and the flowers. It is composed of five indistinct groups corresponding roughly to the old *A. costata, A. plumosa, A. vitiensis, A. montana* and *A. marquisensis*. These groups, however, merge into each other and cannot be recognised even at varietal level.

The specimens from New Caledonia show less variation in contrast to the specimens from outside New Caledonia, which vary not only in size, but also in shape and pubescence. The Fijian and Samoan populations show the most variation. The specimens from the Marquesas Islands (formerly under *A. marquisensis*) mostly have larger flowers, but the sepals are shorter than the specimens ascribed to typical *A. costata* from the Society Islands. Shorter sepals, as in the old *A. marquisensis*, are also found in specimens that were formerly assigned to *A. elliptica* and *A. fragrans* from the Society Islands, especially from Raiatea Island and Cook Island. They are also similar to many specimens from Melanesia (Solomons to Samoa).

Whitmore mentioned that there was no latex in the bark of the trunks of the specimens that he collected in the Solomon Islands.

Specimens studied: Solomons: 19 specimens. – Vanuatu: 19. – New Caledonia: 73. – Fiji: 179. – Samoa: 28. – Tonga: 2. – Society Islands: 101. – Marquesas Islands: 23.

14. Alstonia curtisii King & Gamble — Fig. 5.15 & 5.16

Alstonia curtisii King & Gamble, J. Asiat. Soc. Bengal 74, 2 (1907) 439; Kerr, Fl. Siam. En. 2 (1939) 439. — Type: *Curtis 3242* (holo K), Thailand, Kasoom, Nov. 1896, fl. & fr.

Shrub, c. 2 m high. *Branches* smooth or rather rough, without or with sparse lenticels; branchlets terete, glabrous, pale brown or blackish. *Leaves* in whorls of 4, petiolate; petiole 3–10 × c. 1 mm, glabrous, compressed above, colleters minute or linear and densely packed together in the axils, pinkish even when dried; blade chartaceous, narrowly ovate to narrowly obovate, 5–12 × 0.8–2.5 cm, index 4–6.3, acute or acuminate with an acumen up to 1.5 cm long and a pointed tip, base cuneate or decurrent onto the petiole and forming a narrow wing, glabrous on both sides, entire; midrib raised above, flat or shallowly longitudinally canaliculate in the middle when dried; secondary veins in 26–50 pairs, almost parallel and forming an angle of 50–70° with the midrib, (0.6–)1–2 mm from each other, slightly arched and very often confused with some thin (shorter) interstitial veins; tertiary venation inconspicuous. *Inflorescence* 4.5–8 cm long, terminal, 2 or 3 together, few-flowered; peduncle 0.5–1.5 cm long, c. 1 mm wide, glabrous as on the branches; pedicels 6–11 × 0.5–0.7 mm, glabrous. *Bracts* and *bracteoles* scale- or sepal-like, suborbicular to subtriangular, apex rounded to acuminate, not ciliate, glabrous on both sides, mostly irregularly dentate at the margin, some colleters in the axils or united at the base. *Flowers: Sepals* connate at the base for 0.2–0.3 mm, ovate or triangular, 1.5–1.6(–2) × 0.8–1 mm, index 1.6–2, erect or slightly spreading when dried, glabrous on both sides, acute, almost translucent around the margin, not ciliate. *Corolla* 17–33 mm long in the mature bud and forming a narrowly ovoid head 0.33–0.35 of the bud length (10–12 × c. 2 mm) with a pointed apex, glabrous outside, two sericeous belts inside, the first belt at the broader part of the tube, starting from c. 2 mm below the stamens (= 14.5–15.2 mm above the base) and ending around the apex of the stamens (c. 4.5 mm wide), the second belt surrounding the mouth of the corolla tube; tube 24–26.5 mm long, 0.8–1.2 mm wide at the base, rather abruptly widening around the stamens to 2.5 mm wide, narrowing again to a similar width to the base and forming a long throat up to the mouth of the

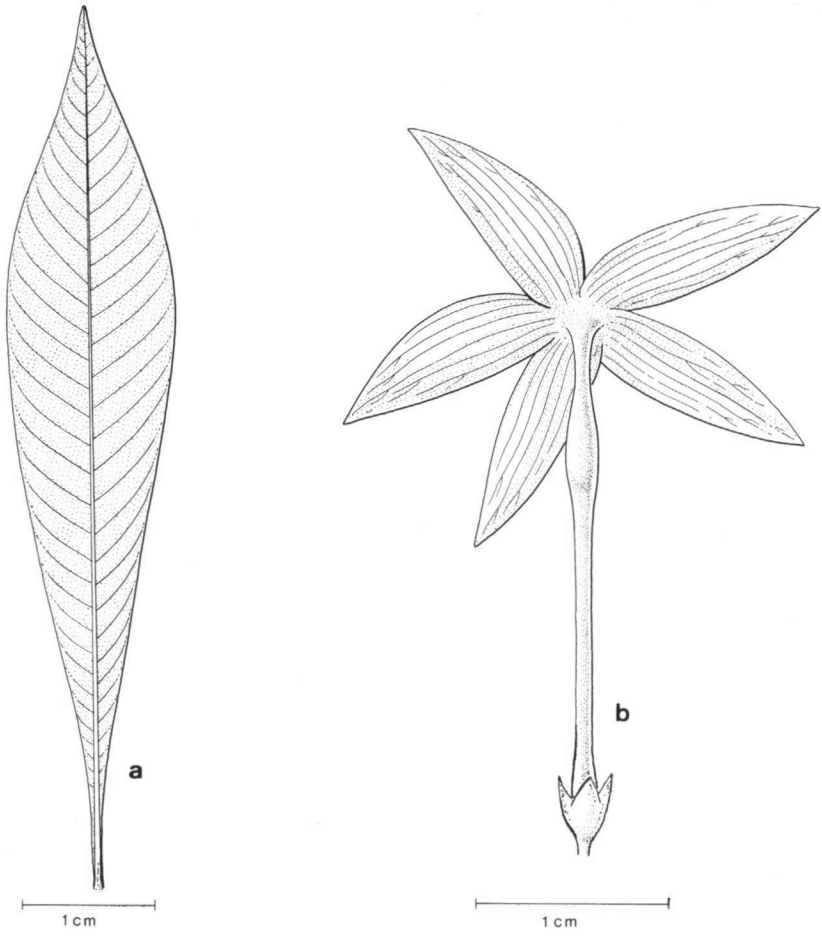


Fig. 5.15. *Alstonia curtisii* King & Gamble – a: Leaf; b: open flower (a, b: *Curtis 3242*).

corolla tube, 13.2–16.6 × as long as the sepals, 1.4–1.8 × as long as the lobes; lobes elliptic or ovate, mostly slightly oblique, 14–18 × 5–6.2 mm, index 2.5–3, not ciliate, minutely auriculate at the base on the left side. *Stamens* with apex 6–7 mm below the mouth of the corolla tube, inserted at 0.64–0.7 of the length of the corolla tube (at 15–17 mm from the base); filaments c. 0.6 mm long, filiform; anthers narrowly ovate, 2.4–2.6 × 0.4–0.7 mm, apiculate. *Pistil* 7.8–9.7 × as long as the sepals, 15.7–17 mm long; ovary ovoid, 1.5–1.6 × 0.8–0.9 mm, composed of 2 carpels, glabrous, a disk with 2 long lobes alternating with the carpels, 0.9–1 mm high, usually with wavy or irregularly lobed margin; style 14–15.5 mm long, filiform; pistil head pagoda-shaped, 1.2–1.7 mm high, composed of a membranous basal veil 0.2–0.3 × 0.6–0.7 mm, a woolly ring c. 0.2 × 0.6–0.7 mm, a conical or ovoid central part 0.8–1.1 × 0.6–0.8 mm, and a rather robust cleft stigmoid apex c. 0.25 mm high. *Fruit* a pair of follicles, 8–9.2

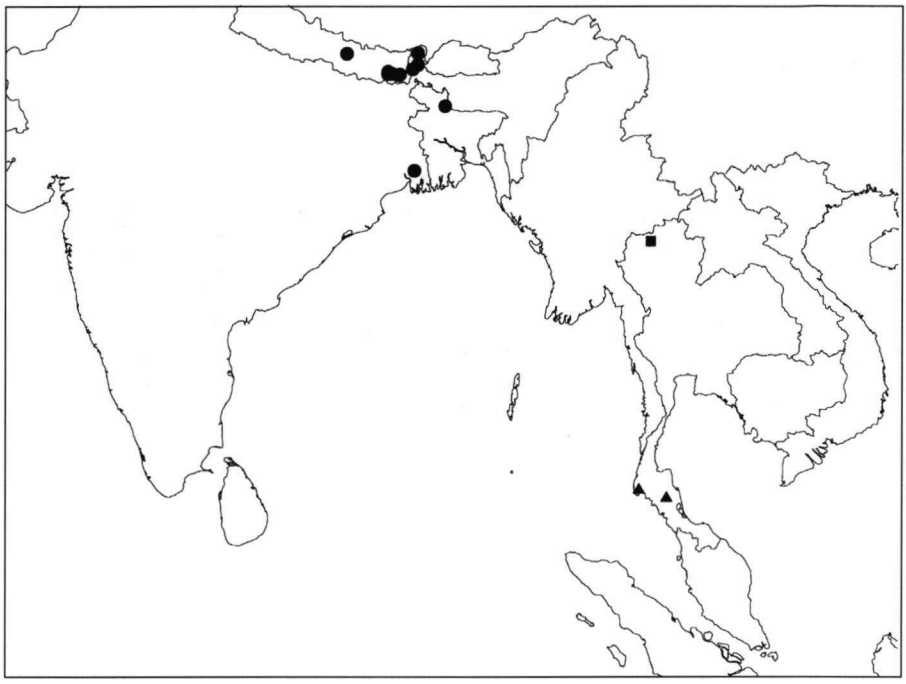


Fig. 5.16. Distribution of *Alstonia curtisii* King & Gamble (▲), *A. neriifolia* D. Don (●), and *A. rupestris* Kerr (■).

cm long, 2.5–4 mm in diameter, minutely striate or almost smooth, glabrous, not stipitate, rostrum 3–7 mm long. *Seeds* narrowly elliptic or oblong, 6–8 × 1.8–2.1 mm, ends rounded, usually unequally lobed, pitted on the hilar side, smooth or slightly so on the other side, glabrous or sometimes with sparse long silky hairs near the margin, cilia 2.5–4 mm long, hilum elliptic, c. 0.2 × 0.1 mm, or circular, c. 0.2 mm in diameter.

Distribution — Endemic to Thailand.

Habitat & Ecology — Limestone island and cliffs. Altitude 50–250 m. Fl. & fr. Aug., Oct., Nov.

Specimens studied: Thailand, Kasoom: *Curtis 3242* (type); Phangnga: Takua Thung, *Shimizu et al. T. 8129* (L); Krabi Province, Tam Soea (Tiger Cave), 10 km N of Krabi, *Larsen et al. 42558* (AAU).

15. **Alstonia deplanchei** Van Heurck & Müll. Arg. — Fig. 5.17

Alstonia deplanchei Van Heurck & Müll. Arg., Flora 53 (1870) 171; Monachino, Pacific Sci. 3 (1949) 175; Boiteau et al., Adansonia sér. 2, 16 (1977) 476. — Type: *Deplanche 462 bis* (holo AWH; iso BM, G, GH, K, L, P, W), New Caledonia, Poume, 1861–1867, fl. & fr.

Alstonia retusa S. Moore, J. Linn. Soc., Bot. 45 (1921) 363. — Type: *Compton 2363* (holo BM), New Caledonia, Poume, 12 Dec. 1914, fl. & fr.

Alstonia linearifolia Guillaumin, Bull. Soc. Bot. Fr. 88 (1941) 371. — Type: *Deplanche 466* (lecto L, designated here; isolecto G), New Caledonia, Nehoue ou Cap Tonnerre, 1861–1867, fl.

Alstonia spathulaefolia Guillaumin & Virot, Mem. Mus. Natl. Hist. Nat. sér. B, Bot. 4 (1953) 50. — Type: *Virot 1263* (holo P; iso A), New Caledonia, Pente Ouest du Dome de la Tiebaghi, 27 Oct. 1943, fl.

Alstonia deplanchei var. *ndokoaensis* Boiteau, Adansonia sér. 2, 16 (1977) 478; Fl. Nouv. Caléd. et Dépend. 10 (1981) 207; syn. nov. — Type: *MacKee 27698* (holo P; iso L), New Caledonia, vallée de Poya, Ndokoa, 31 Oct. 1973, fl.

Shrub or small tree, (0.6–)1–2(–4) m high. *Branches* smooth, sparsely lenticellate; branchlets terete or slightly laterally compressed, glabrous, pale brown, usually blackish. *Leaves* opposite, petiolate (sessile only on the specimens with very narrow or

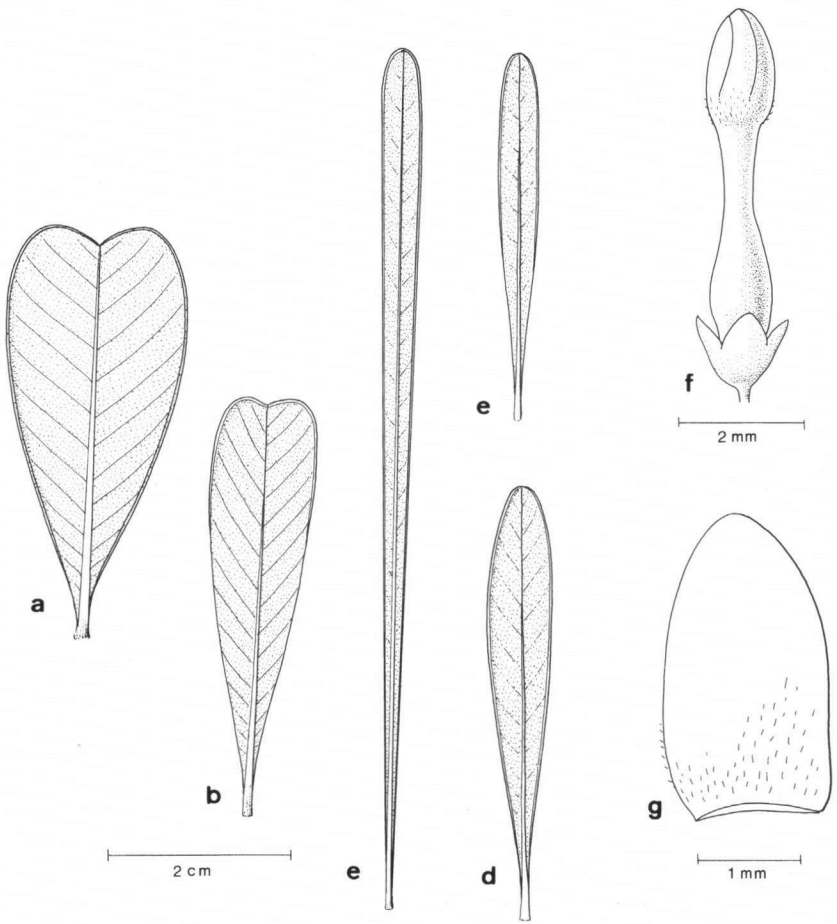


Fig. 5.17. *Alstonia deplanchei* Van Heurck & Müll. Arg. – a–e: Various shapes and sizes of leaves; f: flower in bud; g: corolla lobe (a: *Deplanche 462bis*; b–d: *MacKee 12756*; e–g: *McPherson 6212*).

linear leaves); petiole glabrous, up to 8 mm long, flattened or canaliculate above, colleters minute or shortly lingulate and densely packed together in the axils; blade dark green above, light green beneath, or yellowish green when dried, rarely brown, thinly coriaceous, ovate to very narrowly obovate, sometimes obcordate or linear, 2.7–13 × 0.1–3.8 cm, index 1.4–9.5(–11), glabrous on both sides, apex obtuse or rounded, truncate, emarginate or retuse, base acute or decurrent onto the petiole, margin entire or sometimes slightly undulate and mostly revolute; midrib impressed above; secondary veins in (8–)10–15(–20) pairs, thin, sometimes almost parallel and forming an angle of 30–60° with the midrib, 1–4 mm from each other, sometimes alternating with short intermediate veins, conspicuous on both sides except on linear leaves which are mostly inconspicuous; tertiary venation reticulate, conspicuous or inconspicuous. *Inflorescence* 2–7.5 cm long, terminal, usually together in twos and forming an opposite arrangement, few or many-flowered, peduncle 0.7–3.5 cm long, glabrous; pedicels 1–2(–3) mm long, glabrous, with 1–3 bracteoles. *Bracts* and *bracteoles* scale- or sepal-like, ovate or broadly triangular, up to 1 mm long, almost translucent around the margin and apex, glabrous, not ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.3 mm, ovate or broadly ovate, 1–1.5 × 0.8–1.5 mm, index 0.8–1.5, erect, or slightly spreading when dried, glabrous on both sides, apex obtuse or rounded, almost translucent around the apex and margin, not ciliate, mostly the two outer ones larger than the three inner ones. *Corolla* yellow or cream, 6–10 mm long in the mature bud and forming an ovoid or ellipsoid head 0.26–0.34 of the bud length, 1.5–3 × 1–1.5 mm, with a blunt or rounded apex, glabrous or laxly puberulous outside, with two distinct hairy belts inside, the first belt shortly pubescent from 1–1.2 mm above the base to the insertion of the stamens (0.5–1 mm wide), the second belt sparsely to densely villose starting with sparse hairs from 0.8–1 mm above the stamens to at least the basal half of the corolla lobes (densely villose at the extreme base of the lobes, and then reducing towards the apex), around the stamens mostly with very few and short hairs or entirely glabrous; tube almost cylindrical or slightly widening around the stamens, 5–9 mm long, 1–1.5 mm wide, 4–6.4 × as long as the sepals, 1.9–2.7 × as long as the lobes; lobes ovate or lingulate, 2–4 × 1.1–1.6 mm, index 1.7–2.7, oblique or sometimes slightly falcate, auriculate at the base on the right side, not ciliate, spreading. *Stamens* with apex (2.5–)3–5.3 mm below the mouth of the corolla tube, inserted at 0.2–0.3 of the length of the corolla tube (at 1.5–2.2 mm from the base); filaments 0.3–0.5 mm long, filiform; anthers ovate, 0.9–1.2 × 0.3–0.5 mm, obtuse. *Pistil* 1.6–2.1 mm long; ovary glabrous, ovoid or broadly ovoid, 0.5–1 × 0.6–0.8 mm, mostly slightly laterally compressed, composed of 2 carpels, a disk-like thickening at the base 0.1–0.15 mm high; style 0.5–0.9 mm long; pistil head 0.4–0.65 mm high, sparsely hairy around the apex, composed of a basal ring 0.1–0.2(–0.3) mm high (obscure in *MacKee 29516*), a sparsely hairy conical central part 0.2–0.3 × 0.3 mm, and a minute or narrow cleft stigmoid apical part 0.1–0.3 mm high. *Fruit* a pair of follicles, 3–10 cm long, 2.5–3 mm in diameter, with a pointed apex, striate, glabrous. *Seeds* elliptic or oblong, 5.5–6 × 1.5–1.8 mm (main part elliptic, 3–3.5 × 1.4–1.7 mm), bifid at one end and irregularly lobed or dentate at the other end or sometimes at both ends, softly pubescent on both sides, ciliate up to 1 mm long and reduced towards the middle of the margins, hilum circular, c. 0.2 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Dry creeks or dense forests, on slopes and rocky soils. Altitude 10–600 m. Flowering and fruiting throughout the year.

Specimens studied: New Caledonia: 44 specimens.

16. Alstonia guangxiensis D. Fang & X.X. Chen

Alstonia guangxiensis D. Fang & X.X. Chen, Acta Phytotax. Sinica 18, 2 (1980) 227. — Type: *Fang et al. 76200* (holo GXMI), China, Guangxi, Longzhou Xian (= Lung-Chou), 14 Sept. 1978, fl.

Shrub, 1.5 m high. *Branches* smooth, lenticellate; branchlets terete or slightly sulcate in the young parts when dried, glabrous, grey or dark brown. *Leaves* in whorls of (3 or) 4, sometimes alternate (on the same branchlet), sessile or subsessile; petiolate (if present) up to 1.7 mm long, canaliculate above, glabrous, many narrow or linear colleters densely packed together in the axils; blade thinly coriaceous when dried, very narrowly elliptic 12–20 × 1.7–2.5 cm, index 7.1–9.1, apex narrowly acuminate with an acute tip, base narrow with a rounded end, glabrous above and softly densely pubescent beneath, entire; midrib impressed above; secondary veins in 150–180 pairs, parallel and forming an angle of 80–85° with the midrib, 0.7–1.5 mm from each other, slightly arched and joining near the margin forming a thin submarginal vein, very often confused with some thin (shorter) interstitial veins; tertiary venation inconspicuous. *Inflorescence* 7–10 cm long, terminal, many-flowered; peduncle 3.5–5.5 cm long, glabrous as the branches; pedicels slender 7–16 × 0.4–0.6 mm, glabrous. *Bracts* and *bracteoles* ovate or widely triangular, minute, up to 0.8 mm high, ciliate, few to many colleters densely packed together at the base. *Flowers: Sepals* connate at the base for c. 0.2 mm, ovate or subtriangular, 1.5–1.7 × 1–1.2 mm, index 1.4–1.5, acute or obtuse, almost translucent around the margin, ciliate, glabrous on both sides, erect, slightly spreading when dried. *Corolla* white, 25–26 mm long in the mature bud and forming a narrowly ovoid head c. 0.3 of the bud length, c. 7 × 2.3 mm with a blunt apex, glabrous outside, two hairy belts inside, the first belt in the broader part of the tube, starting from c. 3 mm below the stamens (14–15 mm above the base) to c. 1 mm below the mouth (c. 5 mm wide), around the base of the stamens very sparse hairs, the second belt at the extreme base of the corolla lobes or surrounding the mouth moustache-like, c. 0.2 mm wide; tube 20–22 mm long, 1.2–1.5 mm wide at the base, widening around the stamens to the throat, 2.2–2.5 mm wide, 12.9–13.3 × as long as the sepals, 2.2–2.7 × as long as the lobes; lobes ovate, mostly slightly oblique, 8–10 × 4.5–7 mm, index 1.4–1.8, apex rounded, not ciliate, auriculate at the base on the left side, spreading. *Stamens* with apex c. 1 mm below the mouth of the corolla tube, inserted at c. 0.8 of the length of the corolla tube (at 16.7–18 mm from the base); filaments 0.5–0.6 mm long, filiform; anthers narrowly ovate, c. 2 × 0.5–0.6 mm, mucronulate. *Pistil* 16.5–18.2 mm long; ovary ovoid, c. 1.9 × 0.9 mm, glabrous, composed of 2 carpels; disk with 2 short lobes alternating with the carpels, 0.7–0.8 mm high, with wavy or irregularly lobed margin; style 14.5–15.3 mm long, filiform; pistil head pagoda-like, c. 1 mm high, composed of a membranous basal ring c. 0.2 × 0.5

mm, above this a woolly central ring c. 0.2 × 0.5 mm, then again a ring c. 0.4 × 0.4 mm which is glabrous, and a robust and short cleft stigmoid apex c. 0.2 × 0.2 mm. *Fruit* unknown.

Distribution — Endemic to China, known only from the type specimen.

Habitat & Ecology — Rocky soils.

Vernacular name — *Zhe ye yang jiao mian* (Li et al., 1995).

Notes — *Alstonia guangxiensis* is closely related to *A. rupestris* Kerr in the sessile leaves, which are (very) narrowly elliptic. It differs mainly in the leaves which are pubescent beneath, the longer corolla tube (20–22 mm versus 7.5–8 mm long), and much larger corolla lobes (8–10 × 4.5–7 mm versus c. 3 × 2.2–2.6 mm).

Li et al. (1995) placed this species as a synonym of *Alstonia neriifolia* D. Don, which, however, is quite different, mainly in the sessile or subsessile leaves. Besides the characters mentioned above, the higher number of secondary leaf veins (150–180 pairs), the wider hairy belt below the stamens (c. 3 mm versus 1–1.5 mm), and the very short disk lobes of the ovary are good characters to distinguish these two species. As far as is known, *A. neriifolia* does not occur in China.

17. Alstonia iwahigensis Elmer — Fig. 5.18 & 5.19

Alstonia iwahigensis Elmer, Leafl. Philipp. Bot. 4 (1912) 1447. — Type: *Elmer 13167* (holo PNH †; lecto L, designated here; isolecto A, G, GH, HBG, MO, US, Z), Philippines, Palawan, Puerto Princesa (Mt. Pulgar), May 1911, fl.

Tree, 15–45(–70?) m high; trunk 20–80 cm in diameter, fluted at the base and forming tall buttresses up to 6 m high, spreading at the base up to 2 m away from the trunk. *Bark* smooth to slightly rough, scaly or both longitudinally and horizontally fissured, greyish, yellowish or dark brown; inner bark yellow or pale yellow, yellowish brown inside and brownish outside, with copious white latex. *Branches* smooth or both longitudinally and horizontally fissured, sometimes sparsely lenticellate; branchlets terete, glabrous, pale or yellowish brown. *Leaves* in whorls of 4–7, petiolate; petiole glabrous, (5–)10–20(–28) × 0.7–2 mm, flattened and canaliculate above, without distinct intrapetiolar stipule at the base, widening or scale-like colleters in the axils; blade greyish to pale brown beneath and thinly coriaceous when dried, elliptic to narrowly elliptic or obovate, 3.5–10 × 1.5–4 cm, index 1.6–3.4, apex obtuse or rounded, sometimes shortly acuminate, base acute, obtuse or rounded, glabrous on both sides, entire; midrib impressed above; secondary veins in 25–40 pairs, straight and forming an angle of 85–90° (mostly nearly 90°) with the midrib, 1–3 mm from each other; tertiary venation admedial ramified, somewhat conspicuous above. *Inflorescence* 2.5–10 mm long, usually forming two bunches of dense and many clustered flowers; peduncle 1–5.5 cm long, glabrous or puberulous; pedicels 0–1 mm, pubescent. *Bracts* and *bracteoles* ovate to broadly triangular up to 2 mm long, acute. *Flowers* fragrant. *Sepals* pale green, connate at the base for 0.3–0.5 mm, erect or slightly spreading, ovate to narrowly ovate, 1.5–2.1 × 0.6–1 mm, index 1.6–3.5, obtuse, puberulous or densely pubescent outside, glabrous or minutely pubescent around the apex inside, ciliate. *Corolla* yellow or pinkish, 8–10 × 0.6–1.1 mm in the mature bud and forming an

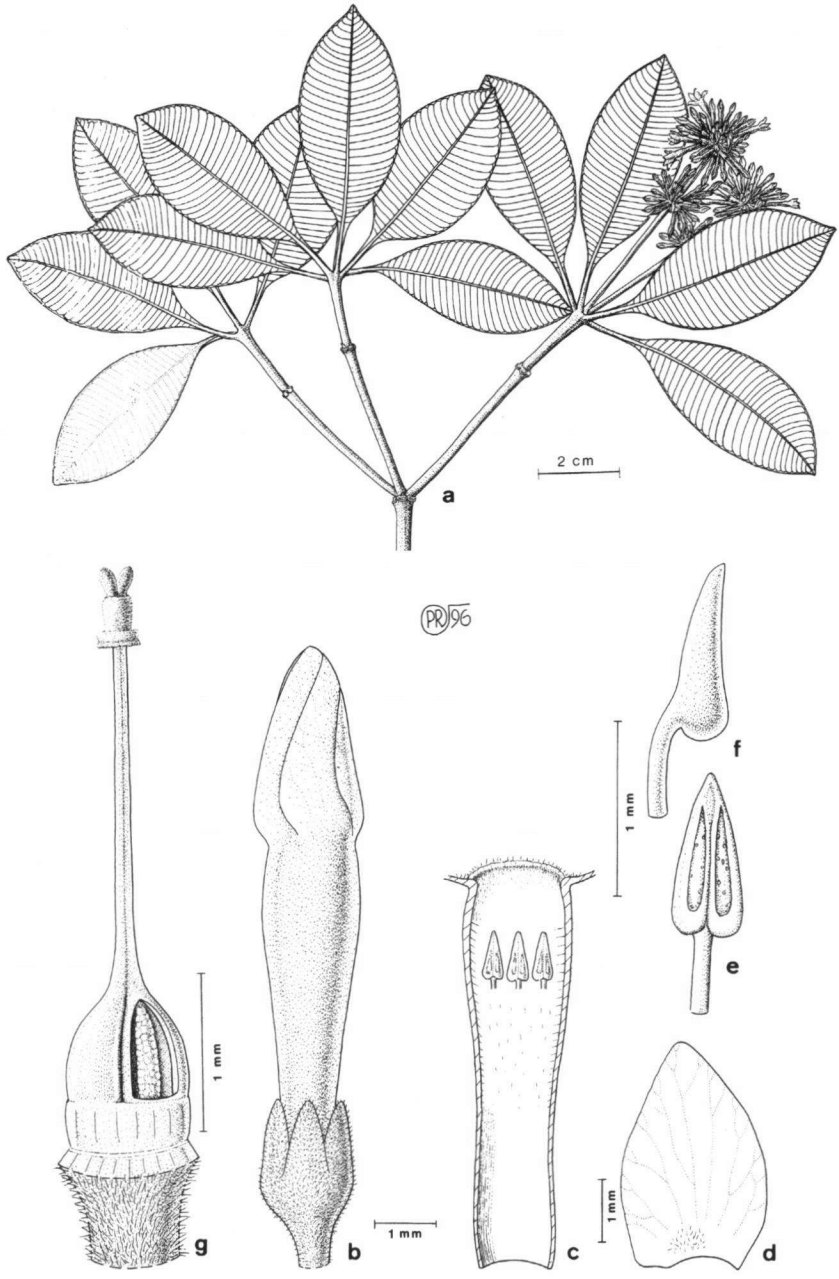


Fig. 5.18. *Alstonia iwahigensis* Elmer – a: Habit; b: flower in bud; c: dissected corolla tube, showing 3 anthers inserted above the hairy belt; d: corolla lobe; e: anthers, front view; f: anthers, side view; g: pistil, showing numerous ovules from the dissected ovary, annular disk-like tickening at the base, and a robust cleft apical part of the stigma (*Ambriansyah & Arifin AA 898*).

ovoid head 0.25–0.31 of the bud length, 2.5–3 × 0.8–1.1 mm when dried, with a blunt apex, glabrous or only sparsely ciliate around the apex of the lobe margins outside, two hairy belts inside, the first belt pubescent, starting from 1.3–2.5 mm above the base and ending at 0.8–1 mm below the mouth or around the apex of the stamens (3.5–5.6 mm wide) (around lower half of stamens usually rather sparse), the second belt pilose, (moustache-like) surrounding the mouth and on the very base of the lobes; tube 6–7.5 mm long, 1–1.5 mm wide at the base, narrowed above 0.6–1 mm wide, widening again at the apex (around the stamens) 1–1.7 mm wide, 3.1–4.7 × as long as the sepals, 1.8–2.7 × as long as the lobes; lobes ovate or lingulate, mostly slightly oblique, 2.6–4 × 1.3–2.8 mm, index 1.1–2.5, spreading. *Stamens* with apex 0.5–1 mm below the mouth of the corolla tube, inserted at 0.7–0.8 of the length of the corolla tube (at 5–5.8 mm from the base); filaments c. 0.5 mm long, filiform; anthers ovate or triangular, 0.8–0.9 × 0.3–0.5 mm, apex obtuse. *Pistil* glabrous, 6–6.3 mm long; ovary ovoid or broadly ovoid, 0.8–1.1 × 0.7–1 mm, composed of 2 carpels, mostly slightly laterally compressed, with or without a disk-like thickening at the base (up to 0.3 mm high); style 4.5–4.9 mm long, filiform; pistil head 0.6–0.8 mm high, composed of a thin basal ring 0.07–0.1 mm high or not, a cylindrical central part 0.3–0.4 × 0.2–0.3 mm, and a short and robust cleft stigmoid apical part 0.2–0.3 mm high. *Fruit* a pair of follicles, 25–35 cm long, c. 1.5(–2) mm in diameter, glabrous. *Seeds* brown, oblong, 5–6 × 1 mm, ends rounded, glabrous on both sides, smooth or with a very minute reticulate structure, hilum linear, usually grey or whitish, coma 13–17 mm long.

Distribution — Malaysia (Sabah), Brunei Darussalam, Indonesia (Central and Eastern part of Kalimantan), Philippines.

Habitat & Ecology — Secondary and primary forests, on hillsides, on loamy or sandy soils. Altitude 20–500 m.

Vernacular names — Sarawak: *tombailik* (Bundu Tuhan); Kalimantan: *pulai gunung*, *pelantan* or *pulantan* (Samarinda-Balikpapan).

Uses — The latex (collected from the bark) mixed in honey is used as a tonic.

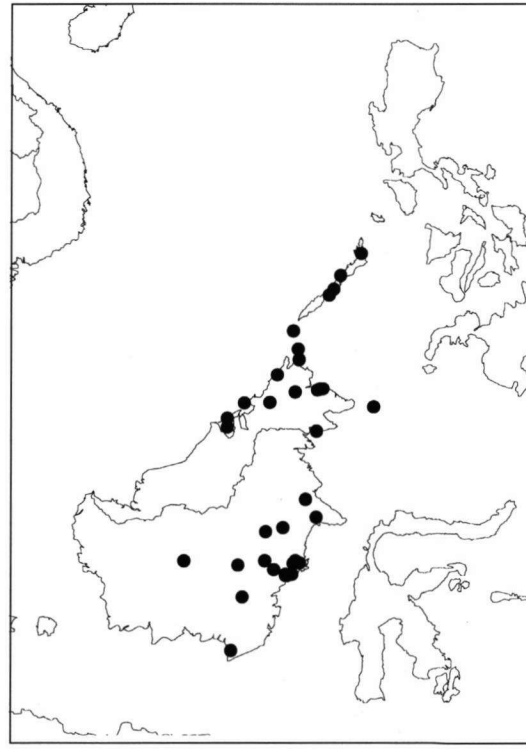


Fig. 5.19. Distribution of *Alstonia iwahigensis* Elmer.

Note — Many authors place *Alstonia iwahigensis* in the synonymy of *A. angustiloba* Miq. The pubescence of the follicles and comparison of the length of the corolla tube to the corolla lobes are two of the important characters to distinguish one from the other. It is difficult to distinguish sterile material. In addition the leaf blade is usually larger and thicker in *A. angustiloba.*

Specimens studied: Malaysia (Sabah only): 26 specimens. – Brunei: 2 (*Ashton 5005, Nangkat 184*). – Indonesia: Kalimantan: 31. – Philippines: 7.

18. Alstonia lanceolata Van Heurck & Müll. Arg. — Fig. 5.20

Alstonia lanceolata Van Heurck & Müll. Arg., Observ. Bot. (1871) 119; Boiteau et al., Adansonia sér. 2, 16 (1977) 474; Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 187. — Type: *Vieillard 921* (holo AWH; iso G, GH, K, L, P, W, Z), New Caledonia, Wagap, 1861–1867, fl. & fr.

Shrub or small tree, 2–10 m high. *Branches* smooth, lenticellate or not; branchlets terete, laterally compressed or slightly sulcate when dried, glabrous, grey-green to dark brown or blackish. *Leaves* opposite, petiolate; petiole glabrous, slender, (3–)5–14 × 0.6–1.5 mm, flattened or shallowly canaliculate above, without an intrapetiolar stipule at the base, colleters minute and densely packed together in the axils; blade dark green above, paler beneath, chartaceous and grey-green or dark brown when dried, narrowly elliptic or linear (rarely elliptic or narrowly obovate), 4.5–18 × 0.8–3.6 cm, index (2.5–)4.2–10, glabrous on both sides, apex obtuse or long-acuminate with a blunt point, base cuneate or decurrent onto the petiole, margin entire or slightly undulate, sometimes revolute; midrib impressed above; secondary veins in 22–50 pairs, very often not parallel, branched, sometimes confused with some thin intermediate veins, forming an angle of 80–90° with the midrib, 1–4(–6) mm from each other; tertiary venation reticulate, inconspicuous above. *Inflorescence* (2–)3–8 cm long, terminal, many-flowered; peduncle slender, (0.5–)1–3 cm long, glabrous as on the branches; pedicels (2–)3–7 × 0.3–0.4 mm, glabrous. *Bracts* and *bracteoles* scale- or sepal-like, ovate or broadly triangular, up to 0.7 mm long, almost translucent around the margin and apex, glabrous on both sides, not ciliate. *Flowers: Sepals* connate at the base for 0.2–0.3 mm, ovate, 1.2–2 × 1–1.5 mm, index 1.1–1.7, erect, mostly slightly spreading when dried, glabrous on both sides, obtuse, almost translucent around the apex and margin, not ciliate, mostly the two outer ones larger than the inner three. *Corolla* white, 5–7.6 mm long in the mature bud and forming an ovoid head 0.3–0.4 of the bud length (2–3 × 1–1.3 mm) gradually narrowed towards the blunt apex, glabrous outside, two densely hairy belts inside, the first belt pubescent starting from c. 1.5 mm above the base to the insertion of the stamens (0.7–1.2 mm wide), the second belt villose, starting with sparse hairs from 0.5–1 mm above the apex of the stamens to over the corolla lobes (dense hairs occur at the base of the corolla lobes, and then reduced gradually towards the apex), around the stamens usually very sparse; tube almost cylindrical, 4.4–5.2 mm long, 1.5–1.7 mm wide, 2.5–3.6 × as long as the sepals, 1.4–1.8 × as long as the lobes; lobes 2.4–3.5 × 1.3–1.6 mm, index 2–2.4, oblique or slightly falcate, rather thick, sparsely ciliate, auriculate at the base on the right side (sometimes on both sides, but on the left always much less), spreading or

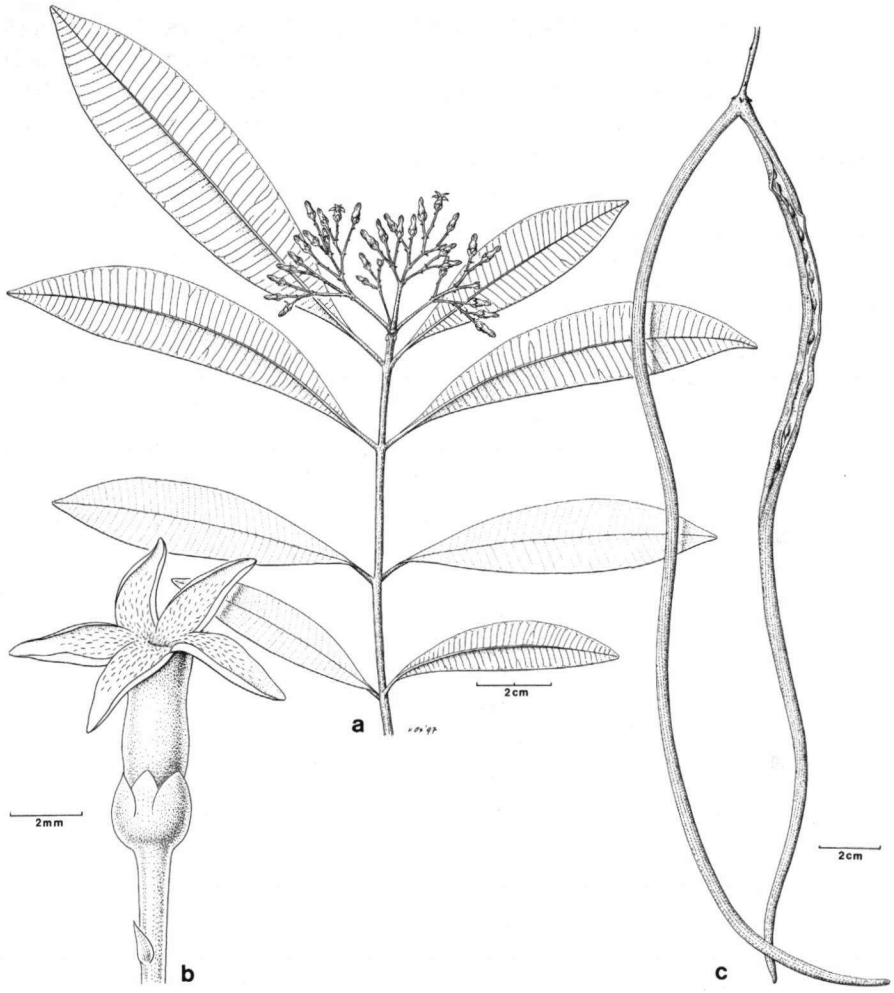


Fig. 5.20. *Alstonia lanceolata* Van Heurck & Müll. Arg. – a: Habit; b: open flower; c: follicles (a, b: *MacKee 33147*; c: *MacKee 26567*).

reflexed. *Stamens* with apex 1–1.5 mm below the mouth of the corolla tube, inserted at 0.5–0.56 of the length of the corolla tube (at 2.2–2.9 mm from the base); filaments short, c. 0.4 mm long, filiform; anthers ovate, 1–1.2 × 0.3–0.5 mm, obtuse. *Pistil* 2.5–3 mm long; ovary ovoid, 0.9–1 × 0.7–0.9 mm, glabrous, composed of 2 carpels; without or with a disk-like thickening at the base 0.1–0.17 mm high; style 1–1.2 mm long; pistil head 0.6–1 mm high, composed of a basal ring 0.15–0.25 mm high, a conical central part 0.2–0.5 × 0.2–0.3 mm (which is mostly sparsely hairy at the apex), and a cleft stigmoid apical part c. 2(–4) mm high. *Fruit* a pair of follicles, (10–)15–50 cm long, 3–3.5 mm in diameter, striate, glabrous, pendulous. *Seeds* 15–30 mm long, main part elliptic, 3.5–4 × 1.5–2 mm, ends caudate with a cauda (5–)7–14 mm long, some-

times bifid at one end, pubescent on both sides, ciliate up to 1(–1.5) mm long, reduced and becoming shorter towards the middle of the margins (the longest hairs occur at the ends of the main part), hilum circular, c. 0.2 mm in diameter.

Distribution — Endemic to New Caledonia.
Habitat & Ecology — Rain forests, on slopes. Altitude 350–900 m.

Specimens studied: New Caledonia: 35 specimens.

19. Alstonia lanceolifera S. Moore — Fig. 5.21

Alstonia lanceolifera S. Moore, J. Linn. Soc. Bot. 45 (1921) 362; Boiteau et al., Adansonia sér. 2, 16 (1977) 476; Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 192. — *Alstonia lenormandii* var. *lanceolifera* (S. Moore) Monach., Pacific Sci. 3 (1949) 176. — Type: *Compton 766* (holo BM; iso P), New Caledonia, Mt. Koghi, 1914, fl.

Alstonia lanceolifera var. *oleoidea* Boiteau, Pl. New Caled. & Depend. 10 (1981) 194; syn. nov. — Type: *Sevenet 384* (holo P), New Caledonia, Dzumac, 1 Feb. 1973, fl. & fr.

Shrub or small tree, 1–8 m high. *Branches* smooth or rough, without lenticels; branchlets terete, slightly laterally compressed or angled when dried, glabrous, grey-green, yellowish brown or blackish. *Leaves* opposite, petiolate; petiole 2–10 × 1–2 mm, flattened or longitudinally canaliculate above, not widened at the base, colleters minute and densely packed together in the axils; blade dark green above, light green beneath, thickly coriaceous and grey-green or dull brown when dried, narrowly elliptic to narrowly ovate, 3.5–13 × 0.6–4.5 cm, index 2.3–7.8, glabrous on both sides, the apex obtuse or rounded, base acute, cuneate or decurrent onto the petiole, entire and with a distinct revolute margin; midrib impressed above; secondary veins in 18–27 (–32) pairs, rather straight and forming an angle of (65–)80–90° with the midrib, (1–)2–5 mm from each other, very often distinctly branched around the middle or near the leaf-margin and with some thin intermediate veins; tertiary venation reticulate, mostly conspicuous. *Inflorescence* 2.5–6(–9) cm long, terminal, many-flowered; peduncle 1–3.3 cm long, glabrous as on the branches; pedicels slender, 2–5(–6.5) × 0.3–0.5 mm, glabrous. *Bracts* and *bracteoles* scale- or sepal-like, ovate or triangular up to 1 mm long (rarely leafy bracts), glabrous on both sides, not ciliate, apex obtuse or acute. *Flowers* fragrant. *Sepals* connate at the base for 0.1–0.2 mm, ovate, suborbicular or broadly ovate, 0.7–1(–1.1) × 0.7–1.2 mm, index 0.7–1.3, erect, glabrous on both sides, apex obtuse or rounded, almost translucent around the apex and margin, not ciliate, mostly the two outer ones larger than the inner three. *Corolla* white or yellow, 2.7–3.4 mm long in the mature bud and forming a subglobose or broadly ovoid head 0.29–0.36 of the bud length, c. 1 mm in diameter, with an obtuse or rounded apex, glabrous outside, with two hairy belts inside, the first belt shortly pubescent starting from 0.7–0.9 mm above the base to the insertion of the stamens (0.3–0.6 mm wide), the second belt villose at the extreme base of the corolla lobes and moustache-like surrounding the mouth of the corolla tube, around the stamens sometimes only a few hairs; the tube almost cylindrical or slightly widening around the stamens, 2.2–2.5 mm long, c. 1 mm wide, 1.9–2.7 × as long as the sepals, 1.1–1.5(–2.5) × as long as the lobes; lobes suborbicular or broadly ovate, (1–)1.5–2 × 1.8–2.2 mm, index 0.5–1, auriculate at the base (on both sides), not ciliate, spreading. *Stamens* with apex 0.3–

0.6 mm below the mouth of the corolla tube, inserted at 0.5–0.6 of the length of the corolla tube (1.2–1.5 mm from the base); filaments 0.2–0.3 mm long, filiform; anthers ovate, (0.4–)0.5–0.8 × 0.3–0.4 mm, obtuse. *Pistil* 1.2–1.5 mm long; ovary glabrous, ovoid, 0.5–0.7 × 0.5–0.7 mm, composed of 2 carpels, a disk-like thickening at the base up to 0.1 mm high (sometimes obscure); style 0.3–0.6 mm long, laterally compressed, mostly longitudinally canaliculate on both sides; pistil head 0.3–0.4 mm high, sparsely hairy around the apex, composed of a basal ring up to 0.1 mm high, a conical central part 0.15–0.2 × 0.2 mm, and a cleft stigmoid apical part up to 0.15 mm high. *Fruit* a pair of follicles, 4.5–15(–21) cm long, 3–4.3(–5.5) mm in diameter, striate, glabrous, spreading and more or less horizontal. *Seeds* 5–11 mm long, main part elliptic or narrowly elliptic 3–5 × 2–3 mm, ends elongated, one end bifid or sometimes with unequal lobes, the other end obtuse or acuminate with an acumen up to 3.5 mm long, pubescent on both sides, ciliate up to 1.2 mm long, reduced and becoming shorter towards the middle of the side margins, hilum circular, c. 0.2 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Riverine or rather dry gully forests, rocky slopes, or on ultrabasic soils. Altitude 20–800 m.

Note — See under *Alstonia stenophylla* Guillaumin.

Specimens studied: New Caledonia: 41 specimens.

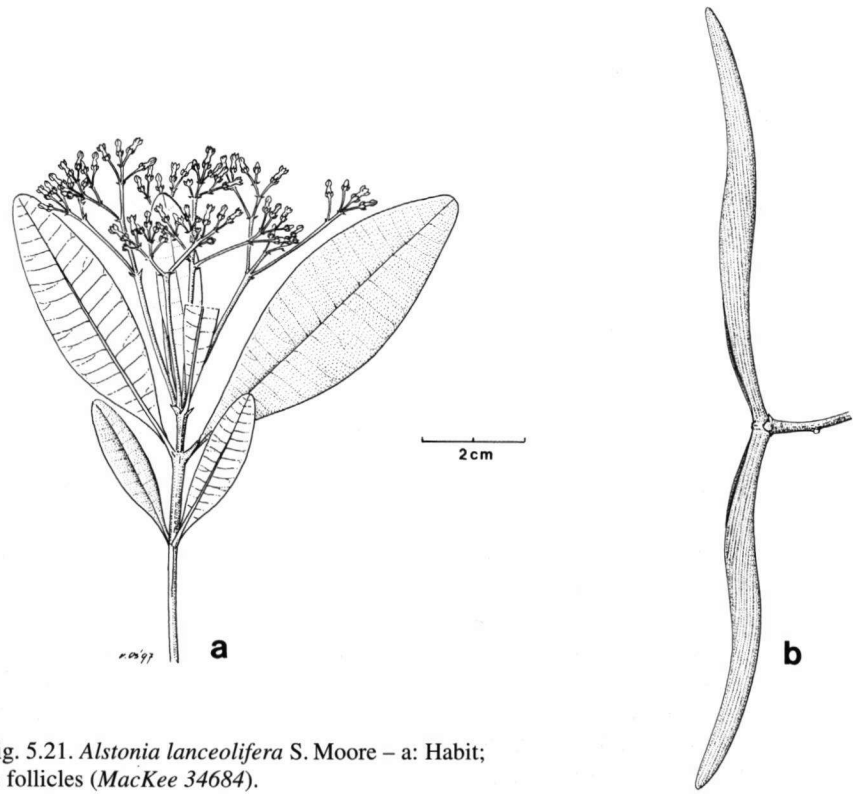


Fig. 5.21. *Alstonia lanceolifera* S. Moore – a: Habit; b: follicles (*MacKee 34684*).

20. Alstonia legouixiae Van Heurck & Müll. Arg.

Alstonia legouixiae Van Heurck & Müll. Arg., Flora 53 (1870) 171. — Type: *Vieillard 920* (holo AWH; iso G, K, P), New Caledonia, Baie de Tupili, 1861–1867, fl.

Alstonia legouixiae var. *linearis* Boiteau, Adansonia sér. 2, 16 (1977) 483; syn. nov. — Type: *MacKee 29115* (holo P; iso K, L), New Caledonia, Mt. Do, 13 Aug. 1974, fl. & fr.

Alstonia legouixiae var. *obtusalabastra* Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 202; syn. nov. — Type: *MacKee 21705* (holo P; iso K, L), New Caledonia, Kouaoua, 30 March 1970, fl. & fr.

Shrub or small tree, (0.6–)1–4 m high. *Branches* rather rough, sometimes lenticellate; *Branchlets* terete, laterally compressed or quadrangular when dried, grey-green, brown or blackish. *Leaves* opposite or in whorls of 3, petiolate; petiole glabrous, 5–20 × 1–2 (–2.5) mm, flattened or shallowly canaliculate above, slightly widening but without an intrapetiolar stipule at the base and more or less clasping the branchlet, few to many minute colleters densely packed together in the axils; blade dark green above and light green beneath, or grey-green to brown above, paler beneath and thinly coriaceous to coriaceous when dried, narrowly ovate to narrowly obovate (rarely elliptic, ovate or obovate), sometimes linear, 3–17.5 × 0.5–4 cm, index 2.3–11.2(–14), glabrous on both sides, apex obtuse or rounded (both may occur on the same branch), base acute to decurrent onto the petiole, margin entire, revolute; midrib impressed above; secondary veins parallel or sometimes not, mostly inconspicuous, rather straight or slightly recurved, in 20–32 pairs and forming an angle of (70–)80–90° with the midrib, 1.5–6(–8) mm from each other, obscure submarginal vein present; tertiary venation inconspicuous or obscurely reticulate. *Inflorescence* 3–19 cm long, terminal, many-flowered; peduncle 1–7.5 cm long, rather stout, 1–2.5 mm wide, glabrous as on the branches; pedicels 4–6(–10) × 0.5–0.7 mm, laterally compressed, glabrous, sometimes with 1 or 2 bracteoles below the calyx or around the middle. *Bracts* and *bracteoles* scale- or sepal-like, triangular, ovate to broadly ovate (more or less 'boomerang-shaped'), 0.1–1.5 mm high, slightly clasping the inflorescence branch or branchlet, glabrous on both sides, with an almost translucent margin, obtuse or rounded, sometimes acute or acuminate, not ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.1–0.2 mm, ovate to broadly ovate, 0.9–1.8 × 0.6–1.6 mm, index 0.7–1.7, erect, sometimes slightly spreading when dried, glabrous on both sides, obtuse or rounded, with an almost translucent margin, not ciliate, mostly the outer three larger than the inner two. *Corolla* white, sometimes purplish or pinkish on the tube, 5–9 mm long in the mature bud and forming an ovoid or narrowly ovoid head 0.4–0.6 of the bud length, 2.2–5 × 1–1.4 mm, with a blunt or sometimes pointed apex, glabrous outside, with two hairy belts inside, the first belt shortly pubescent from 0.8–1 mm above the base to the insertion of the stamens (0.5–1(–1.4) mm wide) (around the stamens usually sparsely hairy, sometimes glabrous), the second belt densely villose starting with short and sparse hairs from 0.3–1(–1.5) mm below the mouth of the corolla tube and becoming dense around the mouth and base of the corolla lobes, then reducing towards the middle to 1–2.5(–3.6) mm above the mouth; tube 3.2–5.2 mm long, almost cylindrical or mostly widening around the stamens and 1.3–1.7 mm wide (at the base 1–1.2 mm wide), 2.2–3.8 × as long as the sepals, 0.6–1.6 × as long as the lobes; lobes ovate to very narrowly ovate, 2.4–7.2 × (1–)1.4–2 mm, index 2–4.8, mostly

slightly falcate, very sparsely ciliate around the apex or not, minutely auriculate at the base on the right side, spreading. *Stamens* with apex 0.9–1.8 mm below the mouth of the corolla tube, inserted at 0.4–0.5 of the length of the corolla tube (at 1.5–2(–2.4) mm from the base); filaments short, 0.2–0.4 mm long, filiform; anthers ovate, 0.9–1.3 × 0.3–0.5 mm, apex obtuse, acute or mucronulate. *Pistil* 0.8–1.5 × as long as the longest sepals, 1.2–1.9 mm long; ovary ovoid, 0.6–0.8 × 0.5–0.8 mm, glabrous, composed of 2 carpels, disk-like thickening at the base indistinct; style 0.1–0.4 mm long; pistil head ovoid or pagoda-like, 0.4–0.6 mm high, minutely hairy at the apex, composed of a basal ring c. 0.2 × 0.3–0.4 mm, a cylindrical or conical central part 0.2–0.3 × c. 0.2 mm, and a cleft stigmoid apical part 0.05–0.2 mm long. *Fruit* a pair of follicles, 2–10.5 cm long, 3.5–5.5 mm in diameter, glabrous, striate, with an obtuse or rounded apex, spreading or reflexed. *Seeds* 4–9 × 2.2–2.5 mm (main part elliptic, 3–4 × 2–2.2 mm), one end obtuse or acuminate with an acumen up to 2 mm long, sometimes irregularly dentate at the margin, the other end usually bifid or sometimes unequally lobed, or sometimes unequally lobed at both ends, densely pubescent on both sides, cilia up to 1 mm long and gradually becoming shorter and sparser towards the margins, hilum circular, c. 0.2 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Open forests, dominated by *Araucaria* and *Nothofagus,* on slopes or riversides, on ultrabasic or serpentinic soils. Altitude 20–1300 m.

Note — There are no suitable characters to subdivide this species into the varieties recognised by Boiteau in the Flora of New Caledonia (1981). Linear leaves may be found in all varieties Boiteau described (var. *legouixiae, linearis,* and *obtusalabastra*); also, the leaf arrangement varies within the varieties.

Specimens studied: New Caledonia: 92 specimens.

21. **Alstonia lenormandii** Van Heurck & Müll. Arg.

Alstonia lenormandii Van Heurck & Müll. Arg., Flora 53 (1870) 172. — Type: *Vieillard 919* (holo AWH; iso A, G, L, P), New Caledonia, Baie d'Urville, Kanala, 1861–1867, fl. & fr.

Alstonia comptonii S. Moore, J. Linn. Soc. Bot. 45 (1921) 363. — *Alstonia lenormandii* var. *comptonii* (S. Moore) Boiteau, Adansonia sér. 2, 16 (1977) 483; syn. nov. — Type: *Compton 953* (holo BM, photograph in P), New Caledonia, Kuakue, 14 May 1914, fl.

Alstonia saligna S. Moore, J. Linn. Soc. Bot. 45 (1921) 364; syn. nov. — Type: *Compton 1009* (holo BM, photograph in P), New Caledonia, River Ngoye, 24 May 1914, fl.

Alstonia lenormandii var. *minutifolia* Boiteau, Adansonia sér. 2, 16 (1977) 480; syn. nov. — Type: *MacKee 22269* (holo P), New Caledonia, Port Boise, 10 July 1970, fl. & fr.

Shrub or small tree, 1–9 m high, with copious white latex. *Branches* smooth or slightly rough, without lenticels; branchlets terete, laterally compressed, slightly sulcate or wrinkled when dried, glabrous, grey-green to dark brown or blackish. *Leaves* opposite, petiolate; petiole glabrous, (2–)4–25(–43) × (0.5–)1–2 mm, canaliculate above, without or with a distinct intrapetiolar stipule on the distal part at the base, slightly widening and more or less clasping the branchlet, few to many minute colleters densely packed together in the axils; blade dark green above and light green beneath, or grey-green to dark brown above, paler beneath, chartaceous or thinly coriaceous when

dried, ovate to narrowly obovate, sometimes linear, (1.5–)3–22 × (0.4–)1–6(–8) cm, index 1.6–7.1(–11.7), glabrous on both sides, apex obtuse, rounded or retuse, base acute to decurrent onto the petiole, rarely obtuse, the margin entire, undulate, mostly reflexed when dried; midrib impressed above; secondary veins parallel or sometimes not, rather straight, sometimes slightly recurved, in (8–)10–30(–40) pairs and forming an angle of (60–)70–90° with the midrib, 1.5–10(–13) mm from each other, often confused by the occurrence of some minute parallel intermediate veins, conspicuous submarginal vein present; tertiary venation reticulate, conspicuous beneath. *Inflorescence* 2–15 cm, many-flowered; peduncle (0.6–)1–7.5 cm long, slender or rather stout, (0.7–)1–1.5 mm wide, glabrous as the branches; pedicels slender, 3–8 × 0.3–0.4 mm, sometimes laterally compressed, glabrous, sometimes with 1 or 2 bracteoles around the middle. *Bracts* and *bracteoles* scale- or sepal-like, triangular, ovate to broadly ovate, 0.2–0.8 mm high, more or less clasping the inflorescence branch or branchlet, glabrous, almost translucent except at the base, obtuse or rounded, sometimes acute, not ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.1–0.2 mm, ovate to broadly ovate, 0.5–0.9(–1.2) × 0.4–1(–1.2) mm, index 0.7–1.3(–1.5), erect, sometimes slightly spreading when dried, glabrous on both sides, obtuse or rounded, with an almost translucent margin, not ciliate, mostly three of them larger than the other two. *Corolla* white (rarely yellow), 3–6(–7) mm long in the mature bud and forming an ovoid or narrowly ovoid head (0.44–)0.5–0.7 of the bud length, (1.5–)2–4 × 0.7–1.1 mm when dried, with a blunt apex, glabrous outside, with two hairy belts inside, the first belt shortly pubescent from 0.6–1 mm above the base to the insertion of the stamens (0.4–0.8(–0.9) mm wide) (around the stamens glabrous or very sparsely hairy), the second belt pilose (0.6–2.3 mm wide) starting with short and sparse hairs from (0–)0.2–0.5 mm below the mouth of the corolla tube and becoming dense around the mouth and the base of the corolla lobes, then reducing towards the middle to 0.3–2.5 mm above the mouth; tube 2–3.8 mm long, almost cylindrical or slightly widening around the stamens and 0.9–1.2 mm wide (at the base 0.8–0.9 mm wide), 2.5–5 × as long as the sepals, 0.4–1.1 × as long as the lobes; lobes ovate to very narrowly ovate, (2–)2.3–6(–7.5) × 1–1.8 mm, index (1.6–)2–4.6, mostly slightly falcate, not ciliate (or rarely very sparsely ciliate), minutely auriculate at the base on the right side, spreading. *Stamens* with apex 0.4–1 mm below the mouth of the corolla tube, inserted at 0.4–0.65 of the length of the corolla tube (at 1–1.7 mm from the base); filaments short, 0.2–0.3 mm long, filiform; anthers ovate, (0.5–)0.6–0.8 × 0.25–0.35 mm, apex obtuse, rarely acute. *Pistil* 1.3–2(–2.5) × as long as the longest sepals, 1.2–1.7(–1.9) mm long; ovary ovoid or subtriangular, 0.5–0.8 × 0.45–0.7 mm, composed of 2 carpels, with or without a disk-like thickening at the base up to 0.1 mm high; style 0.2–0.45(–0.65) mm long; pistil head ovoid or pagoda-shaped, 0.3–0.5 mm high, minutely hairy at the apex, composed of a basal ring 0.05–0.1 × 0.25–0.3 mm, a cylindrical or conical central part 0.1–0.2 × 0.1–0.2 mm, and a cleft stigmoid apical part 0.05–0.15(–0.2) mm long. *Fruit* a pair of follicles, 3.5–13 cm long, 2.7–4 mm in diameter, glabrous, striate, with an obtuse apex, spreading or reflexed. *Seeds* 6–11.5(–14) × 1.7–2.5 mm (main part elliptic 3–4.7 × 1.5–2.3 mm), one end shortly or narrowly long acuminate with an acumen 1.5–4 mm long, sometimes irregularly dentate at the margin, the other end bifid or sometimes unequally lobed, densely pubescent on both sides, sometimes glabrescent or less hairy on the hilar side, cilia up to 1–1.4 mm long and

gradually becoming shorter and often fewer towards the middle (side) of the margin, hilum ellipsoid, c. 0.23 × 0.15 mm, sometimes circular, c. 0.15 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Humid forests, on riversides, on alluvial or rocky serpentinic soils. It was reported (*Gentry & McPherson 34586*) that this species grows on ultrabasic soil in *Nothofagus* forest. Altitude 0–400 m.

Notes — *Alstonia comptonii* S. Moore (= *A. lenormandii* var. *comptonii* Boiteau), *A. lenormandii* var. *minutifolia* Boiteau, and *A. saligna* S. Moore cannot be maintained here. There were some intermediate specimens found which approach one of the species (*A. lenormandii*). Listed in an intergrading order, some of these specimens are: *MacKee 26652, 27099, 32531, Compton 953* (type of *A. comptonii*), *1009* (type of *A. saligna*), *Baumann-Bodenheim 13811, Franc 235, 235 ser. A, MacKee 19015, 31911, 32964, 32970, 36568* and some other specimens which are very similar to *Vieillard 919* (type of *A. lenormandii*). Clearly this species has a very large variation in leaf characters. Linear leaves are found in *Compton 1009* (up to 11.7 × as long as wide, 4.5–8.2 × 0.4–0.7 cm), and the longest leaves (up to 22 × 5 cm) and highest number of secondary veins (up to 40 pairs) are found in the type of *A. comptonii.*

In addition, two other sources of variation were observed: very sparsely ciliate corolla lobes are found only in some flowers of *Guillaumin & Baumann-Bodenheim 10938* and *Hürlimann 1511*, and yellow flowers have been noted only in *MacKee 2633*, collected on the northern side of the Thi River Valley, altitude 200–300 m.

Boiteau (1981) placed *A. saligna* in the synonymy of *A. legouixiae* var. *linearis* Boiteau, from which it looks very different. *Alstonia saligna* has much smaller flowers, the secondary veins are conspicuous beneath, and the leaves are chartaceous. Based on flower characteristics, Monachino (1949) also suggested that the species was better placed within *A. lenormandii.*

Specimens studied: New Caledonia: 82 specimens.

22. Alstonia longifolia (A.DC.) Pichon — Fig. 5.22 & 5.23

Alstonia longifolia (A.DC.) Pichon, Bull. Mus. Nat. Hist. Nat. Paris 2, 19 (1947) 297. — *Rauvolfia longifolia* A. DC., Prodr. 8 (1844) 338. — *Tonduzia longifolia* (A. DC.) Markgr. in Feddes Repert. 20 (1924) 112. [(Woodson, N. Am. Fl. 29 (1937) 122, made a similar combination previously done by Markgraf.] — Type: *Hartweg 491* (holo G-DC; iso K, P), Mexico, (mountain) near San Miquel Sola, 1839, fl.

Rauvolfia stenophylla Donn. Sm., Bot. Gaz. 44 (1907) 115. — *Tonduzia stenophylla* (Donn Sm.) Pittier, Contr. U.S. Natl. Herb. 12 (1908) 104. — Type: *Carlos Renson 289* (holo US, not seen), El Salvador, near San Salvador.

Tonduzia parvifolia Pittier, Contr. U.S. Natl. Herb. 12 (1908) 103. — Type: *Cook & Doyle 33* (holo US), Costa Rica, Angostura, near Turrialba, 11 Apr. 1903, fl. & fr.

Tonduzia pittieri Donn. Sm., Bot. Gaz. 49 (1910) 456. — *Alstonia pittieri* (Donn. Sm.) A.H. Gentry, Ann. Missouri Bot. Gard. 70 (1938) 206; syn. nov. — Type: *Deam 6098* (lecto US, designated here; isolecto MO, not seen), Guatemala, 1 June 1909, fl. & fr.

Tonduzia macrantha Woods., Ann. Missouri Bot. Gard. 24 (1937) 12. — *Alstonia macrantha* (Woods.) A.H. Gentry, Ann. Missouri Bot. Gard. 70 (1983) 206; syn. nov. — Type: *Skutch 871* (holo MO, not seen; iso US), Guatemala, Quezaltenango, 30 July 1934, fl. & fr.

Tonduzia longipedunculata Woods., Publ. Field Mus. Nat. Hist. Bot. 23 (1944) 78. — Type: *Steyermark 47313* (holo MO, not seen).

Shrub or tree, 3–20 m high; trunk up to 40 cm in diameter. *Branches* smooth, lenticellate or not, very often with minute horizontal rings formed by leaf-scars; branchlets terete, or slightly angled or sometimes sulcate when dried, glabrous, grey or yellowish brown, often resinous on the bud when dried. *Leaves* in whorls of 3 or sometimes 4, petiolate; petiole (3–)5–15(–20) × 0.7–1.3 mm, canaliculate above, glabrous, intrapetiolar stipule absent, many minute colleters densely packed together in the axils; blade chartaceous or thinly coriaceous when dried, narrowly ovate to narrowly obovate (usually narrowly elliptic), rarely elliptic, 3.5–20 × 1–3.8 cm, index (2.2–)3.5–8.4, apex gradually acuminate with a pointed acumen, base acute or decurrent onto the petiole, glabrous on both sides, margin entire or sometimes slightly undulate and/or revolute; midrib flat or impressed above; secondary veins thin, in 15–40 pairs, parallel or not and forming an angle of 50–70° with the midrib, (1–)2–4(–6) mm from each other, sometimes confused with some thin (shorter) intermediate veins, slightly arched and joining near the margin forming a thin submarginal vein; tertiary venation reticulate, mostly inconspicuous. *Inflorescence* 2–7 cm long, terminal, many-flowered; peduncle 0.5–3 cm long, glabrous as on the branches; pedicels slender, 1.5–5(–6.5) × 0.3–0.5 mm, glabrous. *Bracts* and *bracteoles* scale- or sepal-like, ovate or triangular up to 1(–1.5) mm long, obtuse, acuminate or mucronulate, glabrous and almost translucent around the margin, and some colleters in the axil. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.3 mm, ovate or triangular, 1–1.5 × 0.8–1(–1.5) mm, index 1–1.5, acute, obtuse or mucronulate, almost translucent around the margin, erect, sometimes slightly spreading when dried, glabrous on both sides, not ciliate. *Corolla* white or cream, 6–12(–14) mm long in the mature bud and forming an ovoid or narrowly ovoid head 0.36–0.54 of the bud length, 2.3–5(–7) × 1–1.5 mm with a blunt or rounded apex when dried, glabrous outside, a hairy belt inside, starting with dense hairs from 0.8–2 mm above the base and ending at the insertion of the stamens and then reduced to shortly pubescent above the stamens or around the basal part of the throat, and again from there with longer hairs (sparsely velutinous) to the base of the corolla lobes (up to 2 mm above the mouth); tube 4.2–8 mm long, slightly widening around the stamens and 1–1.8 mm wide (the base and throat usually roughly similar and 0.8–1 mm wide), 4.2–5.9 × as long as the sepals, 0.8–1.7 × as long as the lobes; lobes ovate or lingulate, 2.5–8.5 × 1.2–3.7 mm, index (1.52–)1.8–3, sometimes slightly oblique, apex rounded, not ciliate, auriculate at the base on the left side, spreading. *Stamens* with apex 1.5–3.7 mm below the mouth of the corolla tube, inserted at 0.31–0.57 of the length of the corolla tube (at (1.6–)2–4 mm from the base); filaments 0.3–0.5 mm long, filiform; anthers ovate or narrowly ovate, 1–1.3(–1.6) × 0.3–0.4 mm, acute, obtuse or mucronulate. *Pistil* 2–4(–5) mm long; ovary glabrous, subglobose or slightly quadrangular in transverse section, 0.5–1 × 0.5–0.9 mm, composed of 2 carpels, a disk-like thickening at the base 0.1–0.35 mm high; style 1–2.7 mm long, filiform; pistil head 0.7–1.3 mm high, composed of a narrow membranous basal veil up to 0.1 mm high, then a woolly ring 0.1–0.2 × 0.3–0.5 mm, a cylindrical central part (which sometimes has minute hairs at the apex) 0.2–0.4 × 0.2–0.3 mm, and a narrow cleft stigmoid apex 0.3–0.7 mm high. *Fruit* a pair of follicles, 5–17 cm long, 3–5 mm in diameter, base stipitate (up to 10 mm long) or not, apex with an obscure or a distinct

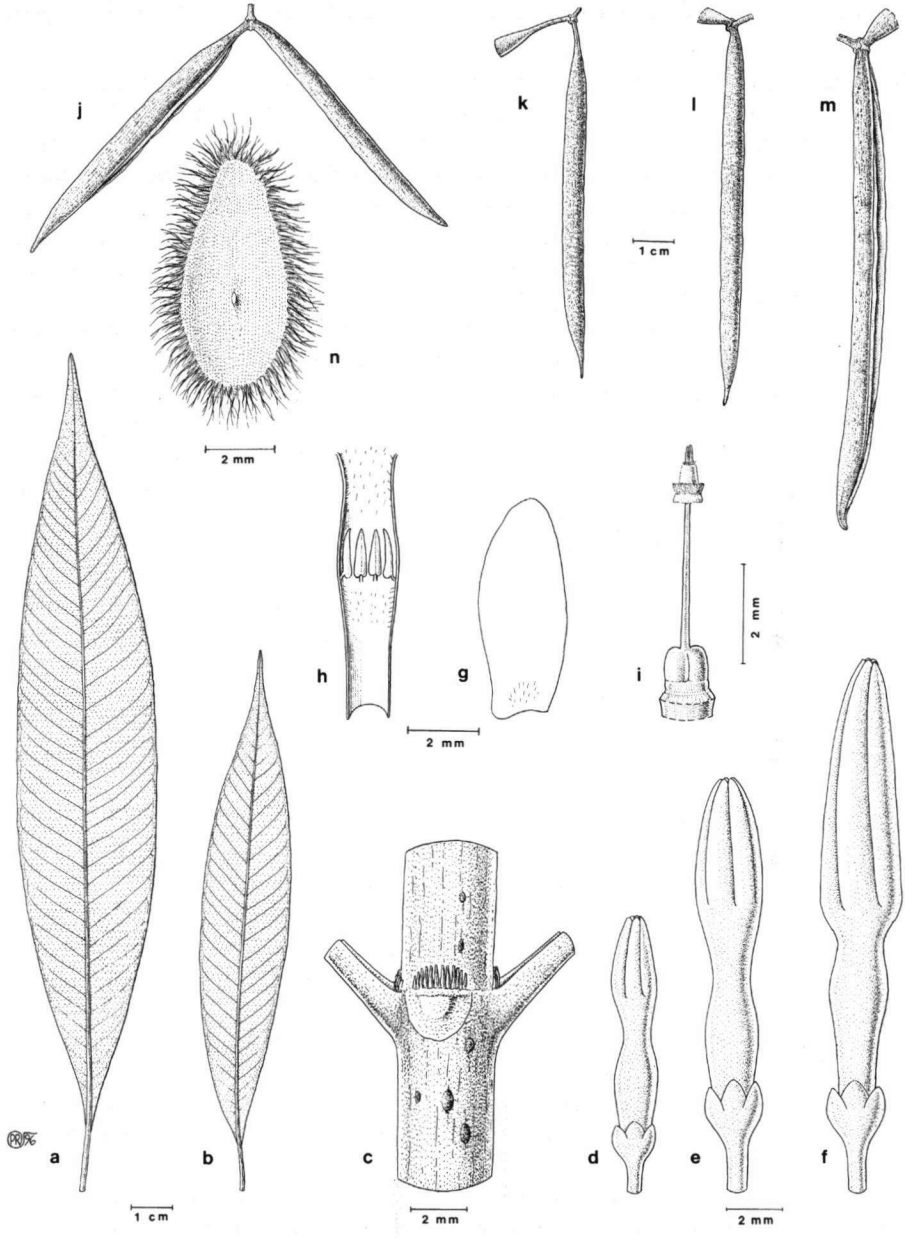


Fig. 5.22. *Alstonia longifolia* (A. DC.) Pichon – a, b: Leaves; c: branchlet, showing colleters in the leaf axils; d–f: flowers in bud; g: corolla lobe; h: dissected corolla tube, showing 4 anthers; i: pistil; j: stipitate and non-stipitate follicles occurring side by side; k: follicles both distinctly stipitate; l, m: follicles obscurely stipitate; n: seed (a, c: *Skutch 871*; b, k: *Allen & Severen 6924*; d: *Deam 6098*; e: *Haber & Bello 7202*; f: *Hartweg 491*; g–i: *Hinton 3968*; j: *Tonduz 11619*; l: *Stevens & Krukoff 6082*; m: *Cook & Doyle 33*; n: *Soejarto et al. 7241*).

narrow tip up to 6 mm long, minutely striate, glabrous, slightly spreading, sometimes even horizontally. *Seeds* elliptic or narrowly elliptic, 7–13(–15) × (2.6–)3–3.5 mm, ends various in shape, one end mostly obtuse, sometimes acuminate with an acumen up to 2.5 mm long, the other end bifid or unequally lobed (similar shapes at both ends can also be observed), glabrescent on hilar side, pubescent with dense scale-like hairs or glabrescent on the other side, forming a minute reticulate structure on both sides, cilia arranged in groups of various shapes and sizes and thus seem to be branching, up to 1–3.5 mm long, hilum circular and 0.1–0.2 mm in diameter or elliptic and 0.25–0.35 × c. 0.1 mm.

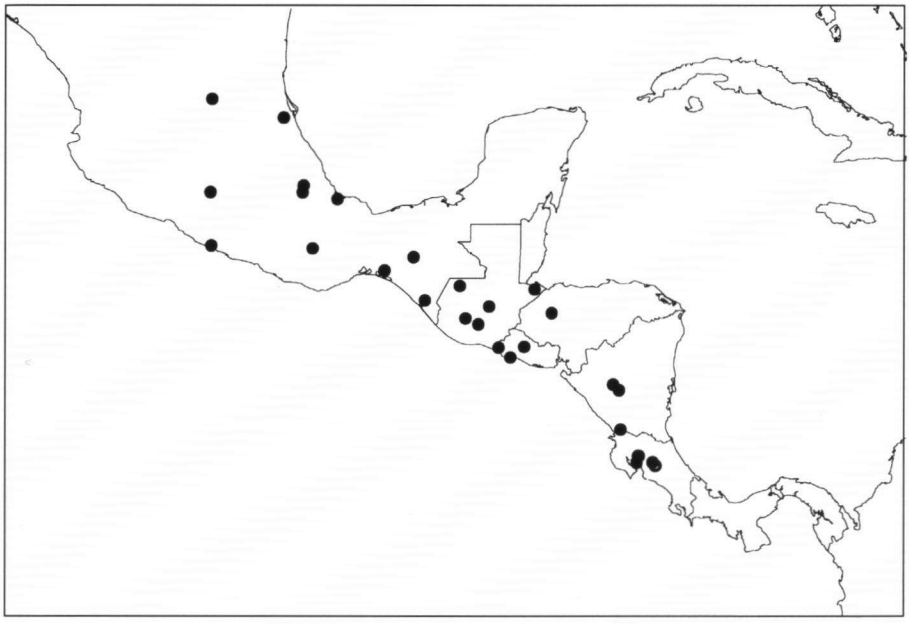


Fig. 5.23. Distribution of *Alstonia longifolia* (A. DC.) Pichon.

Distribution — Central America: Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica.

Habitat & Ecology — Open woodlands or dense tropical forests, on slopes or on hills and rocky soils, usually as secondary growth trees. Altitude 650–1700(–2050) m.

Vernacular name — Guatemala, El Progeso: *quina* (Spanish).

Uses — Reported to remedy malaria (*Castillo & Luarca 1758*).

Notes — Very variable characters were observed within this species, e.g., in leaf size, flower, and fruit characteristics. Elliptic leaves have only been found in one specimen from Oaxaca (Mexico). This specimen was collected at a high altitude, 2050 m, *Torres & Garcia C 6650* (F).

Two new synonyms are added here (*Alstonia pittieri* = *Tonduzia pittieri,* and *Alstonia macrantha* = *Tonduzia macrantha*). According to Gentry (1983), who included both species in *Alstonia*, *A. macrantha* has larger leaves and flowers than *A. pittieri*.

Woodson (1937) (including the species in *Tonduzia*) wrote that *A. macrantha* had larger leaves and flowers than the other American species of *Alstonia*. The present author observed several specimens which were intermediate in the size of the leaves and flowers. Some of these specimens: *Bernoulli & Cario 1809* (K), *Bourgeau 2446* (K, P), *Hartweg 491* (type of *Rauvolfia longifolia*) (K, P), *Ortega 300* (K).

A stipitate follicle could have been a good character to subdivide the taxon into various species, but it is not consistent. One specimen, *Tonduz 11619*, has both stipitate and non-stipitate follicles. Some other specimens with obscurely stipitate follicles are *Castillo & Luarca 1695* (F), *Doranthes DO 13391* (=*1238*) (GH), *Stevens & Krukoff 6082* (MO), *Tonduz 17694* (Z).

Specimens studied: Mexico: 19 specimens. – Guatemala: 10. – Honduras: 1 (Dept. of Comayagua, Yojoa Lake, *Edwards 448*). – El Salvador: 7. – Nicaragua: 6. – Costa Rica: 9.

23. Alstonia macrophylla Wall. ex G. Don — Fig. 5.24 & 5.25

Alstonia macrophylla Wall. ex G. Don, Gen. Syst. 4 (1837) 87; De Candolle, Prodr. 8 (1844) 409; Kerr, Fl. Siam. En. 2 (1939) 440. — Type: *Wallich 1648* (holo K-W), India, Hort. Bot. Calcutta, fl. & fr.

Alstonia macrophylla β *glabra* A. DC., Prodr. 8 (1844) 410. — *Alstonia costata* Wall. ex Miq., Fl. Ind. Bat. 2 (1856) 439, non R. Br. (1811). — Type: *Wallich 1649* (holo K-W; iso K), Malaysia, Penang, 1822, fl. & fr.

Alstonia batino Blanco, Fl. Philipp. 2 (Suppl.) (1845) 589. — Neotype: *Merrill Species Blancoanae 335* (neo L, designated here; isoneo A, BM, BO, F, K, MO, P, W), Philippines, Luzon, Bulacan Province, Angat, Sept. 1913, fl.

Alstonia acuminata Miq., Ann. Mus. Bot. Lugd.-Bat. 4 (1869) 140. — *Alstonia macrophylla* var. *acuminata* (Miq.) Monach., Pacific Sci. 3 (1949) 166. — Type: *de Vriese & Teijsmann s.n.* (holo L), Indonesia, Maluku, Ceram (= Seram), 1859–1860, fl.

Alstonia subsessilis Miq., Ann. Mus. Bot. Lugd.-Bat. 4 (1869) 140. — Type: *de Fretes 5574* (holo L; iso U), Indonesia, Amboina (= Ambon).

Alstonia pangkorensis King & Gamble, J. Asiat. Soc. Bengal 74, 2 (1907) 442. — Type: *Scortechini 1024* (lecto BM, designated here), Malaysia, Pangkor Island, July 1884, fr.

Alstonia paucinervia Merr., Philipp. J. Sci. 5, Bot. (1910) 224. — Type: *Darling (For. Bur.) 18726* (holo PNH †; lecto US, designated here), Philippines, Luzon, Camarines Province, 1910, fr.

Alstonia oblongifolia Merr., Philipp. J. Sci. 10, Bot. (1915) 65. — Type: *Curran (For. Bur.) 4495* (holo PNH †; lecto K, designated here; isolecto P, US), Philippines, Palawan, 5 June 1906, fl.

Alstonia macrophylla var. *mollis* Merr., Enum. Philipp. Flow. Pl. 3 (1923) 322. — Type: *Curran (For. Bur.) 17128* (holo PNH †; lecto L, designated here; isolecto BO), Philippines, Luzon, Nagayan Province, Feb. 1909, fl.

Alstonia glabriflora Markgr., Bot. Jahrb. Syst. 61 (1927) 179; Monachino, Pacific Sci. 3 (1949) 167; syn. nov. — Type: *Ledermann 12649* (holo B †; lecto L, designated here), Papua New Guinea, Sepik, 1912–1913, fl.

Alstonia brassii Monach., Pacific Sci. 3 (1949) 166; syn. nov. — Type: *Brass 5138* (holo NY, not seen; iso A, BM), Papua New Guinea, Central District, Mafulu, 9 Nov. 1933, fl.

Alstonia brassii × *spectabilis* Markgr., Blumea 22 (1974) 29; syn. nov. — Type: *van Royen 5333* (lecto L, designated here; isolecto BO, K, KEP), Indonesia, Irian Jaya, Waigeo Island, SW of Kabare, 27 Jan. 1955, fl.

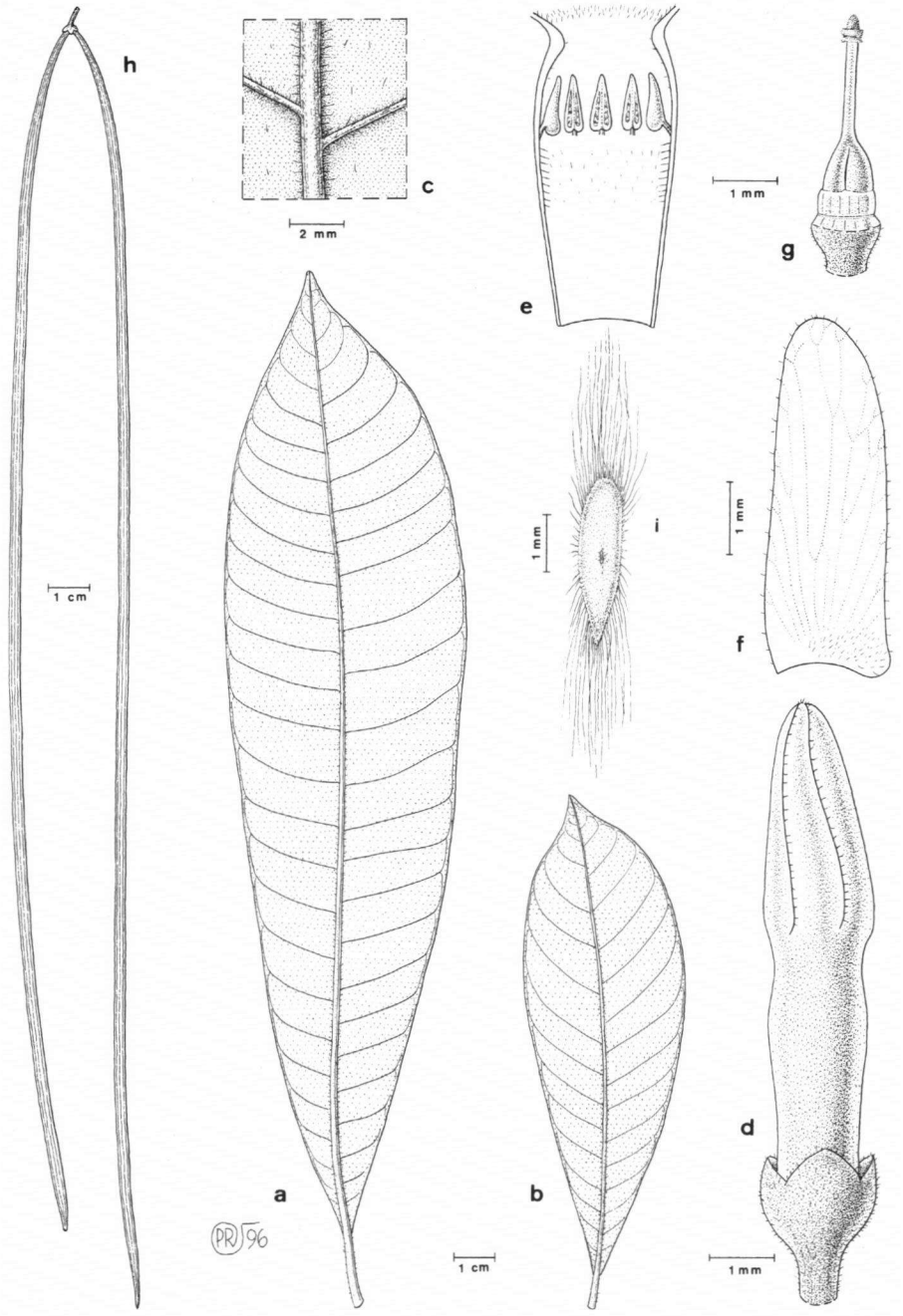


Fig. 5.24. *Alstonia macrophylla* Wall. ex G. Don – a, b: Leaves; c: detailed leaf beneath; d: flower in bud; e: dissected corolla tube; f: corolla lobe; g: pistil, showing an annular disk-like thickening at the base; h: follicles; i: seed (a, d–g: *Ramos 1895*; b: *Tandon 3567*; c, h, i: *Tandon 3257*).

Small or big tree 3–40(–50) m high; trunk 5–100 cm in diameter, buttresses usually absent or small up to 1 m high and spreading up to 2 m at the base. *Bark* smooth or rough, minutely scaly, tuberculate, shallowly longitudinally fissured or both longitudinally and horizontally fissured, silver grey to dark brown; inner bark brittle, hard, creamy, yellowish brown or straw-coloured with cream or orange streaks, whitish inside; softwood pale yellow or pale brown, heartwood light brown to dark-brown. *Branches* smooth or slightly rough, rarely sparsely lenticellate; branchlets terete or slightly angular and sulcate when dried, glabrous, grey-green, brown, or blackish. *Leaves* in whorls of 3 or 4, petiolate, sometimes subsessile; petiole glabrous, 2–25 × 1–2.5(–3) mm, canaliculate or impressed above, colleters minute and densely packed together in the axils, without intrapetiolar stipules; blade shiny dark-green above, light green beneath, chartaceous or coriaceous when dried, obovate or narrowly obovate, sometimes elliptic or narrowly elliptic, 4.5–25(–32) × 1.5–10.5 cm, index 1.7–4.8(–5.8), apex varies from rounded to narrowly acuminate, acumen up to 20 mm long with a blunt tip, base acute to decurrent onto the petiole, sometimes abruptly so, entire, glabrous above, glabrous or densely pubescent beneath; midrib impressed above; secondary veins in 12–25(–31) pairs (short intermediate veins sometimes present), almost straight or slightly arched, forming an angle of (45–)60–80(–90)° with the midrib (both the narrow or the wide angle may occur at the base of the leaves), 3–15 mm from each other, sometimes joining near the margin forming a submarginal vein; tertiary venation reticulate, conspicuous beneath or sometimes on both sides. *Inflorescence* 2–11 cm long, terminal, many-flowered; peduncle 1–6(–8) cm long, slender or rather stout, 0.5–1.5 mm wide, glabrescent or puberulous as on the branches; pedicels (0–)1–4(–6)) × 0.3–0.6(–0.8) mm, puberulous or glabrescent. *Bracts* and *bracteoles* sepal- or scale-like, ovate, triangular, up to 1.5(–2) mm long, obtuse or acute, ciliate, glabrous or puberulous outside, glabrous inside (the bracts at the very base of the inflorescence sometimes larger up to 4 × 1.5 mm, or leafy up to 2.5 × 1 cm). *Flowers* fragrant. *Sepals* connate at the base for 0.5–0.8 mm, ovate or broadly ovate, sometimes turbinate, 1–2.5 × 0.8–1.8 mm, index (0.9–)1.1–2, apex obtuse or rounded, sometimes mucronulate, ciliate, glabrous or puberulous outside, glabrous inside, erect, slightly spreading, sometimes closed when dried. *Corolla* white or cream (sometimes pinkish on the tube), 5–12 × 0.8–1.5 mm in the mature bud and forming an ovoid or narrowly ovoid head 0.25–0.56 of the bud length, 2–6 × 0.8–1.5 mm, with a blunt apex, glabrous or sparsely hairy around the stamens and on the lobed margins outside, two hairy belts inside, the first belt pubescent from 1.5–2.6 mm above the base to the insertion of the stamens (0.8–2 mm wide), the second belt pilose starting from 0–0.7 mm below the mouth to varying from only around the base to over half the length of the lobes (around the stamens very sparsely hairy); tube almost cylindrical or slightly widened around the stamens, 4–6.3 mm long, 0.9–1.8 mm wide (at the base 0.8–1.4 mm wide), 2–5.5 × as long as the sepals, 0.7–1.5 × as long as the lobes; lobes ovate or narrowly ovate, sometimes slightly falcate or oblique, (2.8–)3.6–7 × 1–2.6 mm, index 2.2–5, ciliate (rarely not), apex rounded, auriculate at the base on the right side, spreading. *Stamens* with apex (0.1–)0.3–1.4 mm below the mouth of the corolla tube, inserted at 0.5–0.75 of the length of the corolla tube (at 2.5–3.8(–4.1) mm from the base); filaments 0.4–0.6(–0.8) mm long, filiform; anthers ovate, 0.8–1.5

× 0.3–0.6 mm, apex obtuse, sometimes acute or mucronulate. *Pistil* 1.3–3.2 × as long as the longest sepals, 2.6–4.2 mm long; ovary superior, ovoid (rarely broadly ovoid), (0.6–)0.8–1.4 × 0.7–1 mm, sometimes slightly laterally compressed, composed of 2 carpels, with an annular disk-like thickening at the base 0.2–0.4 mm high, mostly conspicuous; style 1.4–2.5(–2.9) mm long, filiform, canaliculate on both sides; pistil head ovoid 0.4–1 mm long, composed of a thin basal ring 0.1–0.2 mm high, a conical or cylindrical central part 0.3–0.4 × 0.2–0.4 mm, and a minute or narrow cleft stigmoid apical part 0.1–0.4 mm high. *Fruit* a pair of follicles, 25–62 cm long, 2–4(–4.5) mm in diameter, glabrous, minutely or roughly striate. *Seeds* elliptic (sometimes slightly ovate), 5–10.5(–12) × 1.6–2.5 mm, pubescent on both sides, one end acuminate with an acumen 1–5 mm long (sometimes bifid at the apex), the other end rounded (rarely obtuse); cilia forming comas at both ends, 5–10 mm long, becoming gradually shorter along the margins; hilum circular, c. 0.1 mm diameter or elliptic, 0.2–0.3 × c. 0.1 mm.

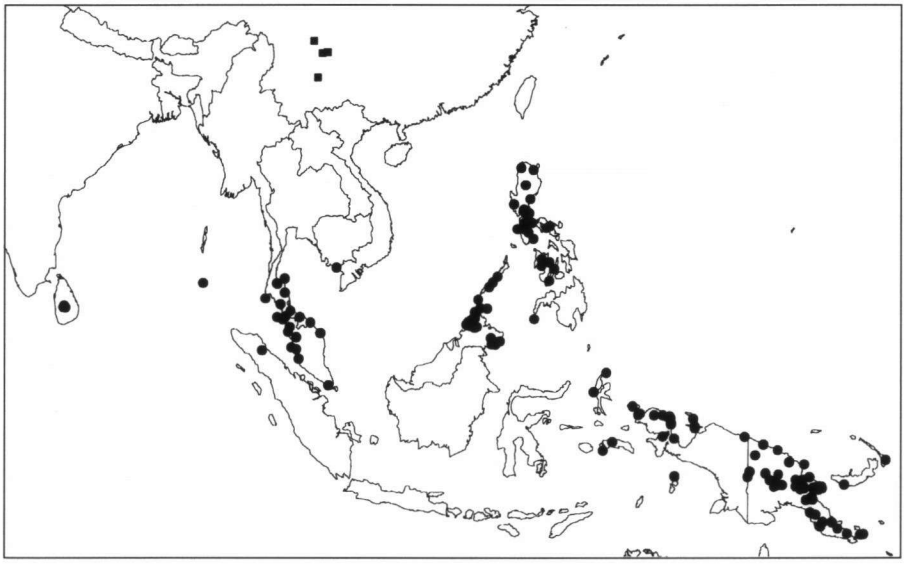


Fig. 5.25. Distribution of *Alstonia macrophylla* Wall. ex G. Don. (●) and *A. mairei* H. Lév. (■).

Distribution — Sri Lanka, India (Nicobar Islands), Thailand, Cambodia, Vietnam, throughout Malesia (except Java, Sulawesi, and Nusa Tenggara). Planted in the Botanical Gardens of Calcutta (India), Singapore, and Bogor (Indonesia, tree no. IV.A. 55A, originally from Ambon).

Habitat & Ecology — Lowland to montane primary and secondary forests, on level lands, slopes or ridges, edge of mangrove, sometimes on flooded areas, and heath forests, with as soil types sandy clay or loam, volcanic, or limestone. Altitude 0–2870 m.

Vernacular names — Philippines: *batialang* (Ifugao, Luzon), *batino*. Malaysia, Sarawak: *sarakad* (Dusun Rungus). Indonesia: Maluku: *galomodorat(i)a* (Tobelo), *kai riti(e)* (Seram), *pule batu* (Ambon); Irian Jaya: *bilimbowo*, *wowor* (Mooi), *ai oi*

(Biak), *warprop* (Amberbakan), *kauba*, *katorori* (Ambai), *setak(k)a* (Manikiong), *aimon* (Kabare), *buo* (Atam, Manikiong). Papua New Guinea: *ai wawoi* (Papua), *andelagar* (Enga, Kepilan), *araba* (Mendi), *dero* (Madang), *hebara* or *hebare* (Huli, Papua), *kabale* (= *?kapare*) (Kutubu, Papua), *kek* (Ingambit).

Uses — Powdered bark mixed with water is used as a traditional medicine, especially against skin diseases.

Notes — *Alstonia macrophylla* is a widespread and very variable species. It is particularly variable in the leaves, flowers, and fruits. According to Monachino (1949) this species probably also occurs in Sulawesi (around Manado and Tomohon) based on some specimens collected by *Koorders* (nos. *16041* (BO), *16042* (BO), *16044* (BO), *19745* (L), and *24068* (L)). Markgraf agreed (l.c. 1974: 28) but only based on *Koorders 16044*. These specimens, in very bad condition, are mostly sterile or have only very old and bad fruits. As yet no flowering specimens have been collected from this area. Therefore, in my opinion, these specimens could also be *A. spectabilis*, a common secondary small to medium tree in Central Sulawesi around Tentena and along the road of Palu-Parigi, in S Sulawesi (around Malili and Soroako), or in SE Sulawesi (between Kendari and Kolaka).

I have reduced *A. glabriflora* Markgr. and *A. brassii* Monach. to the synonymy of *A. macrophylla*. The type of *A. glabriflora* is the specimen with the shortest corolla lobes in the species. Monachino (1949) did not see any specimens belonging to *A. glabriflora* during his revision of the genus. He also described one new species (*A. brassii*) which was mainly differentiated by its longer corolla lobes. This character has become very weak because some transitional characters have been observed in some other (recent) specimens. Many New Guinean specimens (including Irian Jaya) could not be differentiated from *A. macrophylla* as represented by specimens from Maluku. Some specimens showing the transitional characters are: *Argent C 87132* (Seram), *Beguin 1391* (Ternate), *van Royen 5333* (Waigeo Is.), *Iwanggin BW 5783* (Manokwari, Irian Jaya), *Kostermans & Soegeng 895*, *Vink BW 12036* and *BW 15260* (Biak, Irian Jaya), *Schram 12491, 12493* (Sorong, Irian Jaya), *Foreman & Vinas LAE 60288*, *Pullen 8406*, *Sayers NGF 21492*, *Vandenberg et al. NGF 39799*, and *Womersley et al. NGF 37336* (all from Papua New Guinea).

Specimens studied: Sri Lanka: 13 specimens. – Nicobar Islands: 5. – Thailand: 18. – Cambodia: 2. – Vietnam: 2. – Malaysia: Peninsular Malaysia: 31, Sarawak: 2, Sabah: 49. – Singapore: 3. – Philippines: 80. – Indonesia: Sumatra (Aceh): 2, Maluku: 21, Irian Jaya: 32. – Papua New Guinea: 47.

24. Alstonia mairei H. Lév. — Fig. 5.25

Alstonia mairei H. Lév., Cat. Pl. Yunnan (1915) 9; Monachino, Pacific Sci. 3 (1949) 157; Li et al., Fl. China 16 (1995) 156. — *Blaberopus mairei* (H. Lév.) Ly, Feddes Repert. 97 (1986) 616. — Type: *Maire s.n.* (holo E; iso A), China, Yunnan, Rochers de Kiang-ti, fl.

Wikstroemia hemsleyana H. Lév., Bull. Acad. Int. Geogr. Bot. 25 (1915) 41. — Type: *Maire s.n.* (holo E; iso A), Yunnan, Mount de Mo-tsou, fl.

Alstonia paupera Hand.-Mazz., Anz. Ak. Wiss. Wien 57 (1920) 241. — Type: *Handel-Mazzetti 696* (holo W, photo A), China, Yunnan, 18 March 1914, fr.

Shrub up to 1.5 m high. *Branches* smooth or horizontally fissured, without lenticels; branchlets terete, glabrous, greyish or sometimes blackish. *Leaves* in whorls of 3–4 (–5), petiolate; petioles 3–14 × 0.7–1.2 mm, flattened and canaliculate above, winged, many narrow or linear colleters densely packed together in the axils; blade chartaceous when dried, narrowly elliptic or narrowly obovate, sometimes linear, 3–11 × 0.4–2.1 cm, index 3.9–10, apex acute or narrowly acuminate with a pointed tip, acumen up to 1 cm long, base decurrent and forming a narrow wing along the petiole, glabrous on both sides, entire; midrib flat or impressed above; secondary veins in 25–40 pairs, almost parallel and forming an angle of 50–70° with the midrib (near apex and base usually with a smaller angle), (0.6–)1–2 mm from each other, slightly arched and very often confused with some thin (shorter) interstitial veins; tertiary venation inconspicuous. *Inflorescence* 2.5–10 cm long, many-flowered; peduncle (0.5–)1–3 mm long, glabrous; pedicels slende,r 2–10(–15) × 0.3–0.4(–0.5) mm, glabrous. *Bracts* and *bracteoles* scale- or sepal-like, ovate or triangular, up to 1.5(–2) mm long, acute or obtuse, almost translucent, many colleters in the axils, glabrous on both sides. *Flowers* fragrant. *Sepals* connate at the base for c. 0.2 mm, ovate, 1.5–1.8 × 0.8–1 mm, index 1.6–2.1, erect, sometimes slightly spreading when dried, glabrous on both sides, obtuse, almost translucent around the margin, not ciliate. *Corolla* white, 17–22 mm long in the mature bud and forming a narrowly ovoid head 0.27–0.36 of the bud length, narrower than the widest part of the tube (5–8 × 1.2–1.8 mm) with a blunt or pointed apex, glabrous outside, two densely villose belts inside, the first belt at the broader part of the tube, starting from 1–1.5 mm below the stamens (10–14 mm above the base) to 0.5–1 mm below the mouth (3.5–4.5 mm wide), the second belt at the extreme base of the corolla lobes (other parts entirely glabrous); tube 14–20 mm long, widening around the stamens to 2–2.3 mm wide, narrowing at the base to 0.7–0.9 mm wide, 7.8–12 × as long as the sepals, 1.7–2.3 × as long as lobes; lobes ovate or lingulate, 8–9 × 3–3.6 mm, index 1.9–2.7, not ciliate, auriculate at the base on the left side, spreading. *Stamens* with apex 1–1.5 mm below the mouth of the corolla tube, inserted at 0.79–0.82 of the length of the corolla tube (11.5–15.5 mm from the base); filaments 0.7–0.8 mm long, filiform; anthers narrowly ovate, 2.3–2.7 × 0.7–0.8 mm, obtuse. *Pistil* 12.5–15.5 mm long; ovary glabrous, ovoid, 1.3–2 × 0.7–1 mm, composed of 2 carpels, disk with 2 long lobes alternating with the carpels, narrowly ovoid or linear and shorter than the ovary, 0.8–1.1 mm long, mostly slightly laterally compressed; style 9.2–13 mm long, filiform; pistil head pagoda-shaped, 1–1.1 mm high, composed of a membranous basal ring 0.2–0.3 × 0.7–0.8 mm, a woolly cylindrical central part 0.3–0.4 × 0.5–0.8 mm, and an ovoid apical part 0.3–0.4 × 0.3–0.4 mm which has a minute cleft stigmoid at the apex. *Fruit* a pair of follicles, 2.5–6.7 cm long, 2–2.5 mm in diameter, minutely striate or almost smooth, glabrous, usually not stipitate but sometimes with a shortly stipitate follicle together with a non-stipitate one, rostrum 2–3 mm long. *Seeds* elliptic or oblong, 4–6 × 1.6–2 mm, ends rounded, unequally lobed, glabrescent except around the margin with sparse long silky hairs to 6–7.5 mm long; hilum elliptic, c. 0.2 × 0.1 mm or circular, c. 0.15 mm in diameter.

Distribution —Endemic to China: only in the Provinces Szechuan (= Sichuan) and Yunnan.

Habitat & Ecology — Rocky mountains, on slopes or ridges. Altitude (490–)800–2600 m.

Uses — The roots and leaves are used to stop external bleeding (Li et al., 1995).

Specimens studied: China: 16 specimens.

25. Alstonia muelleriana Domin — Fig. 5.26

Alstonia muelleriana Domin, Bibl. Bot. 22 (Heft 89) (1928) 1081; Monachino, Pacific Sci. 3 (1949) 163; Markgraf, Blumea 22 (1974) 27; P.I. Forster, Austral. Syst. Bot. 5 (1992) 752; Fl. Australia 28 (1996) 120. — *Alstonia villosa* F. Muell., Fragm. 6 (1868) 117, non Blume (1826). — Type: *Domin 7855* (lecto PR, designated by P. I. Forster, 1992), Queensland, Cook District, Lake Eacham, Feb. 1910, vegetative.

Alstonia muelleriana var. *parvifolia* Domin, Bibl. Bot. 22 (Heft 89) (1928) 1081. — Type: *Domin 7857* (lecto PR, designated by P.I. Forster, 1992), Queensland, Cook District, Yarraba, Jan. 1910, fl.

Small to medium-sized tree 5–25 m high; trunk 4–40 cm in diameter. *Bark* rough, grey or pale brown, shallowly longitudinally and shallowly horizontally fissured; inner bark yellow or yellowish brown, without exudate. *Branches* smooth or rather rough, lenticellate; branchlets terete, sometimes angular and slightly sulcate when dried, pubescent or glabrous, brownish to dark brown. *Leaves* in whorls of 3 or 4, petiolate; petiole pubescent or glabrous, 4–17 mm long, few or many minute colleters and densely packed together in the axils; blade subcoriaceous when dried, obovate to very narrowly obovate, 3–15 × 1–5.5 cm, index 2.7–4.6, apex shortly acuminate with a blunt acumen up to 7 mm long, sometimes obtuse, base cuneate or decurrent onto the petiole, glabrous above or pubescent only on the midrib and on the secondary veins, pubescent beneath, entire; midrib impressed above; secondary veins rather straight, in 10–15 pairs and forming an angle of 50–80° with the midrib, 4–12 mm from each other; tertiary venation reticulate, conspicuous beneath or sometimes on both sides. *Inflorescence* 4–9 mm long, terminal, many-flowered; peduncle slender, 1.8–6 cm long, pubescent; pedicels 1–2.5 mm long, pubescent. *Bracts* and *bracteoles* scale- or sepal-like, ovate, 1–2 mm long. *Flowers* fragrant. *Sepals* pale green, connate at the base for 0.5–1(–1.5) mm, ovate, 1.7–2.5 × 0.7–1.3 mm, index 1.6–3.6, obtuse, pubescent outside, pubescent or puberulous inside, ciliate, erect. *Corolla* white, 4–9.2 × 1–1.3 mm in the mature bud and forming an ovoid or narrowly ovoid head 0.25–0.5 of the bud length (1–4.2 × 0.9–1.2 mm), with a blunt apex, pubescent outside (except at the base which is surrounded by the calyx), ciliate on lobes, two pubescent belts inside, the first belt starting from 0.8–1.2 mm above the base to the insertion of the stamens (1.4–2.6 mm wide), the second belt from 0.3–1 mm below the mouth and continuing all over the corolla lobes (around the stamens usually very sparsely hairy); tube almost cylindrical or slightly widening around the stamens, 3–5.5 mm long, 1–2 mm wide, 1.3–2.2 × as long as the sepals, 0.7–1.8 × as long as the lobes; lobes obliquely strap-shaped, more or less falcate, 2.1–5 × 0.8–1.4 mm, index 2.6–5, acute or obtuse, spreading. *Stamens* with apex 0.4–1.8(–2.2) mm below the mouth of the corolla tube, inserted at 0.4–0.7 of the length of the corolla tube (at 1.7–2.3 mm from the base); filaments c. 0.5 mm long, filiform, glabrous; anthers ovate, 0.8–1 × 0.3–0.5

mm, apex obtuse. *Pistil* 1.8–2.6 mm long; ovary ovoid, 0.7–1.3 × 0.6–1 mm, mostly slightly laterally compressed, glabrous or sparsely hairy, a disk-like thickening at the base and 0.15–0.35 mm high; style 0.8–1.3 mm long; pistil head ovoid, 0.4–0.8 × 0.3–0.5 mm, composed of a (sometimes double) basal ring 0.07–0.2 mm high, a conical central part 0.2–0.5 × 0.2–0.35 mm, and a cleft stigmoid apical part c. 0.1 mm high, glabrous or minutely hairy. *Fruit* a pair of follicles, 13–32 cm long, 2.5–3 mm in diameter, striate, glabrous. *Seeds* oblong (rarely elliptic), c. 7.5 × 1.3 mm, one end rounded and the other long-acuminate up to 2.5 mm long, pubescent on both sides, coma 8–10 mm long, reducing gradually towards the margins.

Distribution — Indonesia (Irian Jaya), Papua New Guinea, Australia (Queensland).

Habitat & Ecology — Primary or secondary forests, on dry soils. Altitude from 0–700 m.

Specimens studied: Indonesia: Irian Jaya: 2 specimens (*Hoogerwerf 26, Versteegh 4855*). – Papua New Guinea: 14. – Australia: 35.

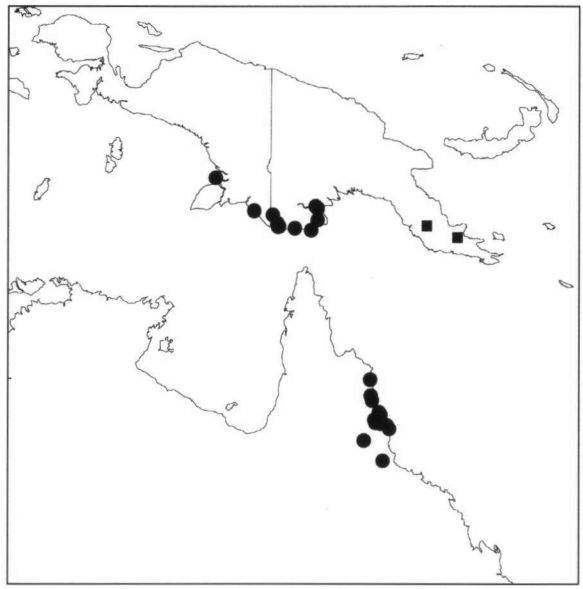


Fig. 5.26. Distribution of *Alstonia muelleriana* Domin (●) and *A. rubiginosa* Sidiyasa (■).

26. Alstonia neriifolia D. Don — Fig. 5.16 & 5.27

Alstonia neriifolia D. Don, Prodr. Nepal. (1825) 131; G. Don, Gen. Syst. 4 (1837) 87; Monachino, Pacific Sci. 3 (1949) 156. — *Blaberopus neriifolius* (D. Don) A. DC., Prodr. 8 (1844) 411. — Type: *Wallich 1646-B* (= *1646-2*) (holo K-W; iso E, L, M, W), India, Calcutta, fl. & fr.

Alstonia sericea Blume, Bijdr. Fl. Ned. Ind. 16 (1826) 1038. — *Blaberopus sericeus* (Blume) A. DC., Prodr. 8 (1844) 411. — Type: *Blume s. n.* (lecto L 925.250-177, designated here; iso L 898.129-125, L 898.129-129, L 898.129-134, L 898.129-137, U), Indonesia, West Java, Mt. Salak, fl.

Alstonia neriifolia var. *glabra* Monach., Pacific Sci. 3 (1949) 157; syn. nov. — Type: *Gamble 7574* (holo K; iso K), India, Darjeeling, Dec. 1879, fr.

Shrub 1.5–3.5 m high. *Branches* smooth, lenticellate; branchlets terete or slightly sulcate in the young parts when dried, glabrous, puberulous or densely pubescent, yellowish grey or pale brown, with a ring-like formation of the densely packed colleters

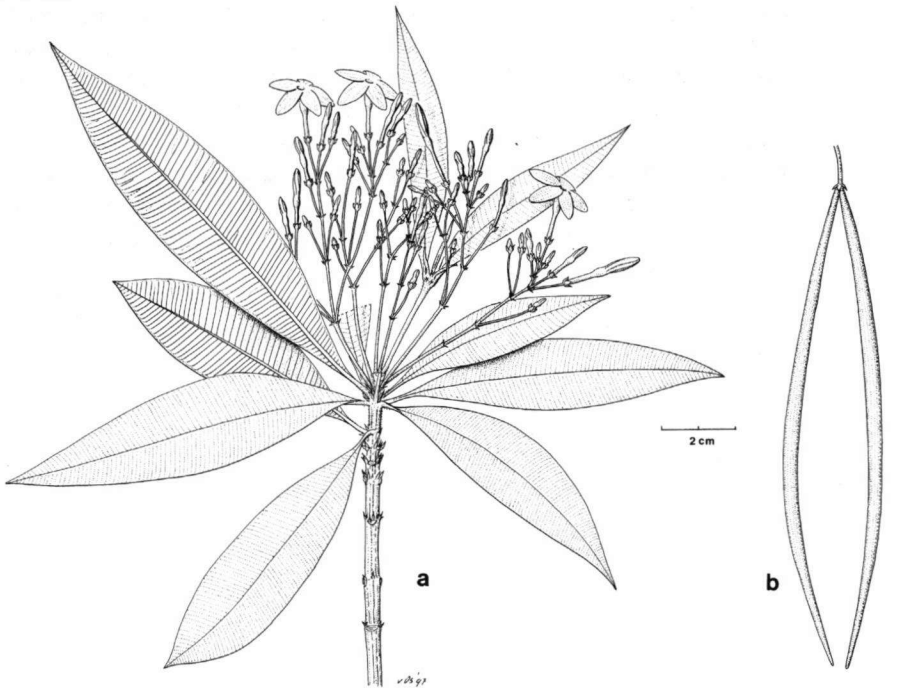


Fig. 5.27. *Alstonia neriifolia* D. Don – a: Habit; b: follicles (a: *Stainton 6997*; b: *Williams & Stainton 8515*).

at the nodes. *Leaves* in whorls of 3 (or 4), petiolate; petiole 3–10(–20) × 0.5–1(–1.6) mm, canaliculate above, glabrous, puberulous or densely pubescent, many narrow or linear colleters (up to 4(–4.5) mm long) densely packed together in the axils; blade chartaceous or thinly coriaceous when dried, elliptic to narrowly obovate, sometimes narrowly ovate, (3.5–)5–34 × 1.2–6.2 cm, index (2.3–)2.9–5.8, apex short or gradually long acuminate with an acute acumen up to 2.5(–3) cm long, base decurrent onto the petiole, glabrous on both sides or puberulous above and puberulous or softly densely pubescent beneath, margin entire; midrib impressed above; secondary veins in 50–100 pairs, parallel and forming an angle of c. 80–85° with the midrib, 0.6–3(–4) mm from each other, slightly arched and joining near the margin, forming a thin submarginal vein, very often confused with some thin (shorter) interstitial veins; tertiary venation inconspicuous. *Inflorescence* 6–10 cm long, terminal, many-flowered; peduncle (0.7–)1.5–6.5 cm long, glabrous or puberulous like the branches; pedicels slender (7–)10–20 × 0.2–0.3(–0.4) mm, glabrous. *Bracts* and *bracteoles* minute, ciliate, few to many colleters densely packed together in the axils. *Flowers: Sepals* connate at the base for 0.1–0.3 mm, ovate, 1.4–2.3 × 0.8–1.2 mm, index 1.4–2.3, obtuse or gradually acuminate with a blunt apex, mostly almost translucent around the margin, ciliate, glabrous on both sides, erect, slightly spreading when dried. *Corolla* white or pale yellow, 18–26(–35) mm long in the mature bud and forming a narrowly ovoid

head 0.3–0.4 of the bud length, 5.5–13 × 1.5–2.5 mm with a blunt or pointed apex, glabrous outside, two pilose belts inside, the first belt in the broader part of the tube, starting from 1–1.5 mm below the stamens (12–14 mm above the base) to 1–2 mm below the mouth (4–4.5 mm wide), around the base of the stamens usually with very sparse hairs, the second belt at the extreme base of the corolla lobes or surrounding the mouth moustache-like, c. 0.4 mm wide; tube 15–19.5(–22.5) mm long, 1–1.6 mm wide at the base, narrowing above to 0.7–1 mm wide, and again widening around the stamens to the throat 1.7–2.2 mm wide, 7.2–11.7 × as long as the sepals, 1.2–2.6 × as long as the lobes; lobes ovate, mostly slightly oblique, 6.5–16 × (3–)4–6 mm, index 1.8–2.9, acute, not ciliate, auriculate at the base on the left side, spreading. *Stamens* with apex 1.5–2 mm below the mouth of the corolla tube, inserted at 0.75–0.82 of the length of the corolla tube (at 13–15.5(–18.5) mm from the base); filaments 0.6–1 mm long, filiform; anthers narrowly ovate, 1.9–2.6 × 0.5–0.7 mm, obtuse, sometimes mucronulate or acute. *Pistil* 13–16.5(–19.5) mm long; ovary glabrous, narrowly ovoid, 1.9–2.3 × 0.8–1 mm, composed of 2 carpels; disk with 2 long lobes alternating with the carpels, narrowly ovoid, 1–1.5(–2) mm long, mostly slightly laterally compressed, apex pointed; style 10–13(–16.5) mm long, filiform; pistil head pagoda-like, 1–1.5 mm high, composed of a membranous basal ring 0.2–0.3 × 0.4–0.7 mm, above this a woolly central ring 0.3–0.4 × 0.4–0.7 mm, again a ring 0.3–0.4 × 0.3–0.5 mm which is mostly sparsely hairy on the distal part, and a robust and short cleft stigmoid apex c. 0.2(–0.4) × 0.2–0.3 mm. *Fruit* a pair of follicles, 10–20 cm long, 2.5–3.5 mm in diameter, minutely striate or almost smooth, glabrous, gradually narrowed to the apex with a blunt point, not spreading. *Seeds* narrowly elliptic or oblong, 7–10 × 1.8–2.5 mm, both ends manifestly rounded, irregularly dentate or unequally lobed, shortly pubescent or scale-like on both sides, sometimes with very sparse long hairs near the margin, or glabrous later and forming a very minute reticulate structure, slightly ridged on the hilar side, longest cilia 6–13 mm long, hilum elliptic and c. 0.2 × 0.1 mm or circular and c. 0.15 mm in diameter.

Distribution — India, Nepal, and Bhutan. Planted in the Botanical Garden of Calcutta, Penang (Malaysia), Singapore, Bogor (Indonesia), and Honduras.

Habitat & Ecology — Altitude 330–1330 m.

Vernacular name — *Chalion* (India).

Notes — In the type specimens of *A. sericea* Blume, *Blume s.n.* (L 925.250-177, L 898.129-125, L 898.129-129, L 898.129-134, L 898.129-137), *Blume s.n.* (L 898.129-131), *William & Stainton 3842, Stainton 6822*, and *Voigt s.n.*) the mature bud is up to 35 mm long, in contrast to the other specimens in which they are up to 26 mm long.

I agree with Markgraf (l.c., 1974: 29) that *Alstonia neriifolia* is not indigenous in Malesia. It seems to have been cultivated in Java and in other places in Malesia. Backer and Bakhuizen van den Brink (Flora of Java vol. 2, 1965) suggested that the locality on Mt. Salak in West Java, Indonesia, given by Blume, was wrong. The species is only known in the wild from India, Nepal, and Bhutan.

Specimens studied: India: 19 specimens. – Nepal: 9. – Bhutan: 1 (*Hara et al. 3782*). – Indonesia: Java: 8.

27. Alstonia odontophora Boiteau — Fig. 5.28

Alstonia odontophora Boiteau, Adansonia sér. 2, 16 (1977) 472; Fl. Nouv. Caléd. et Dépend. 10 (1981) 176. — Type: *MacKee 15378* (holo P, iso K, L), New Caledonia, Rivière Blanche, Plaine des Lacs, 27 July 1966, fl.

Shrub or small tree, 1.5–10 m high. *Branches* smooth, sparsely lenticellate; branchlets terete, slightly laterally compressed or slightly sulcate when dried, glabrous, yellowish brown to blackish. *Leaves* opposite, petiolate; petiole glabrous, slender or rather stout, 10–35(–50) × 1–2.5(–4) mm, flattened or canaliculate above, without intrapetiolar stipule at the base, few to many shortly lingulate colleters densely packed together in the axils; blade dark green above, paler below, grey-green or brown when dried, thickly coriaceous, elliptic, narrowly elliptic or narrowly obovate, 5.5–30 × 1.5–12.5 cm, index (1.9–)2.4–4.1, glabrous on both sides, apex obtuse or shortly acuminate with a blunt point, base acute or decurrent onto the petiole, margin entire or undulate (sometimes roughly undulate and forming irregular teeth), revolute; midrib impressed above; secondary veins in 11–18 pairs, conspicuous on both sides, very often not parallel and

Fig. 5.28. *Alstonia odontophora* Boiteau (*MacKee 15378*).

forming an angle of (50–)60–80(–90)° with the midrib, 3–15(–25) mm from each other; tertiary venation reticulate, mostly conspicuous. *Inflorescence* 7–20 cm long, terminal, many-flowered; peduncle 2–10.3 cm long, glabrous as on the branches; pedicels (3–)5–13 × 0.4–0.7 mm, glabrous. *Bracts* sometimes leafy, c. 2–3 × 0.5–1 cm, mostly scale- or sepal-like like the bracteoles, ovate or broadly ovate, 0.5–1(–2) mm long, almost translucent around the margin and apex, glabrous on both sides, not ciliate. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.3 mm, ovate or suborbicular, 1.5–2 × 1–2 mm, index 1–1.8, erect, glabrous on both sides, apex obtuse, almost translucent around the apex and margin, not ciliate, very often the two outer ones larger than the inner three. *Corolla* pinkish or white, 8–13 mm long in the mature bud and forming a narrowly ovoid head (0.4–)0.5–0.6 of the bud length, 4.5–6 × 1.7–2.5 mm, with a blunt apex, glabrous outside, two densely hairy belts inside, the first belt pubescent starting from 1.5–2 mm above the base to the insertion of the stamens (1.2–1.5 mm wide), the second belt pilose from 0.5–1 mm above the apex of stamens starting with sparse hairs, and then densely surrounding the mouth or at the extreme base of the corolla lobes, and then becoming sparse, usually up to 1 mm above the mouth, rarely over the basal half of the corolla lobes (around stamens very sparsely hairy); tube almost cylindrical or slightly widening around the stamens (in the middle), 5.3–8 mm long, 1.7–2.3 mm wide, 2.6–4.4 × as long as the sepals, 0.8–1.2 × as long as the lobes; lobes narrowly ovate or oblong, 6–8.6 × 2–3 mm, index 2.4–3.4, sometimes oblique or slightly falcate, auriculate at the base on the right side, sparsely ciliate or not, spreading. *Stamens* with apex 1.8–2.8 mm below the mouth of the corolla tube, inserted at 0.4–0.6 of the length of the corolla tube (at 3–3.5 mm from the base); filaments c. 0.5 mm long, filiform; anthers ovate, 1.2–1.7 × 0.4–0.6 mm, obtuse and very often with a pointed apex. *Pistil* 3–4 mm long; ovary ovoid, 0.7–1 × 0.6–0.9 mm, glabrous, composed of 2 carpels, a disk-like thickening at the base 0.1–0.25 mm high; style 1.4–2 mm long, very often narrowing towards the apex; pistil head 0.8–1 mm high, composed of a basal ring 0.2–0.3 × 0.3–0.5 mm, a sparsely hairy conical central part 0.3–0.5 × 0.2–0.3 mm, and a cleft stigmoid apical part 0.15–0.3 mm high. *Fruit* a pair of follicles, 7.5–17 cm long, grain 3–4 mm in diameter, glabrous, striate. *Seeds* 10–14 × 2–2.5 mm (main part elliptic, 4–5 × 1.9–2.3 mm), ends narrowly caudate or acuminate with an acumen 2–4 mm long, bifid at one end, glabrescent on the hilar side, densely pubescent on the other side, longest cilia 1–1.5 mm long, somewhat becoming shorter towards the side margins, hilum elliptic, 0.2–0.3 × c. 0.1 mm or circular, c. 0.3 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Rain forests, on margin of primary forests, on serpentinic soils and limestone. Altitude 200–1100 m.

Specimens studied: New Caledonia: 23 specimens.

28. Alstonia parvifolia Merr. — Fig. 5.29

Alstonia parvifolia Merr., Govt. Lab. Publ. 35 (1906) 59; Philipp. J. Sci. 1, Suppl. (1906) 116; Enum. Philipp. Flow. Pl. 3 (1923) 322; Markgraf, Blumea 22 (1974) 25. — Type: *Meyer (For. Bur.) 2209* (holo PNH †; lecto K, designated here), Philippines, Luzon, Bataan Prov., Mt. Mariveles, Dec. 1904, fl.

Small tree, up to 8 m high. *Branches* smooth or shallowly longitudinally fissured, dark-grey or black, without lenticels; branchlets terete or slightly angular, very often sulcate when dried, glabrous. *Leaves* in whorls of 4 (rarely of 3), petiolate; petiole glabrous, 10–26(–35) × 1–2.5 mm, flattened above, many minute or shortly lingulate colleters densely packed together in the axils; blade dark-grey to dark-brown above (usually almost black on the very old specimens), dull grey-brown or reddish brown beneath, and thinly coriaceous when dried, elliptic, narrowly elliptic or narrowly obovate, 6.5–20 × 2–5.5 cm, index (2.7–)3–4.4, apex acuminate, acumen up to 1 cm long with a blunt tip, rarely obtuse, base acute, entire, glabrous on both sides; midrib impressed above; secondary veins in 13–17 pairs, slightly curved near the margin and forming an angle of 60–80° with the midrib, 4–11(–16) mm from each other, sometimes alternating with less conspicuous interstitial veins; tertiary venation inconspicuous, rarely conspicuous beneath. *Inflorescence* 4–11 cm long, many-flowered; peduncle (1.3–)2–7.5 cm long, slender 0.8–1.5 mm in diameter, glabrous; pedicels 1–3.5 × 0.5-0.6 mm, pubescent. *Bracts and bracteoles* sepal- or scale-like, ovate or narrowly ovate, up to 2.5 mm long, pubescent except at the base inside. *Flowers* fragrant. *Sepals* pale green, grey-green or brown when dried, connate at the base for (0.7–)1–1.6 mm, ovate, 2.5–3.2(–3.7) × 1.2–2.5 mm, index 1.4–2.1, apex obtuse or rounded and with a thick margin, densely pubescent except on the fused part inside, erect or slightly spreading (sometimes reflexed) when dried. *Corolla* white, (5–)6–8 × 1.2–1.7 mm in the mature bud and forming an ovoid head 0.4–0.5 of the bud length, 2.5–4 × 1.2–1.7 mm with a blunt apex; glabrous or very sparsely and shortly hairy around the apex outside, dark brown or blackish when dried, two pubescent belts inside, the first belt at the base of the corolla lobes and the second belt just below the stamens, 0.8–1.3 mm wide (around the stamens glabrous or with very sparse hairs), throat rather thick, 0.5–0.6 mm wide; tube almost cylindrical, 3.8–5 mm long, 1.3–2 mm wide, 1.2–2(–2.3) × as long as the sepals, 0.7–1.1(–1.4) × as long as the lobes; lobes ovate, sometimes slightly oblique, 3.5–5.8 × 1.7–3 mm, index 1.7–2.8, ciliate or not, auriculate at the base on the right side, spreading. *Stamens* with apex 0.2–0.5 mm below the mouth of the corolla tube, inserted at 0.6–0.8 of the length of the corolla tube (at 2.3–3.2 mm from the base); filaments short, 0.4–0.5 mm long, filiform; anthers ovate, 1–1.2 × 0.3–0.4 mm, apex pointed. *Pistil* 2.6–3.2 mm long; ovary ovoid or broadly ovoid, 0.9–1.3 × 0.7–1 mm, mostly slightly laterally compressed, glabrous, composed of 2 carpels, with a disk-like thickening at the base 0.2–0.4(–5) mm high; style 1.1–1.9 mm long; pistil head 0.5–0.6 mm high, composed of a basal ring 0.15–0.2 mm high, a cylindrical central part 0.3–0.4 × 0.2–0.3 mm, and a cleft stigmoid apical part up to 0.1 mm high. *Fruit* 16–21(–24?) cm long, c. 3 mm in diameter, glabrous, with narrow and acutish apex, blackish when dried (known only from two collections, *Loher 6512* and *Whitford 1164*). *Seeds* narrowly elliptic, 5.5–7 × 1.5–1.7 mm, dark brown, pubescent on both sides, one end rounded, the other end acuminate, and bifid at the apex up to 1 mm long; longest cilia 4–6 mm long, gradually becoming shorter towards the side margins; hilum circular, c. 0.1 mm diameter, or elliptic, c. 0.2 × 0.1 mm.

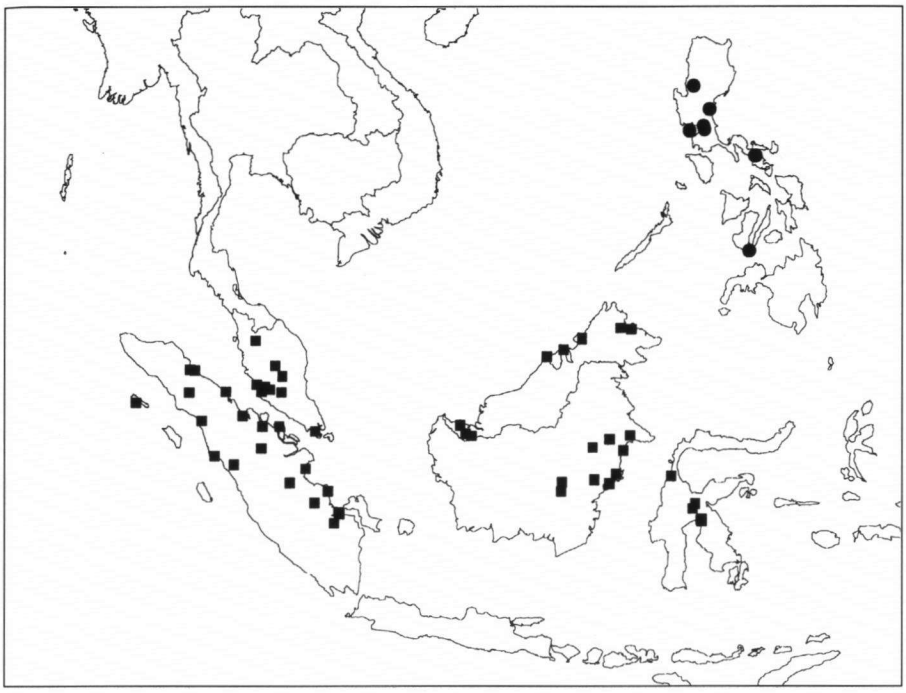


Fig. 5.29. Distribution of *Alstonia parvifolia* Merr. (●) and *A. pneumatophora* Backer ex Den Berger (■).

Distribution — Endemic to the Philippines.

Habitat & Ecology — Secondary growth in logged-over forests. Altitude 700–850 m.

Note — See also under *A. angustifolia*. The sterile material of *A. parvifolia* looks like that of *A. angustifolia*, but differs in the flower and seed characters, and also in the distribution. The species can be distinguished as follow:

- Sepals 2.5–3.7 long, mostly erect or spreading when dried, corolla outside glabrous or minutely hairy (usually on the lobed margins), acumen of the seeds bifid. Known only from the Philippines ..... *A. parvifolia*
- Sepals 1.4–2 mm long, mostly reflexed or spreading, corolla outside rusty pubescent, acumen of the seeds not bifid. Distribution in Malaysia (including Sarawak and Sabah), Singapore, Indonesia (Sumatra, Bangka, and Kalimantan) .... *A. angustifolia*

Specimens studied: Philippines: 14 specimens.

29. Alstonia penangiana Sidiyasa, *spec. nov.* — Fig. 5.30 & 5.41

Arbor grandis ramulis glabris. Folia ternata vel quaternata petiolata chartacea obovata vel anguste obovata apice breviter acuminata basi acuta vel in petiolum decurrentia

integra utroque latere glabra. Inflorescentia multiflora. Sepala basi connata ovata apice acuta vel obtusa extus et parte libera intus pubescentia. Corolla alba extus breviter pubescens tubo lobis longiore. Stamina paulo inclusa filamentis brevibus antherisque ovatis apice obtusis vel mucronulatis. Pistillum glabrum ovario ovoideo. Fructus folliculis duabis separatis longis glabris. Semina anguste ovata vel elliptica utroque latere pubescentia. — Typus: *Whitmore FRI 20548* (holo L; iso K, KEP), Malaysia, Pinang Island, Penang Hill, Moniots Road, 22 Oct. 1971, fl.

Tree, 17–32 m high; trunk 35 cm in diameter. *Bark* smooth, grey or pale brown. *Branchlets* terete or slightly angular, glabrous, dark green or dark brown. *Leaves* in whorls of 3 or 4, petiolate; petiole 12–24 × 1.5–2.5 mm, glabrous, canaliculate above; colleters minute and densely packed together in the axils; blade chartaceous, dull brown when dried, obovate to narrowly obovate, 9.5–23 × 3.2–9.5 cm, index 2.7–3.5, apex shortly acuminate, acumen up to 10 mm long with a blunt point, base acute to decurrent onto the petiole, entire, glabrous on both sides; midrib impressed above; secondary veins in 15–22 pairs and forming an angle of 60–80° with the midrib, 5–14 (–18) mm from each other, joining at the ends and forming a thin submarginal vein; tertiary venation reticulate, mostly conspicuous on both sides. *Inflorescences* in groups of 6–8, 5.5–12 cm long, many-flowered; peduncle (1.5–)2.5–7.5 cm long, glabrous or puberulous; pedicels 1.5–4 × 0.3–0.5 mm, pubescent. *Bracts* and *bracteoles* sepal- or scale-like, ovate to broadly ovate, up to 1 mm long (the bracteoles are usually much smaller), obtuse to acuminate, ciliate, pubescent outside, glabrous inside. *Flowers* with a slightly sour odour. *Sepals* connate at the base for 0.8–1 mm, ovate, 1.7–2.5 × 0.8–1.5 mm, index 1.6–2.1, apex acute or obtuse, pubescent outside and on the free parts inside. *Corolla* white, 6.5–7.2 mm long in the mature bud and forming an ovoid head 2.3–3.5 × 1.2–1.5 mm, shortly pubescent outside (except the basal part within the calyx which is glabrous), two distinctly hairy belts inside, the first belt sparsely pubescent starting from c. 2 mm above the base to the insertion of the stamens (c. 1.5 mm wide), the second belt pilose from 0.4–0.7 mm below the mouth and covering the corolla lobes (around the stamens usually sparsely hairy); tube almost cylindrical, mostly slightly widening around the stamens, 5.4–5.6 mm long, 1.2–1.5 mm wide, 2.2–3.2 × as long as the sepals, 1.2–1.5 × as long as lobes; lobes ovate, 3–4.5 × 1.8–2.3 mm, index 1.7–2, ciliate, spreading. *Stamens* with apex c. 1 mm below the mouth of the corolla tube, inserted at 0.62–0.65 of the length of the corolla tube (at 3.5 mm from the base); filaments 0.4–0.5 mm long, filiform, glabrous; anthers ovate, c. 1 × 0.35 mm, apex obtuse or mucronulate. *Pistil* 3.1–3.7 mm long; ovary ovoid, 0.7–1 × 0.6–0.8 mm, composed of 2 carpels, glabrous, with a slightly wavy disk-like thickening at the base, 0.2–0.3 mm high; style 2–2.2 mm long, filiform, glabrous; pistil head ovoid or funnel-shaped, 0.5–0.7 × 0.3 mm, glabrous, composed of a thin basal ring c. 0.1 mm high, a conical central part 0.3–0.4 × 0.2–0.3 mm, and a cleft stigmoid apical part up to 0.15 mm high. *Fruit* (known only from the type specimen) a pair of follicles, 60 cm long, 3.5 mm in diameter, striate, glabrous. *Seeds* dark brown, narrowly ovate or elliptic, 8.5 × 1.8–2 mm, pubescent, one end acute or acuminate, acumen 1–1.5 mm long, the other end obtuse or rounded; longest cilia 10–12 mm long, gradually becoming shorter towards the edges, hilum elliptic and c. 0.2 × 0.1 mm or circular and c. 0.1 mm in diameter.

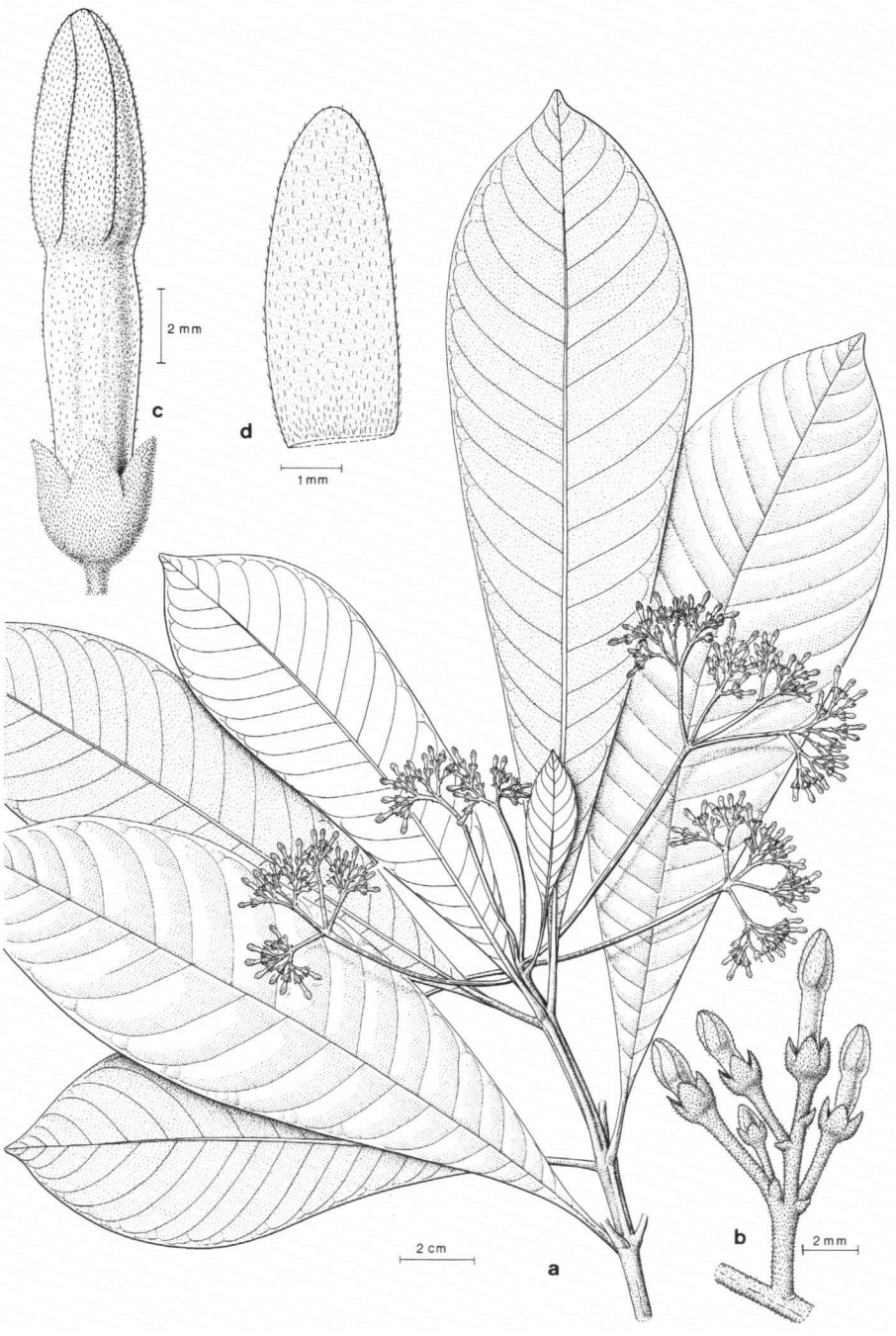


Fig. 5.30. *Alstonia penangiana* Sidiyasa – a: Habit; b: cluster of flowers; c: flower in bud; d: corolla lobe (a–d: *Whitmore FRI 20458*).

Distribution — Malaysia, known only from Penang, Pinang Island.

Habitat & Ecology — Primary or disturbed forests, on hillsides. Altitude from 200–600 m.

Note — *Alstonia penangiana* is very similar to *A. angustifolia* Wall. ex A. DC. and *A. macrophylla* Wall. ex G. Don in its leaf shape and leaf arrangement. Therefore, vegetative specimens cannot be distinguished. It differs from *A. angustifolia* in its longer corolla bud, longer corolla tube, and longer corolla lobes. From *A. macrophylla* it differs mainly in its sepals which are pubescent instead of glabrous or puberulous outside and on the free part of them inside, and in the corolla lobes which are entirely pilose instead of basally pilose inside.

Specimens studied: Penang: Moniots Road, Penang Hill, *Whitmore FRI 20548* (type); Georgetown Botanical Garden, near reservoir, *Chelliah 98132* (A, K, KEP, L).

30. **Alstonia pneumatophora** Backer ex Den Berger — Fig. 5.29

Alstonia pneumatophora Backer ex Den Berger, Meded. Proefst. Thee 97 (1926) 153; Markgraf, Blumea 22 (1974) 25. — Type: *Endert 28E. IP. 505* (lecto L; iso BO, U), Indonesia, Sumatra Selatan, Banjoeasin (= Banyuasin), Dec. 1918, fr.

Alstonia pneumatophora var. *petiolata* Monach., Pacific Sci. 3 (1949) 153; Whitmore, Tree Flora of Malaya 2 (1973) 11. — Type: *Endert 28E. IP. 537* (holo L; iso BO, U), Indonesia, Sumatra Selatan, Palembang, Bayung Lincir, Banyuasin, 1919/1921, fl. & fr.

Tree, 25–55 m high; trunk 30–100(–200) cm in diameter, fluted at the base or forming tall and steep buttresses up to 8 m high, spreading for up to 3 m at the base. *Bark* smooth or sparsely scaly, grey; inner bark pale yellow or orange-brown, soft, granular, with copious white latex. *Branches* smooth, sometimes minutely striate when dried, without lenticels; branchlets terete, glabrous, yellowish grey or dark grey. *Leaves* in whorls of (3–)4–6, sessile or petiolate; petiole 0–5(–20) mm long, laterally compressed, or shallowly canaliculate above, slightly winged, glabrous, with deltoid or scale-like colleters in the axils; blade coriaceous, grey-green above, brown or dark red-brown beneath when dried, spathulate, sometimes obovate, 4.3–13 × 1.5–4.3 cm, index 1.7–3.4(–4.2), apex rounded, sometimes retuse, base acute or decurrent onto the petiole, rarely obtuse, entire, glabrous on both sides, not glaucous beneath; midrib impressed above; secondary veins in 18–30 pairs, straight and forming an angle of (70–)80–90° with the midrib, 1.5–4(–6) mm from each other; tertiary venation admedial ramified, usually inconspicuous on both sides. *Inflorescence* 3–9 cm long, 1–5 together, composed of two bunches of densely clustered flowers; peduncle 1–5 cm long, rather stout, 1–2 mm in diameter, ascending; pedicels 0–1 mm long, puberulous or densely pubescent. *Bracts* and *bracteoles* ovate or triangular, sepal-like, up to 2(–3) mm long, ciliate, pubescent outside, laxly puberulous around the apex inside, glabrous at the base, acute or obtuse. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.4(–0.6) mm, ovate, 1.5–2(–3.5) × 0.5–1.2 mm, index 1.7–2.5(–5), obtuse, pubescent outside, laxly puberulous around the apex and glabrous at the base inside, ciliate, erect, very often spreading when dried. *Corolla* white, 8–13 mm long in the mature bud and forming an ovoid head 0.22–0.37 of the bud length, 2–3.6 × 1.1–1.6 mm, with a blunt apex, glabrous outside, two hairy belts inside, the first belt pubes-

cent starting from 2–3.5 mm above the base and ending at 0.4–0.7 mm below the mouth or about as high as the stamens (5–7.5 mm wide), the second belt pilose, white, at the extreme base of the corolla lobes (moustache-like around the mouth) c. 0.4 mm wide; tube almost cylindrical, 7–10 mm long, 0.8–1 mm wide, (2–)5–6.3 × as long as the sepals, (1.4–)2.3–2.8 × as long as the lobes; lobes ovate, 3–5 × 2–3.2 mm, index 1.2–1.5(–2.5), apex obtuse or rounded, spreading. *Stamens* with apex 0.3–0.6 mm below the mouth of the corolla tube, inserted at 0.7–0.9 of the length of the corolla tube (at 5.2–8.4 mm from the base); filaments 0.4–0.5(–0.8) mm long, filiform; anthers ovate, 0.7–0.9 × 0.3–0.4 mm, apex obtuse. *Pistil* glabrous, (6–)7.5–8.9 mm long; ovary ovoid, 0.8–1.2 × 0.7–0.9 mm, mostly slightly laterally compressed, composed of 2 carpels, with or without a disk-like thickening at the base (if present c. 0.25 mm high); style 5–8 mm long, filiform; pistil head 0.4–0.7 mm high, composed of a thin basal ring up to 0.1 mm high, a cylindrical central part 0.2–0.4 × 0.2 mm, and a short robust cleft stigmoid apical part c. 0.1(–0.3) mm high. *Fruit* a pair of follicles, 10–20(–40) cm long, 1.5–2 mm in diameter, shortly pubescent or tomentose, with a blunt or narrowly acute apex. *Seeds* oblong, 4–4.9 × 1–1.2 mm, ends rounded, glabrous on both sides, longest cilia 8–12 mm long, reduced and becoming shorter (sometimes glabrous) toward the margins, hilum white, linear, c. 1 mm long.

Distribution — Malaysia (incl. Sarawak and Sabah), Singapore, Brunei Darussalam, Indonesia (Sumatra, Kalimantan, Sulawesi).

Habitat & Ecology — Swamps or periodically inundated areas along streams, on sandy loam or heavy loam soils. Altitude 0–50 m.

Vernacular names — *Pule* or *pulai* are the most common names in Malaysia and Sumatra.

Specimens studied: Malaysia: Peninsular Malaysia: 13 specimens, Sarawak: 4, Sabah: 8. – Singapore: 2. – Brunei Darussalam: 5. – Indonesia: Sumatra: 56, Kalimantan: 18, Sulawesi: 16.

31. **Alstonia quaternata** Van Heurck & Müll. Arg. — Fig. 5.31

Alstonia quaternata Van Heurck & Müll. Arg., Flora 53 (1870) 170; Monachino, Pacific Sci. 3 (1949) 177; Boiteau et al., Adansonia sér. 2, 16 (1977) 483; Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 170. — Type: *Deplanche 456* (holo AHW; iso G, K, P), New Caledonia, Pouebo, 1861–1867, fl.

Shrub or small tree, 2–7 m high. *Branches* smooth or slightly rough, without lenticels; branchlets terete, stout, glabrous, very often bluish or glaucous when dried. *Leaves* in whorls of 3, confined to the apex of the branchlets, except on the first node of the vegetative branchlets and on the much narrower and shorter inflorescence branchlets the leaves are usually opposite and usually smaller in size, the opposite leaves are also observed (sometimes) on the first node of the vegetative branchlets, petiolate; petiole glabrous, (15–)20–50(–70) × 1–2 mm, slightly flattened or longitudinally canaliculate above, widening at the base, forming a small ocrea, colleters minute or linear and densely packed together in the axils; blade thickly coriaceous and dark brown when dried, narrowly elliptic or narrowly obovate, 6–17 × 1.7–4.3 cm, index 3–5.2, apex obtuse or rounded, base decurrent onto the petiole, glabrous on both sides, entire and

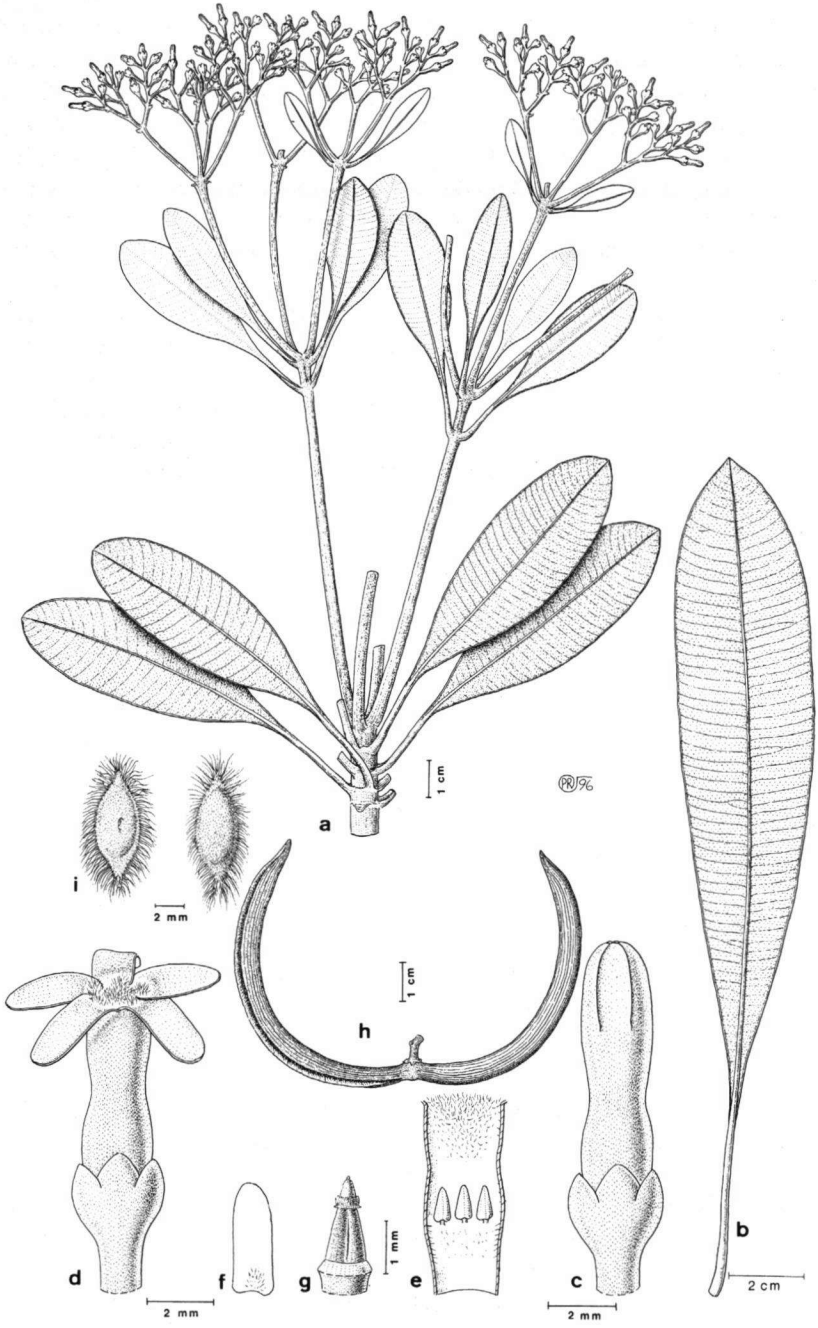


Fig. 5.31. *Alstonia quaternata* Van Heurck & Müll. Arg. – a: Habit; b: larger leaf; c: flower in bud; d: open flower; e: dissected corolla tube, showing 3 anthers inserted in the glabrous zone; f: corolla lobe; g: pistil; h: follicles; i: seeds, left: hilar side, right: opposite hilar side (a–g: *MacKee 13778*; h, i: *MacKee 13848*).

with revolute margin; midrib impressed above; secondary veins in 40–50 pairs, thin and almost straight, forming an angle of 80–90° with the midrib (near the apex usually with a smaller angle), sometimes branched (bifid), 1.2–4 mm from each other; tertiary venation inconspicuous, reticulate. *Inflorescence* 4.5–13 cm long, terminal, many-flowered; peduncle rather stout, 3–8.5 cm long, first branching mostly umbellate up to 2 cm long, glabrous; pedicels 2–5 × 0.6–1 mm, glabrous. *Bracts*: leafy bracts sometimes present, the other bracts similar to the bracteoles and scale- or sepal-like, triangular or broadly ovate, up to 1(–1.5) mm long, glabrous on both sides, apex acute or rounded. *Flowers* fragrant. *Sepals* connate at the base for (0.1–)0.2–0.3 mm, broadly ovate, suborbicular, ovate or sometimes turbinate, 1.2–1.8 × 1–2 mm, index 0.8–1.3, erect, rather thick, glabrous on both sides, apex rounded, not ciliate, mostly the two outer ones larger than the inner three. *Corolla* pinkish, 6.3–8 mm long in the mature bud and forming an ellipsoid or cylindrical head 0.3–0.44 of the bud length, 2.5–3 × 1–1.5 mm with a rounded apex, glabrous outside, with two densely hairy belts inside, the first belt pubescent starting from 0.8–1 mm above the base to the insertion of the stamens (1–1.2 mm wide), the second belt pilose from c. 0.5 mm above the stamens and covering the basal half of the corolla lobes (dense hairs at the base of the lobes, then reducing towards the apex), around the stamens especially behind the anthers usually very sparse; tube almost cylindrical or slightly widening around the stamens, 5–6 mm long, 1.3–1.7 mm wide, 2.8–4.1 × as long as the sepals, 1.5–1.9 × as long as lobes; lobes lingulate, 2.7–3.5 × 1–1.8 mm, index 1.8–3, sometimes slightly falcate, thick and fleshy, spreading, not auriculate at the base, not ciliate. *Stamens* with apex (1.8–)2–2.5 mm below the mouth of corolla tube, inserted at 0.35–0.42 of the length of the corolla tube (at 2–2.5 mm from the base); filaments 0.4–0.5 mm long, filiform; anthers ovate, 1–1.4 × 0.35–0.5 mm, obtuse. *Pistil* very short, 1.5–1.7 mm long; ovary glabrous, ovoid or conical, 0.8–1.1 × 0.6–0.8 mm, composed of 2 carpels, a very narrow disk-like thickening at the base (mostly indistinct); style absent; pistil head 0.5–0.7 mm high, glabrous or minutely hairy only around the apex, composed of a basal ring 0.17–0.3 mm high, a cylindrical or conical central part 0.25–0.4 × c. 0.3 mm, and a cleft stigmoid apical part up to 0.1 mm high. *Fruit* a pair of follicles, 4–12.5 cm long, 5–6 mm in diameter, glabrous and with a roughly striate surface, spreading or reflexed. *Seeds* elliptic, 7–9 × 2.8–3.2 mm, ends mostly acuminate with an acumen up to 2 mm long with a blunt or bifid apex, sometimes one end shorter and forming an obtuse or unequally lobed apex, pubescent on both sides, mostly sparsely hairy or almost glabrous on the hilar side, longest cilia 1.5(–2) mm long and usually reduced and becoming shorter towards the margins, hilum circular, 0.1–0.2 mm in diameter.

Distribution — Endemic to New Caledonia.
Habitat & Ecology — Rain forests, growing on schists. Altitude 300–900 m.

Specimens studied: New Caledonia: 14 specimens.

32. Alstonia rostrata C.E.C. Fisch. — Fig. 5.32 & 5.33

Alstonia rostrata C.E.C. Fisch., Kew Bull. (1929) 315; Middleton & Gilbert, Taxon 43 (1994) 478. — Type: *C.E. Parkinson 6563* (holo K), Burma, Thanton, Yatheytaung, Sept. 1928, fl.

Winchia calophylla A. DC., Prodr. 8 (1844) 326, not *Alstonia calophylla* Miq. (1856), synonym of *A. angustiloba* Miq. — *Alstonia glaucescens* (K. Schum.) Monach., Pacific Sci. 3 (1949) 144. — Type: *Wallich 1607* (holo K-W; iso C, E, L, M, P, W), Burma, Martabania, 1827, fl.

Alstonia pachycarpa Merr. & Chun, Sunyatsenia 2 (1935) 310. — Type: *N.K. Chun & C.L. Tso 44317* (holo IBSC, not seen; iso A, K, P, US), China, Hainan, Mocheung Ling, Tingon, 1932–1933, fr.

Alstonia undulifolia Kochummen & K.M. Wong, Blumea 29 (1984) 513; syn. nov. — Type: *Kochummen FRI 32505* (holo KEP; iso A, K, L), Malaysia, Kedah, Gunong Jerai, 31 March 1982, fl.

Tree, 8–35 m high; trunk 15–80 cm in diameter, sometimes slightly fluted at the base, without buttresses. *Bark* shallowly and/or irregularly fissured, pale or yellowish brown; inner bark yellow-orange, light brown or straw-coloured, granular, and with copious

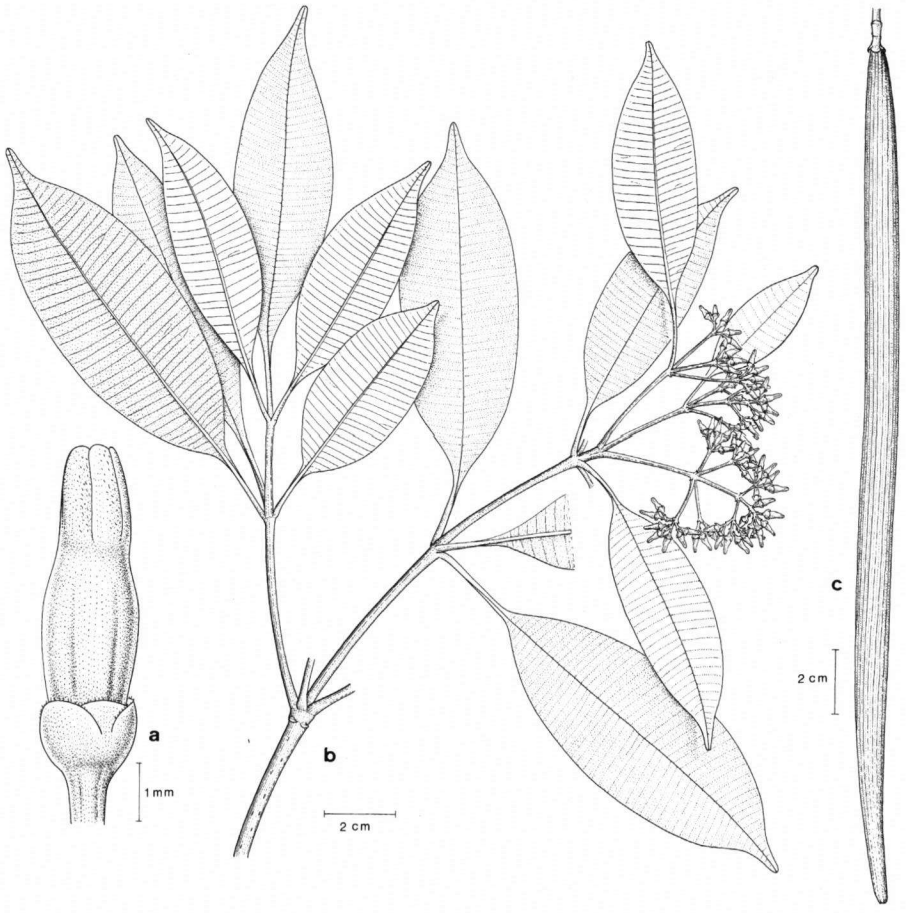


Fig. 5.32. *Alstonia rostrata* C.E.C. Fisch. – a: Habit; b: flower in bud; c: follicle (a, b: *Sirirugsa 457*; c: *Poilane 2085*).

white latex. *Branches* smooth, sometimes lenticellate, pale to dark brown, always with a short internode at the end; branchlets terete, glabrous, dark brown or blackish. *Leaves* in whorls of 3–4(–6), petiolate; petiole glabrous, 8–20(–25) × 1–2 mm, flattened or canaliculate above, sometimes forming a very small (obscure) intrapetiolar stipule at the base, with deltoid or scale-like colleters in the axils; blade dark green above, light green beneath, coriaceous and grey-green or shiny dark brown above (paler beneath) when dried, elliptic or narrowly elliptic, rarely ovate or obovate, 4.5–13(–20) × 1.5–5.5 cm, index 1.9–4.8, apex usually abruptly acuminate, up to 12 mm long with a blunt acumen, base obtuse or acute, sometimes rounded, mostly continuing downwards onto the petiole and forming a slightly winged petiole, entire or undulate, glabrous on both sides; midrib impressed above; secondary veins in 23–60 pairs, rather straight and forming an angle of 80–90° with the midrib, 1–3(–5) mm from each other, joining near the margin to form a thin submarginal vein; tertiary venation admedial ramified, mostly conspicuous on both sides, descending towards the midrib and more or less parallel with the secondary veins. *Inflorescence* 2–5 long, many-flowered; peduncle (0.5–)1–2.5 long, glabrous or minutely puberulous as on the branches; pedicels (0.5–)1–2 × 0.3–0.5 mm, glabrous or puberulous. *Bracts* and *bracteoles* scale- or sepal-like, up to 1 mm long, ovate or subtriangular, curving or not, apex obtuse or acute, glabrous on both sides, not ciliate, leafy bracts sometimes present. *Flowers* fragrant. *Sepals* dark green or pink, sometimes red, connate at the base for 0.2–0.4 mm, ovate or suborbicular, 0.9–1.2(–1.7) × 0.9–1.2(–1.5) mm, index 0.9–1.1(–1.4), erect, rounded, glabrous outside, glabrous or laxly puberulous around the apex inside, ciliate. *Corolla* white or pink, 5.5–7 mm long in the mature bud and forming an ovoid head 0.27–0.36 of the bud length (1.5–2.5 × 1–1.5 mm) with a blunt apex; partly puberulous outside (usually on the lobed part or sometimes starting from the throat to the apex, except on the lobe margins), two hairy belts inside, the first belt pubescent from 1.8–2 mm above the base to around the apex of the stamens (around the anthers usually rather sparse), the second belt pilose on the corolla lobes; tube 5–6 mm long, 1–1.5 mm wide at the base, gradually widening around the stamens 1.5–2 mm wide, (2.9–)4.6–6 × as long as the sepals, 1.7–2.4 × as long as the lobes; lobes ovate, 2.3–3 × 1.7–2.5 mm, index 1.2–1.4, spreading. *Stamens* with apex 0.3–0.7 mm below the mouth of the corolla tube, inserted at 0.5–0.66 of the length of the corolla tube (at 3–3.3 mm from the base); filaments c. 0.4 mm long, filiform; anthers ovate or subtriangular, 1–1.2 × 0.35–0.5 mm, apex obtuse or acute. *Pistil* 3.2–4 mm long; ovary subglobose, 0.6–0.9 × 0.6–0.9 mm, syncarpous, lobed on top at the insertion of the style, glabrous or minutely hairy, disk-like thickening at the base obscure; style 1.5–2.6 mm long, filiform; pistil head 0.9–1 mm high, composed of a woolly basal ring c. 0.1 × 0.25–0.4 mm, a cylindrical central part 0.3–0.4 × 0.2–0.3 mm, and an elongate and robust cleft stigmoid apical part 0.4–0.6 mm high. *Fruits* solitary, composed of a united pair of follicles, 16–30 cm long, 8–12 mm wide, slightly laterally compressed and with distinct and narrow grooves on both sides on the flattened parts, glabrous, roughly striate and thick-walled. *Seeds* elliptic or oblong, 9–11 × 2.8–3 mm, glabrous and tuberculous on both sides (except surrounding the hilum, which is smooth), ends rounded; margin slightly thickened, longest cilia 10–17 mm long, hilum linear, 1–1.5 mm long.

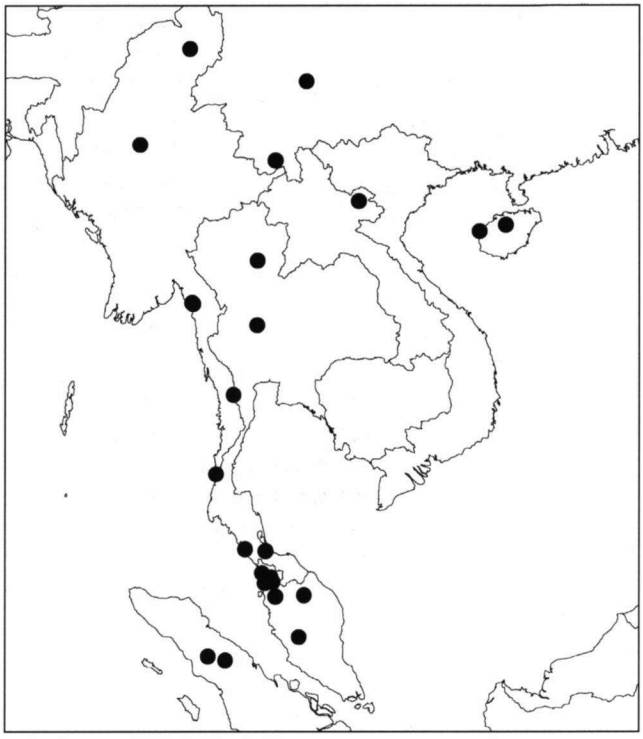


Fig. 5.33. Distribution of *Alstonia rostrata* C.E.C. Fisch.

Distribution — China (Yunnan, Hainan), Burma, Laos, Thailand, Malaysia (Peninsular Malaysia), Indonesia (known only from N and W Sumatra).

Habitat & Ecology — Secondary and primary forests, in open places, or on hillsides. Altitude 367–1800 m.

Vernacular names — China: *pen jia shu*. Burma: *taung kala, taung-ma-yo*. Indonesia: *gecih* (Batak, Tapanuli), *bulai pipit* (Lubuk Sikaping, West Sumatra)

Specimens studied: China: 7 specimens. – Laos: 2. – Vietnam: 3. – Burma: 7. – Thailand: 9. – Malaysia: Peninsular Malaysia: 13. – Indonesia: Sumatra: 4.

33. **Alstonia rubiginosa** Sidiyasa, *spec. nov.* — Fig. 5.26 & 5.34

Arbor parva vel grandis ramulis puberulis. Folia ternata vel quaternata petiolata lamina coriacea elliptica usque ad anguste elliptica vel anguste obovata apice anguste acuminata basi cuneata vel in petiolum decurrente integra supra glabra vel glabrescente subtus dense pubescente. Inflorescentia cymosa. Sepala subaequalia basi connata ovata apice obtusa ciliata extus dense pubescentia intus glabra. Corolla alba extus glabra vel pro parte minute pilosa tubo lobis lingulatis multo longiore. Stamina paulo inclusa filamentis potius robustis antherisque ovatis apice obtusis vel mucronulatis basi cordatis. Pistillum glabrum ovario ovoideo. Fructus folliculis duabis separatis longis glabris. Semina elliptica vel ovata utroque latere pubescentia. — Typus: *Foreman & Vinas LAE 60288* (holo M; iso K), Papua New Guinea, Central District, Port Moresby Subdistrict, near Boridi, 2 Oct. 1973, fl.

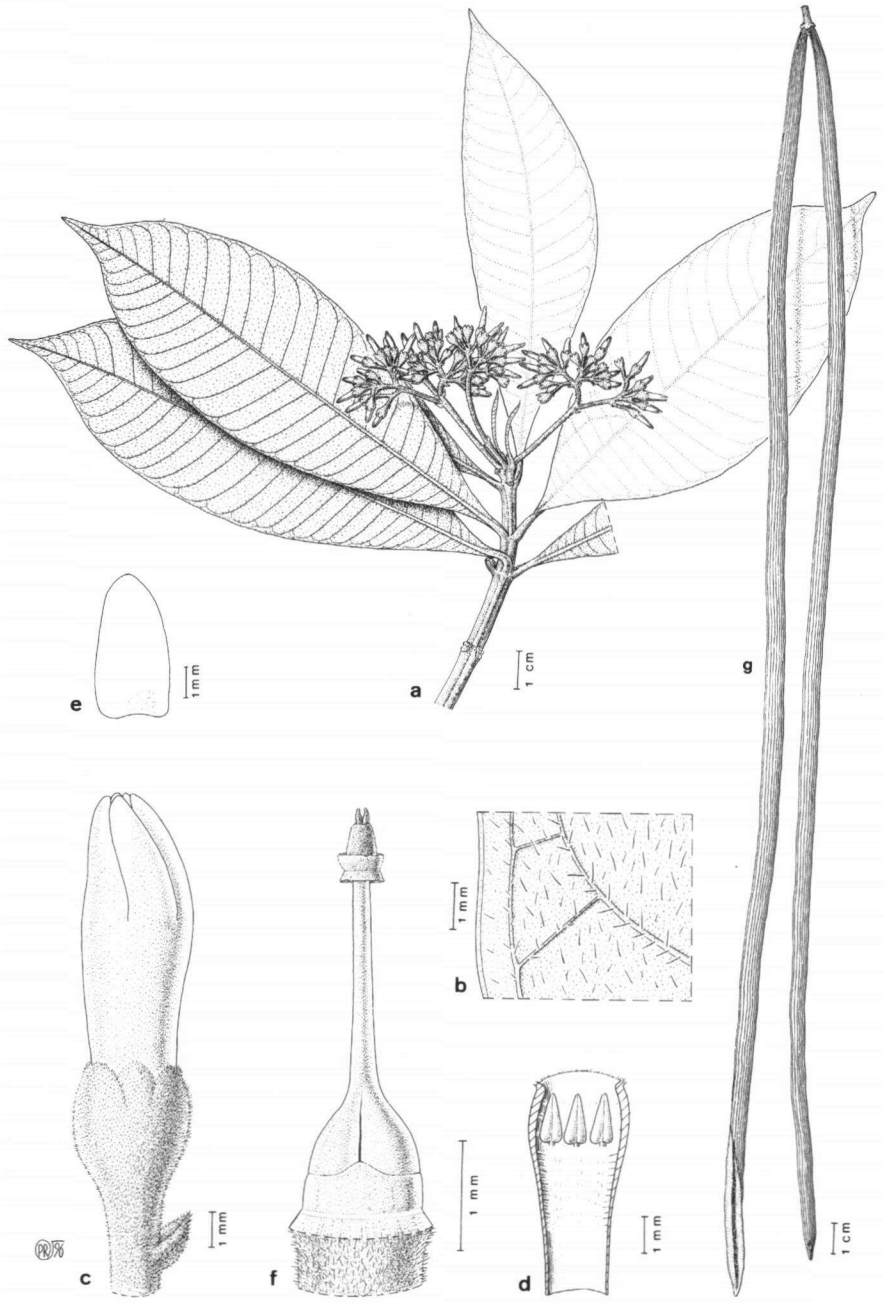


Fig. 5.34. *Alstonia rubiginosa* Sidiyasa – a: Habit; b: leaf beneath in detail; c: flower in bud, also showing one bracteole on the pedicel; d: dissected corolla tube; e: corolla lobe; f: pistil; g: follicles (a–f: *Foreman & Vinas LAE 60288*; g: *Veldkamp & Stevens 5921*).

Tree, 12–25 m high. *Bark* dark brown; inner bark light brown, without white latex from the trunk; softwood yellow or straw-coloured. *Branches* smooth or slightly rough from the leaf-scars, dark brown or blackish; branchlets terete, angular or slightly sulcate when dried, glabrescent. *Leaves* in whorls of 3 or 4, petiolate; petiole puberulous or glabrescent, 5–11 × 1.6–2.5 mm, canaliculate or impressed above, colleters minute, densely packed together in the axils, without intrapetiolar stipules; blade shiny and dark green above, light green beneath, or grey-brown (usually darker beneath) and coriaceous when dried, elliptic to narrowly elliptic or obovate, 10–18 × 3–6.7 cm, index 2.4–3.5, apex narrowly acuminate (sometimes abruptly acuminate), acumen up to 2 cm long with a blunt tip, base acute or decurrent onto the petiole, entire, glabrous or glabrescent above, densely pubescent (velutinate) beneath; midrib impressed above; secondary veins in 23–26 pairs (short interstitial veins sometimes present), parallel and slightly arched, forming an angle of 70–80(–90)° with the midrib (the widest angles usually at the base of the leaves), 3–8 mm from each other, submarginal vein very distinct; tertiary venation reticulate, mostly conspicuous on both sides. *Inflorescence* 3.5–5 cm long, many-flowered; peduncle 1.2–3.5 cm long, rather stout, 1–1.5 mm in diameter, puberulous as the branches; pedicels stout 1–2(–3) × 0.6–0.9 mm, usually slightly laterally compressed, softly pubescent. *Bracts* and *bracteoles* sepal- or scale-like, ovate or triangular, 1–1.5 mm long, acute or acuminate, ciliate, densely pubescent outside, glabrous inside, linear bracts (17–25 × 1–1.5 mm) and leafy bracts (c. 4.5 × 1 cm) sometimes present at the base of the inflorescence. *Flowers* fragrant. *Sepals* connate at the base for 0.8–1 mm, ovate, 2.4–2.8 × 1.6–2 mm, index 1.4–1.5, apex obtuse, ciliate, densely pubescent outside, glabrous inside, erect. *Corolla* white, 8–8.5 × 1.5–1.7 mm in the mature bud and forming an ovoid (acuminate) head 0.47–0.5 of the bud length, c. 4 × 1.5 mm, with a blunt apex, glabrous or minutely hairy around the stamens outside, two hairy belts inside, the first belt pubescent starting from 1.8–2 mm above the base and ending at the insertion of the stamens (1.5–1.8 mm wide), the second belt pilose on the lower half of the corolla lobes (around the stamens usually very sparse); tube almost cylindrical or slightly widening around the stamens, 5.5–5.8 mm long, 2(–2.5) mm wide, 2–2.3 × as long as the sepals, 1.2–1.3 × as long as the lobes; lobes lingulate, slightly oblique, 4.6–5.2 × 2–2.5 mm, index c. 2.1, not ciliate, apex rounded, auriculate at the base on the right side. *Stamens* with apex 0.2–0.6 mm below the mouth of the corolla tube, inserted at 0.63–0.65 of the length of the corolla tube (at 3.6–3.7 mm from the base); filaments rather stout, 0.6–0.8 × c. 0.15 mm; anthers ovate 1.2–1.4 × 0.4–0.6 mm, apex obtuse or mucronulate. *Pistil* glabrous, 1.4–1.6 × as long as the longest sepals, 4–4.1 mm long; ovary ovoid, c. 1 × 1 mm, composed of 2 carpels, with a disk-like thickening at the base, c. 0.5 mm high; style c. 2.5 mm long, filiform; pistil head ovoid, c. 0.7 mm long, composed of a membranous basal veil, c. 0.1 mm high, a ring c. 0.1 × 0.3 mm, a cylindrical central part 0.3 × 0.3 mm, and a cleft stigmoid apical part 0.2 mm high. *Fruit* a pair of follicles, c. 43 cm long, 4.7–5 mm in diameter, glabrous. *Seeds* dull-brown, elliptic or ovate, 6–8.5 × 2.6–3 mm, pubescent on both sides, one end acuminate with an acumen 1.5–3 mm long, the other end rounded; longest cilia 3–5 mm long and becoming gradually shorter towards the margins; hilum (on ridge) more or less elliptic, 0.2 × 0.1 mm (known from only one specimen collected by *Veldkamp & Stevens 5921*).

Distribution — Endemic to Papua New Guinea.

Habitat & Ecology — Primary and secondary forests, in forests dominated by *Ficus* and *Euphorbia*. Altitude 1370–1420 m.

Vernacular name — *Tutuen* (Daga, Bonenau) (*Veldkamp & Stevens 5921*).

Note — *Alstonia rubiginosa* is very similar to *A. parvifolia* Merr. and *A. beatricis* Sidiyasa in having densely pubescent sepals outside and glabrous or very sparsely hairy corollas outside. It differs from both species in the leaves, which are densely velutinous beneath, a higher number of secondary veins (23–26 pairs versus 12–17 pairs), and in having pubescent sepal lobes inside (except on the fused part). From *A. parvifolia* it also differs in having a thin margin of the sepals and in having glabrous corolla lobes inside (except at the extreme base of the corolla lobes). From *A. beatricis* it differs mainly in having much larger flowers: sepals 2.4–2.8 × 1.6–2 mm versus c. 1.7 × 1 mm, corolla in the mature bud 8–8.5 mm versus c. 3 mm long, the corolla tube 5.5–5.8 mm versus c. 2 mm long, and the corolla lobes 4.6–5.2 × 2–2.5 mm versus c. 2 × 1.1–1.2 mm and in not being ciliate on the corolla lobes.

Specimens studied: Papua New Guinea, Central Province, Port Moresby Subprovince, near Boridi, alt. 1370 m, *Foreman & Vinas LAE 60188a* (L) and *LAE 60288* (type); Goropu Mountains (Mt. Suckling), alt. 1420 m, *Veldkamp & Stevens 5921* (L).

34. Alstonia rupestris Kerr — Fig. 5.16 & 5.35

Alstonia rupestris Kerr, Kew Bull. (1937) 43; Fl. Siam. En. 2 (1939) 440. — *Blaberopus rupester* (Kerr) Pichon, Bull. Mus. Hist. Nat. Paris 2, 19 (1947) 300. — Type: *Kerr 5660* (holo BM; iso K, P), Thailand, Doi Chiengdao, 4 June 1921, fl.

Shrub, 4 m high. *Branches* smooth, densely lenticellate; branchlets terete or slightly quadrangular when dried, glabrous, pale to dark brown. *Leaves* in whorls of 4, sessile or subsessile; petiole up to 1 mm long, glabrous, canaliculate above, colleters minute or linear and densely packed together in the axils; blade chartaceous or thinly coriaceous, pale to dark brown above and paler beneath when dried, very narrowly obovate, 3.5–12 × 0.7–2.2 cm, index 4.4–6.3, apex gradually acuminate with a pointed tip, base tapered and rounded before attaching to the branchlet, glabrous on both sides, margin mostly revolute; midrib raised above, flat or shallowly longitudinally canaliculate in the middle when dried; secondary veins in 60–80 pairs, almost parallel, sometimes branched and forming an angle of 60–75° with the midrib, 1–2.5 mm from each other, slightly arched and very often confused with some thin (shorter) interstitial veins; tertiary venation inconspicuous. *Inflorescences* 2.5–5 cm long, in groups of 7–10, many-flowered; peduncle (0.5–)1–2.8 cm long, 0.6–1.2 mm wide, glabrous as on the branches; pedicels 2.5–4 × 0.4–0.5 mm, glabrous, minute bracteole sometimes present. *Bracts* and *bracteoles* scale- or sepal-like, ovate, up to 1.5 mm long, apex acute or narrowly acuminate with an acumen up to 0.4 mm long, sometimes irregularly dentate, sometimes some colleters united at the base of the bracts, at the base of the inflorescences the bracts usually much longer, linear up to 15 mm long, or leafy, not ciliate, glabrous on both sides. *Flowers: Sepals* connate at the base for c. 0.3 mm, ovate or triangular, 1.2–1.4 × 1–1.3 mm, index 1–1.2, erect, glabrous on both sides, obtuse, not ciliate. *Corolla* greenish, c. 10 mm long in the mature bud and

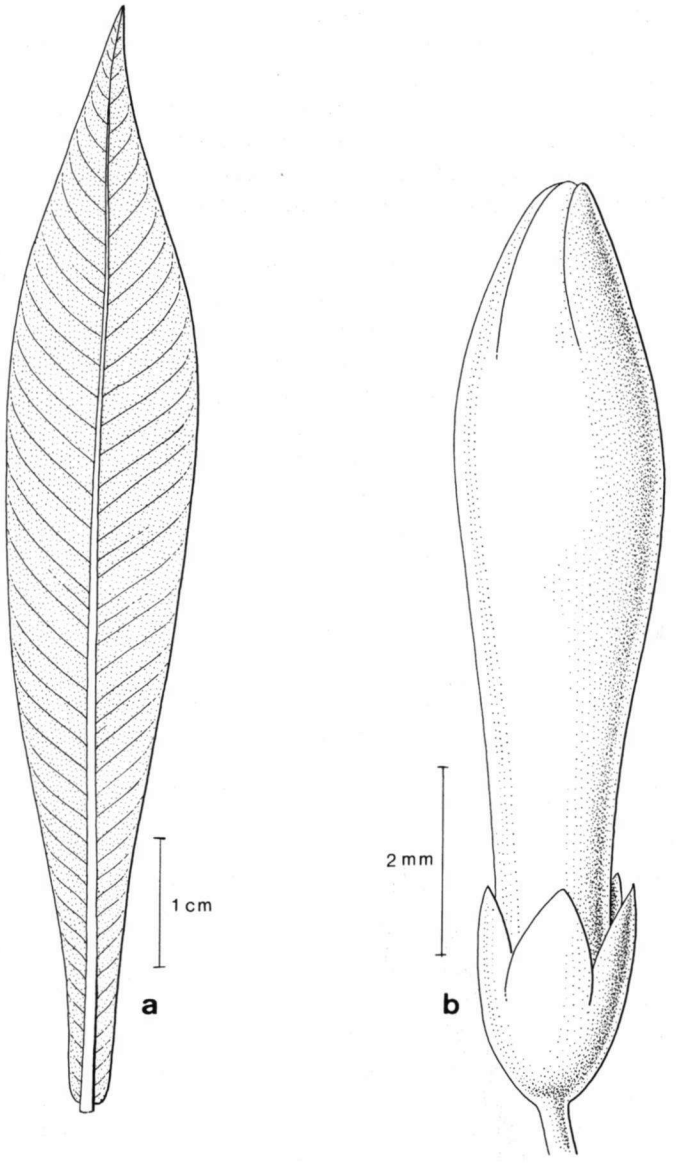


Fig. 5.35. *Alstonia rupestris* Kerr – a: Leaf; b: flower in bud (a, b: *Kerr 5560*).

forming a narrowly ovoid head c. 0.25 of the bud length, c. 2.5 × 1.5 mm (narrower than the tube) with a blunt apex, glabrous outside, a sericeous belt inside at the broader part of the tube (about half of the tube length), c. 4 mm wide, other parts entirely glabrous; tube 7.5–8 mm long, c. 1.5 mm wide at the base, gradually widening around the stamens, to 2.5–3 mm wide, 5.7–6.3 × as long as the sepals, 0.37–0.4 × as long as

the lobes; lobes ovate or slightly triangular, c. 3 × 2.2–2.6 mm, index 1.15–1.36, not ciliate, auriculate at the base on the left side. *Stamens* with apex 0.1 mm below the mouth or about the same height as the corolla tube, inserted at c. 0.75 of the length of the corolla tube (at c. 6 mm from the base); filaments 0.8–1 mm long, filiform; anthers ovate, 1.1–1.3 × c. 0.7 mm, obtuse or apiculate. *Pistil* 4.7 × as long as the sepals, c. 6.6 mm long; ovary ovoid, c. 1.2 × 1 mm, composed of 2 carpels, glabrous, disk as high as or somewhat higher than the ovary, with 2 broad lobes alternating with the carpels, and with wavy or irregularly lobed margins; style 4.5 mm long, filiform; pistil head pagoda-shaped, c. 1 × 1 mm, composed of a membranous basal veil 0.2 × 0.9 mm, a woolly ring 0.2 × 1 mm, then a hairy-margined ring (central part) 0.15 × 0.8 mm, and a broadly ovoid (robust) cleft stigmoid apical part 4.5 × 6 mm. *Fruit* a pair of follicles, 5.4–8.3 cm long, 3–4 mm in diameter, slightly laterally compressed, minutely striate or almost smooth, glabrous, not stipitate, rostrum 3–5 mm long. *Seeds* narrowly elliptic or oblong, 9–11 × 2.4–2.6 mm, ends rounded, usually irregularly dentate or unequally lobed, pubescent or glabrescent on both sides, and with long hairs similar to the cilia near the margin on the distal surface, longest cilia 4–4.5 mm long, hilum elliptic, c. 0.4 × 0.2 mm.

Distribution — Thailand. Also reported from China (Li et al., 1995) but no material was cited.

Habitat & Ecology — Limestone rocks in open evergreen forest. Altitude (500–) 1800 m.

Specimens studied: Thailand: *Kerr 5560* (type) and *Put 366* (A, BM, K, L, P).

35. Alstonia scholaris (L.) R. Br. — Fig. 5.36 & 5.37

Alstonia scholaris (L.) R. Br., On Asclepiad. (1810) 65; Mem. Wern. Nat. Hist. Soc. 1 (1811) 76; De Candolle, Prodr. 8 (1844) 408; Monachino, Pacific Sci. 3 (1949) 146 (excl. syn. *Tabernaemontana alternifolia* Burm.); Markgraf, Blumea 22 (1974) 23. — *Echites scholaris* L., Mant. Pl. (1767) 53. — Type: *LINN. 302.2* (holo LINN), fl. & fr.

Echites pala Ham., Trans. Linn. Soc. 13 (1822) 518. — Type: '*Pala*' Rheede, Hort. Malab. 1 (1678) 81, t. 45.

Alstonia scholaris var. *blumii* A. DC., Prodr. 8 (1844) 409. — Type: (Blume, Bijdr. Fl. Ned. Ind. 16, 1826, 1037), Java, at the base of Salak mountain (untraced).

Alstonia scholaris var. *avae* A. DC., Prodr. 8 (1844) 409. — Type: *Wallich 1644 f* (holo G-DC; iso K, K-W), "in montibus Tong-Dong prove Avam", Ava in Burma, 1827, fl.

Alstonia kurzii Hook. f., Fl. Brit. India 3 (1882) 643. — Type: *Kurz s.n.* (holo CAL?, not seen), Andaman Islands.

Alstonia scholaris var. *velutina* Monach., Pacific Sci. 3 (1949) 150. — Type: *Holttum s.n.* (*SF no. 24680*) (holo: SING, not seen), Malaysia, Pahang.

Medium-sized to big tree, 10–50(–60) m high; trunk 20–80(–130) cm in diameter, fluted at the base or forming tall and steep buttresses up to 10 m high, spreading to up to 4 m at the base. *Bark* smooth, scaly or shallowly fissured and peeling off in rectangular flakes, fawn or light brown; inner bark granular, creamy, yellow or straw-coloured, with copious white latex. *Branches* smooth or slightly rough, scaly, with sparse or dense lenticels; branchlets terete, glabrous, grey, yellowish brown or some-

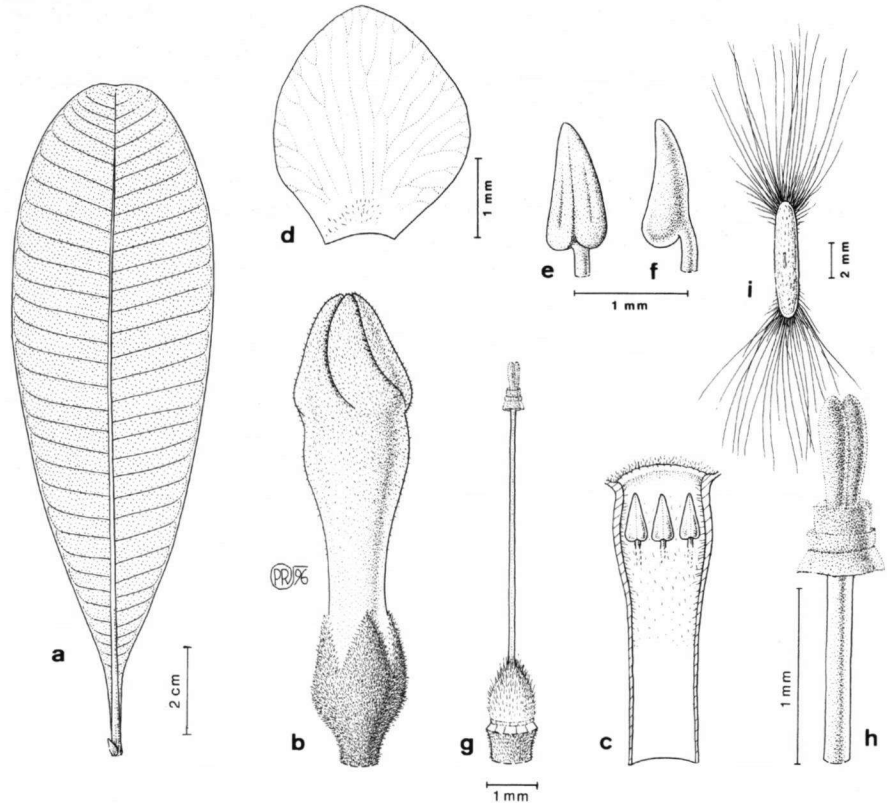


Fig. 5.36. *Alstonia scholaris* (L.) R. Br. – a: Leaf, with an intrapetiolar stipule at the base of the petiole; b: flower in bud; c: dissected corolla tube, showing 3 anthers; d: corolla lobe; e: anthers, front view; f: anthers, side view; g: pistil, showing the pubescent ovary; h: pistil head, supported by the style and showing a robust cleft stigmoid apex; i: seed (a: *Maxwell 75-1083*; b–i: *Henty & Sayer NGF 20588*).

times dark brown. *Leaves* in whorls of 4–8(–9), petiolate; petiole glabrous, 5–20 (–25)×1–2(–3) mm, flattened and shallowly canaliculate above, slightly winged, with intrapetiolar stipule at the base and 1–3 mm long, colleters narrowly triangular and densely packed together in the axils; blade glossy and dark green above, pale or grey-green beneath, subcoriaceous when dried, narrowly elliptic to obovate, (5–)6–17 (–22) × (1.5–)2.5–7.5(–8.5) cm, index 1.7–4.5, apex obtuse or rounded or often retuse (in young trees, the leaves usually much larger, shortly acuminate and with blunt acumen up to 1 cm long), base often decurrent onto the petiole, less often acute or obtuse, entire, glabrous or velutinous beneath; midrib impressed above; secondary veins in 25–45(–55) pairs, rather straight, forming an angle of (70–)80–90° with the midrib, (1.5–)2–5(–7) mm from each other; tertiary venation reticulate, sometimes admedial ramified, conspicuous above. *Inflorescence* 4–13(–17) cm long, many-flowered, mostly formed of two dense bunches of flowers; peduncle 0.5–5(–9) cm long,

glabrescent or pubescent; pedicels 0–2 × 0.3–0.5 mm, pubescent. *Bracts* and *bracteoles* scale- or sepal-like, ovate or narrowly ovate, acuminate or sometimes trilobed or irregularly lobed at the apex, 1–3 mm long, ciliate. *Flowers* fragrant. *Sepals* pale green, connate at the base for 0.3–0.7(–1) mm, ovate, 1.5–2.4 × 0.8–1.9 mm, index 1.2–2.8, obtuse, sometimes acute or mucronulate, pubescent outside, minutely pubescent or less often glabrous inside, erect, ciliate. *Corolla* white, yellow or cream, 7–12 × 0.8–1.5 mm in the mature bud and forming an ovoid head 0.22–0.35 of the bud length, 2.5–3.5 × 1.7–2.4 mm, with a blunt apex; pubescent or partly pubescent outside (frequently glabrous on basal half, at least within the calyx), two distinctly hairy belts inside, the first belt pubescent starting from 2–4 mm above the base and usually ending at the level of the stamens ((2.5–)3.4–6.6 mm wide), although often rather sparsely, the second belt densely pilose at the base of the corolla lobes (moustache-like surrounding the mouth) and then becoming softly pubescent over the surface of the lobes, ciliate; tube almost cylindrical, slightly widening around the anthers and at the base around the ovary, 7–10 mm long, 0.8–1.6 mm wide, 2.5–6.4 × as long as the sepals, 1.7–4.8 × as long as the lobes; lobes broadly ovate or suborbicular, 3–5 × 2.5–4.5(–7) mm, index 0.6–1.1, spreading. *Stamens* with apex 0–0.8 mm below the mouth of the corolla tube (one collection with the apex 0.3 mm above mouth), inserted at 0.7–0.85 of the length of the corolla tube (at 5.2–8.4 mm from the base); filaments 0.5–0.7 mm long, filiform; anthers ovate, 0.9–1.2 × 0.4–0.5 mm, apex obtuse. *Pistil* 6–9.5 mm long; ovary superior, ovoid or broadly ovoid, 0.9–1.5 × 0.7–1 mm, mostly slightly laterally compressed, densely pubescent, with or without a narrow disk-like thickening at the base; style 4.2–8 mm, filiform; pistil head 0.5–1 mm high, glabrous, composed of a basal ring 0.1–0.2 × 0.3–0.5 mm, a cylindrical central part 0.1–0.2 × 0.2–0.35 mm, and an elongate and robust cleft stigmoid apical part 0.3–0.7 mm high. *Fruit* a pair of follicles, 20–40(–63) cm long, c. 2(–2.5) mm in diameter, glabrous.

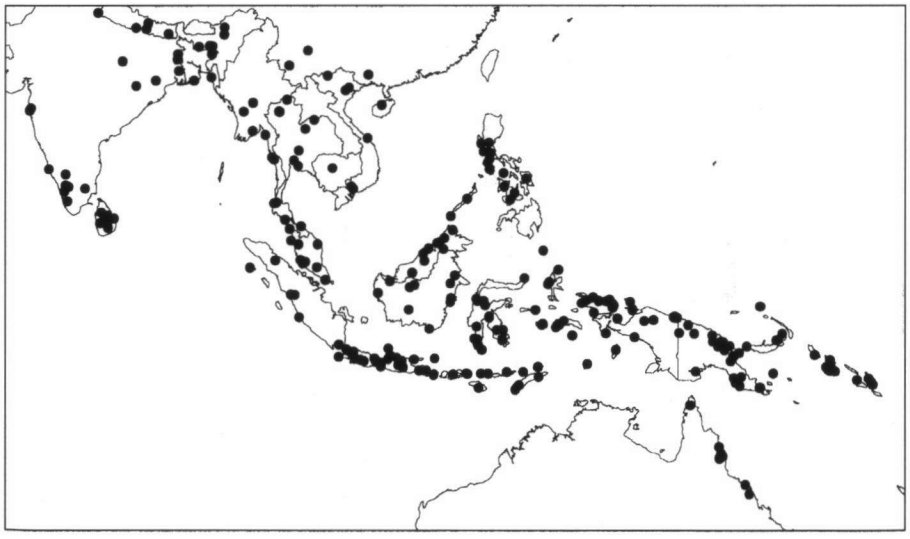


Fig. 5.37. Distribution of *Alstonia scholaris* (L.) R. Br.

Seeds dark brown, oblong, 4.5–5.5(–7) × 1.2–1.6(–2) mm, glabrous, smooth or very minutely undulate on both sides, ends rounded; margin slightly thickened, longest cilia 8–12(–14) mm long, becoming much shorter or glabrous towards the margins, hilum linear, 0.7–1(–1.5) mm long.

Distribution — India, Nepal, Bangladesh, Sri Lanka, Bhutan, Pakistan, Burma, Thailand, Cambodia, China, Laos, Vietnam, Flora Malesiana area, Australia, and Solomon Islands. Planted in the Botanical Gardens of Brazil, Trinidad, Mauritius, Calcutta, Singapore, Bogor, in the Arboretum of Dehra Dun (India), Malaysia, and in a public garden in the Caroline Islands.

Habitat & Ecology — Secondary and primary forests, savannas, along streams (rarely in swamps), in coastal plains, on ridges or montane, on clay or ultrabasic soils, granite bedrock and limestone. Altitude 0–1230 m.

Vernacular names — India: *chatiun* (Hindi), *yehalimaran*. Burma: *taung meok*. Malaysia, Sarawak: *kacau gitik* (Kiput). Indonesia: *pulai* or *pule* (the most common names), *lame* (W Java), *p(e)lantan*, *pulantan* (E and S Kalimantan). Philippines: *bita* or *dita* (Tagalog).

Uses — Against diarrhoea and stomach ache (*Madulit et al. 7240*), snake bites by applying the latex at the edge of the wound (*Awa & Lee S 50108*), and for treating herpes zoster by applying the latex on the affected parts (*Munting et al. S 52828*).

Note — Several localities were mentioned for the specimens of *Wallich 1644* (non *Wallich 1644-f*). The specimens in the herbaria of Leiden, Geneva, and Munich indicate Nepal as the locality; but of the two specimens in the Wallich Herbarium (K-W), one is labelled from Bangladesh and the other from Burma.

Specimens studied: India: 65 specimens. Nepal: 6. – Bhutan: 1 (*Grierson & Long 3726*). – Bangladesh: 4. – Sri Lanka: 12. – Burma: 11. – Thailand: 22. – Cambodia: 4. – China: 10. – Laos: 1 (*Vidal 1100*). – Vietnam: 24. – Malaysia: Peninsular Malaysia: 22, Sarawak: 6, Sabah: 8. – Singapore: 1 (*Sao Kyi Win s.n.*). – Brunei Darussalam: 1 (*Ashton 5407*). – Indonesia: Sumatra: 9, Java: 199, Kalimantan: 13, Lesser Sunda Islands: 38, Sulawesi: 31, Maluku: 43, Irian Jaya: 64. – Philippines: 49. – Papua New Guinea: 50. – Australia (Queensland): 15. – Solomon Islands: 24.

36. **Alstonia sebusi** (Van Heurck & Müll. Arg.) Monach. — Fig. 5.38

Alstonia sebusi (Van Heurck & Müll. Arg.) Monach., Pacific Sci. 3 (1949) 157. — *Blaberopus sebusi* Van Heurck & Müll. Arg., Obs. Bot. 2 (1871) 188. — Type: *Griffith 2343* (holo AWH; iso BM, G, K), India Orientalis, fl.

Alstonia henryi Tsiang, Sunyatsenia 6, 2 (1941) 112. — *Alstonia sebusi* var. *szemaoensis* Monach., Pacific Sci. 3 (1949) 157; syn. nov. — Type: *Henry 11932* (holo NY, not seen; iso E, K, MO), China, Yunnan, Szemao, 1900, fl.

Shrub or small tree, 1–5 m high. *Branches* lenticellate, grey to yellowish brown; branchlets, terete or slightly sulcate when dried, glabrous or pubescent. *Leaves* in whorls of 3 or 4, petiolate; petiole 5–18 × 0.8–1.6 mm, canaliculate above, glabrous, puberulous, or densely pubescent, many colleters densely packed together in the axils, very narrow, up to 3 mm long; blade chartaceous or thinly coriaceous when dried, elliptic, narrowly ovate to narrowly obovate, 4–20 × 1–3.6 cm, index 2.6–6, apex

acute or shortly acuminate with a pointed acumen, c. 0.5 cm long, base acute or decurrent onto the petiole, glabrous or puberulous at least on the venation above, glabrous to densely pubescent beneath, margin entire; midrib flat or impressed above; secondary veins in (30–)50–90 pairs, parallel and forming an angle of 80–85° with the midrib, 0.6–4 mm from each other, slightly arched and joining near the margin forming a thin submarginal vein, very often confused with some thin (shorter) interstitial veins; tertiary venation inconspicuous. *Inflorescence* 4–8 cm long, many-flowered; peduncle 1–4 cm long, glabrous or pubescent as on the branches; pedicels slender, 3–10(–12) × 0.3–0.4 mm, glabrous to densely pubescent. *Bracts* and *bracteoles* scale- or sepal-like, broadly ovate to narrowly ovate, up to 2.5 mm long, obtuse or acuminate, ciliate, glabrous or pubescent outside and glabrous inside, and with some colleters in the axils, leafy bracts sometimes present, or sometimes linear up to 3 cm long. *Flowers: Sepals* connate at the base for 0.2–0.3 mm, ovate or subtriangular, 1.7–2.5 × 0.8–1.5 mm, index 1.3–2.8, obtuse, mucronulate or acuminate with a blunt apex, almost translucent around the margin, glabrous to pubescent outside, glabrous inside, ciliate, erect. *Corolla* pink, 9–12 mm long in the mature bud and forming an ovoid head 0.15–0.22 of the bud length, narrower than the widest part of the tube, c. 2 × 1.5 mm, with a blunt apex, glabrous or sparsely hairy only on the lobe-margin or at the apex outside, with a densely villose belt inside from the mouth downwards up to 1.5–2(–3) mm below the stamens, entirely glabrous at the base (in a belt 3.5–5.8 mm wide); tube 8.2–10.5 mm long, 1–1.7 mm wide at the base, gradually widened around the stamens to 2.3–2.7 mm, 4.1–5.9 × as long as the sepals, 2.7–6.3 × as long as the lobes; lobes ovate or broadly ovate, (1.6–)2–3.5 × (1.2–)1.6–3 mm, index 0.9–1.75, obtuse or rounded, minutely ciliate or not, glabrous inside, auriculate at the base on the left side or sometimes on both left and right side, spreading. *Stamens* with the apex 0.4–1 mm below the mouth of the corolla tube, inserted at 0.66–0.75 of the length of the corolla tube (at 6–7.7 mm from the base); filaments 0.7–1 mm long, filiform; anthers ovate or narrowly ovate, 1.6–2 × 0.6–0.9 mm, obtuse. *Pistil* 7.2–9 mm long; ovary glabrous, ovoid or narrowly ovoid, 1.7–2.2 × 0.7–1 mm, composed of 2 carpels; disk with 2 long lobes alternating with the carpels, narrowly ovoid, as high as or somewhat shorter than the ovary, 1.2–2.2 mm long, mostly slightly laterally compressed; style 4–5 mm long, filiform; pistil head pagoda-like, 1.5–1.8 mm high, composed of a basal membranous ring 0.1–0.3 × 0.8–1 mm, a woolly and usually wider central ring-like part 0.2–0.4 × 0.8–0.9 mm, then a ring c. 0.3 × 0.5–0.6 mm, and a robust and long cleft stigmoid apex 0.4–1 × 0.2 mm. *Fruit* a pair of follicles, 5–10 cm long, 4–4.7 mm in diameter, closely striate or almost smooth, glabrous, not spreading, stipitate and rostrate, stipe 8–14 mm long, rostrum 3–8 mm long. *Seeds* elliptic, 8–10 × 2.5–3.2 mm, with a distinct wing surrounding the grain, both ends rounded, irregularly dentate or unequally lobed, and slightly so at the margin, glabrous and slightly ridged on the hilar side, with sparse long hairs only near the margin on the distal side; grain usually situated slightly oblique towards one end; longest cilia 3–5 mm long, hilum elliptic, 0.2–0.3 × 0.1 mm.

Distribution — Bhutan, India (Assam), Burma, China (Yunnan).

Habitat & Ecology — Riversides, open woodland on mountains. Altitude 1300–1700 m.

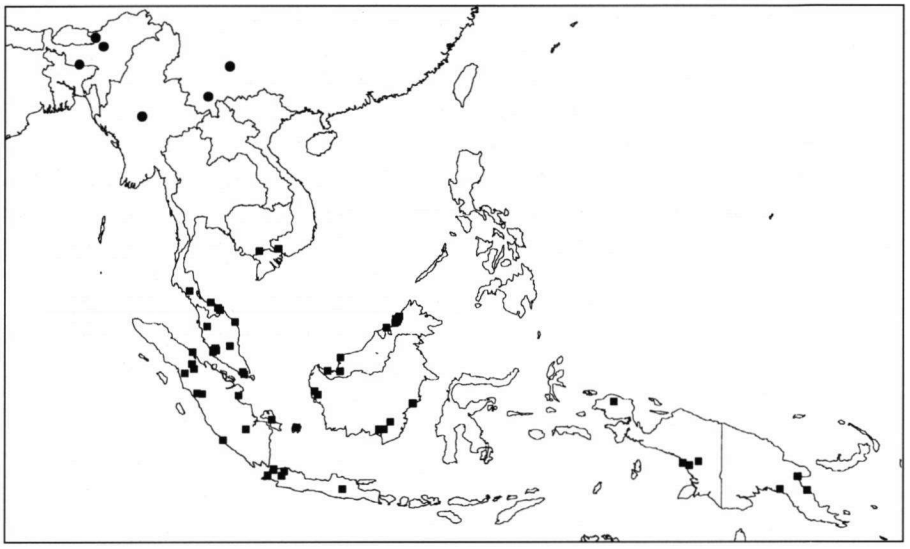


Fig. 5.38. Distribution of *Alstonia sebusi* (Van Heurck & Müll. Arg.) Monach. (●) and *A. spatulata* Blume (■).

Notes — This species can be recognised by leaves which are puberulous above and pubescent beneath. The glabrous form is found in Assam and Burma and usually has shorter and fewer colleters.

When sterile this species is difficult to distinguish from *A. venenata* R. Br. Both species have very similar leaves and form of indumentum. The greenish colour of the dried leaves of *A. sebusi* (especially for the pubescent form) could be a good character for identification.

There are two different species on the type specimen sheets: flowering branchlet and only follicle or fruiting branchlet. After study I concluded that the follicle or fruiting branchlet material belongs to the pubescent form of *A. venenata* in which the seeds are much longer (12.5–14.5 mm long) and the grain is situated approximately in the middle of the seed.

Specimens studied: Bhutan : 4 specimens. – India: 3. – Burma: 1 (*Cooper 6014*). – China: 2 (*Henry 11932 & 13244*).

37. Alstonia spatulata Blume — Fig. 5.38 & 5.39

Alstonia spatulata Blume, Bijdr. Fl. Ned. Ind. 16 (1826) 1037; Hooker, Fl. Brit. India 3 (1882) 642; King & Gamble, J. Asiat. Soc. Bengal 74, 2 (1907) 437; Ridley, Fl. Malay Penins. 2 (1923) 346; Monachino, Pacific Sci. 3 (1949) 153; Markgraf, Blumea 22 (1974) 25. — Type: *Blume s.n.* (holo L [898.129-143]), Indonesia, W Java, near Rompin (= Rumpin), fl.

Alstonia cuneata Wall. ex G. Don, Gen. Syst. 4 (1837) 87. — Type: *Govan s.n. in Wallich 1645* (holo K-W), India, Punjab, Sermore (= Sirmur), fr. The locality is incorrect according to Hooker (1882) and King & Gamble (1907).

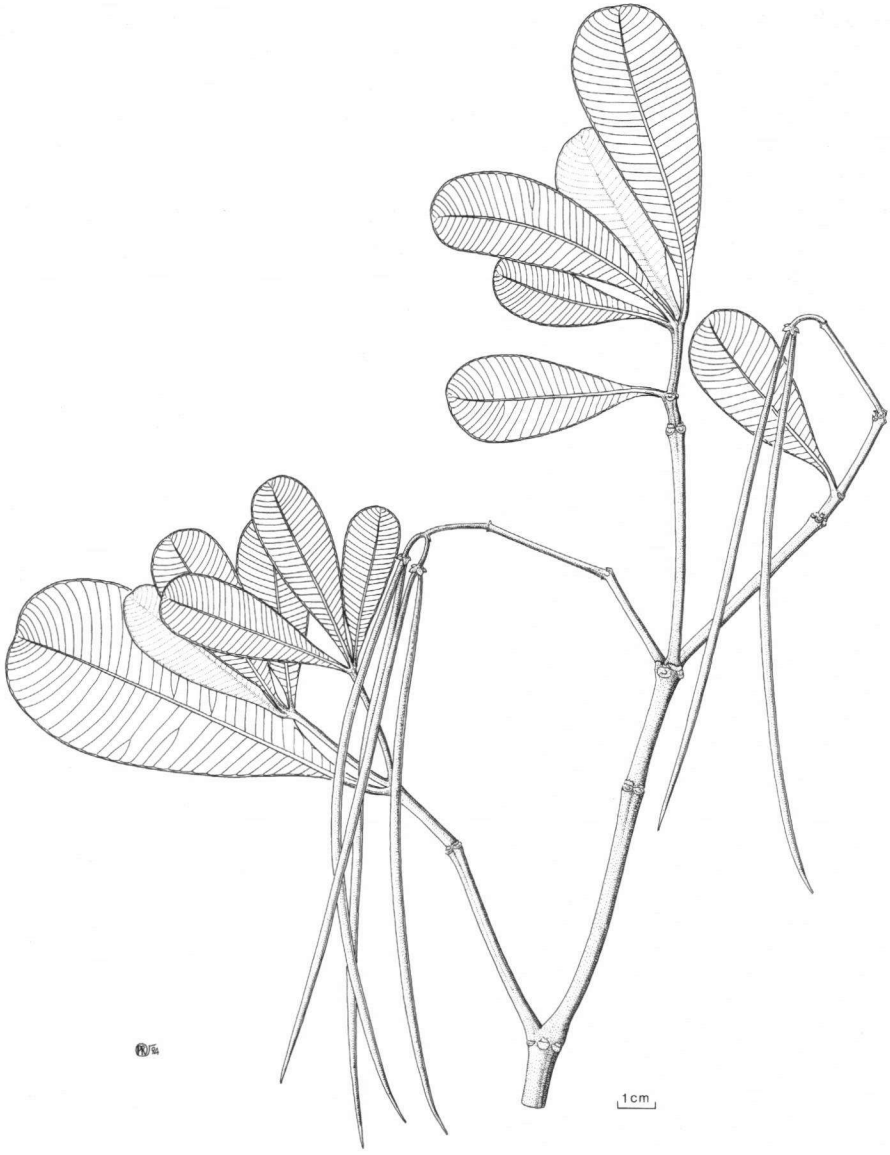


Fig. 5.39. *Alstonia spatulata* Blume (*Ambriansyah AA 944*).

Tree, 10–25 m high; trunk 15–40 cm in diameter, sometimes forming symmetrical plank buttresses up to 1.20 m high (bottle-shaped at the base known in New Guinea). *Bark* smooth, scaly or finely fissured and peeling off in square or rectangular flakes, pale to dark grey or almost black; inner bark white, creamy or pale yellow, with copious white latex. *Branches* smooth, without lenticels; branchlets terete, sometimes slightly sulcate when dried, glabrous, yellowish grey. *Leaves* in whorls of 3–4(–5),

petiolate; petiole glabrous, 4–10(–15) × 1–3 mm, flattened above, sometimes slightly winged; colleters deltoid in the axils, mostly not persistent; blade glossy and dark green above, pale or grey-green beneath, coriaceous and yellowish grey when dried, spathulate or obovate, 3–12 × 1.8–4.8 cm, index 1.6–2.5(–2.96), apex rounded, sometimes retuse, base obtuse, acute, or decurrent onto the petiole, entire, glabrous on both sides; midrib impressed above; secondary veins in 20–35(–40) pairs, straight and forming an angle of 70–80° with the midrib, 1.5–3(–4) mm from each other; tertiary venation admedial ramified, inconspicuous. *Inflorescence* 3–11 cm long, terminal, few (3–6)-flowered on each cluster; peduncle 2.5–5(–8) cm long (only specimens from New Guinea have the peduncle up to 8 cm long), glabrous; pedicels (2.5–)4–9 × 0.4–0.6 mm, glabrous. *Bracts* and *bracteoles* sepal-like, ovate or triangular, up to 1(–1.7) mm long, acute, ciliate or not. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.4 mm, ovate, sometimes broadly ovate or subtriangular, (1.2–)1.5–2 × 1–1.6(–2) mm, index (0.9–)1–1.8, erect, obtuse or rounded, ciliate, glabrous on both sides. *Corolla* white, yellow, or cream, 14–15 mm long in the mature bud and forming a narrowly ovoid head 0.46–0.53 of the bud length, 6.5–7.5 × 2–3 mm (much wider than the corolla tube), with a blunt apex, glabrous outside, two hairy belts inside, the first belt pubescent starting from 2.5–4.2 mm above the base and ending at 0.5–1 mm below the mouth or around the apex of the stamens (3–4.5 mm wide), around the basal half of the stamens usually with rather sparse hairs, the second belt densely white villose at the base of the corolla lobes; tube almost cylindrical, 7–8 mm long, 1–1.5 mm wide, 3.5–5.3(–6.7) × as long as the sepals, 0.7–1.1 × as long as the lobes; lobes elliptic, 6.7–11 × 3.5–6 mm, index 1.4–2.1, mostly undulate, not ciliate, spreading or almost reflexed. *Stamens* with apex 0–0.6 mm below the mouth of the corolla tube, inserted at 0.6–0.8 of the length of the corolla tube (at 5–6.5 mm from the base); filaments 0.5–0.7 mm long, filiform; anthers ovate, 1–1.4 × 0.4–0.5 mm, apex obtuse. *Pistil* glabrous, 5.3–7 mm long; ovary ovoid or broadly ovoid, 0.8–1.5 × 0.9–1.5 mm, mostly slightly laterally compressed, composed of 2 carpels, disk-like thickening absent; style 4.3–5.5 mm long, filiform; pistil head 0.7–0.8 mm high, composed of a thin basal ring up to 0.1 mm high, a cylindrical central part 0.4–0.6 × 0.3(–0.35) mm, and a short (sometimes robust) cleft stigmoid apical part c. 0.1(–0.2) mm high. *Fruit* a pair of follicles, 12–25 cm long, 2.5–3 mm in diameter, minutely striate or almost smooth, glabrous. *Seeds* oblong, 5–6 × 1.6–2.2 mm, ends obtuse or rounded, glabrous with a very minute reticulate structure on both surfaces, thickened margin distinct on the hilar side, longest cilia (12–)15–22 mm long, becoming shorter (rarely glabrous) at the margins, hilum linear, c. 1(–1.7) mm long,

Distribution — Burma, Thailand, Cambodia, Vietnam, Malaysia (including Sarawak and Sabah), Singapore, Brunei Darussalam, Indonesia (Sumatra, Java, Kalimantan, Irian Jaya), and Papua New Guinea.

Habitat & Ecology — Swamps, mostly in secondary vegetation, on sandy soils. Altitude 0–600 m.

Vernacular names — *Pule* or *pulai* are the common names in Malaysia, Sumatra and Java. The other names are *pulai basong* (Peninsular Malaysia); *kayu gabus, gabusan* (Sumatra, W Java); *lame* (Kalimantan); *sideh* or *sireh* (Asmat, Irian Jaya).

Specimens studied: Thailand: 7 specimens. – Cambodia: 1 (*Bejaud 54*). – Vietnam: 5. – Malaysia: Peninsular Malaysia: 45, Sarawak: 12, Sabah: 20. – Singapore: 4. – Brunei Darussalam: 5. – Indonesia: Sumatra: 23, Java: 20, Kalimantan: 11, Irian Jaya: 6. – Papua New Guinea: 10.

38. Alstonia spectabilis R. Br. — Fig. 5.40 & 5.41

Alstonia spectabilis R. Br., On Asclepiad. (1810) 65; Mem. Wern. Nat. Hist. Soc. 1 (1811) 76; Monachino, Pacific Sci. 3 (1949) 161; Markgraf, Blumea 22 (1974) 27. — Type: *R. Brown s.n.* (holo BM), Indonesia, Timor, Coepang (= Kupang), Apr. 1803, fl. & fr.

Alstonia villosa Blume, Bijdr. Fl. Ned. Ind. 16 (1826) 1038, non Seem. — *Blaberopus villosus* (Blume) Miq., Fl. Ind. Bat. 2 (1856) 440. — Type: *Blume 1006* (holo L; iso L, 2 sh.), Indonesia, Java, Kuripan, fr.

Blaberopus villosus var. *petiolata* Miq., Fl. Ind. Bat. 2 (1856) 440. — Type: *Horsfield s.n. (Apoc. 15)* (holo K; iso K), Indonesia, East Java, Belambangan, fr.

Alstonia ophioxyloides F. Muell., Fragm. 1 (1857) 57. — *Alstonia spectabilis* subsp. *ophioxyloides* (F. Muell.) P.I. Forster, Austral. Syst. Bot. 5 (1992) 758; Fl. Australia 28 (1966) 122; syn. nov. — Type: *F. Mueller s.n.* (lecto K, designated by P.I. Forster, 1992), Australia, Northern Territory, Fitzmaurice River, fr.

Alstonia linearis Benth., Fl. Austral. 4 (1869) 314; P.I. Forster, Austral.. Syst. Bot. 5 (1992) 748; syn. nov. — Type: *Cunningham 204* (lecto K, designated by Monachino, 1949; isolecto BM, K), Western Australia, Brunswick Bay, Oct. 1820, fr.

Alstonia longissima F. Muell., Papuan Plants (1877) 91. — Type: *D'Albertis s.n.* (holo FI, not seen), Papua New Guinea, Fly River.

Alstonia villosa var. *glabra* Koord. & Valeton, Meded. 's Lands Plantentuin 11 (Bijdr. 1) (1894) 123. — Type: ex insula Nusabarung ("tantum nobis cognita"), Indonesia, Java (untraced).

Alstonia somersetensis F.M. Bailey, Queensland Agric. J. 1 (1897) 229. — Type: *Jardine s. n.* (holo [AQ332794] BRI), Queensland, Cook District, Somerset, Sept. 1897, fr.

Alstonia villosa forma *calvescens* Markgr., Bot. Jahrb. Syst. 61 (1928) 178. — Type: *K. & L. Rechinger 4114* (lecto W, designated here; isolecto W), Solomons, Matupi Island, Neu-Pommern, Sept. 1905, fl. & fr.

Small or large tree (sometimes shrub), 3–30 m high; trunk up to 90 cm in diameter, sometimes with small buttresses. *Bark* smooth, scaly or longitudinally fissured, corky, grey, brownish or dark brown; inner bark yellowish or straw-coloured, hard, granular, without white latex; softwood pale yellow. *Branches* smooth, sometimes lenticellate; branchlets terete, mostly triangular or quadrangular and slightly sulcate when dried, glabrous or puberulous, pale to dark brown or blackish, sometimes yellowish green. *Leaves* in whorls of 3 or 4, sessile or petiolate; petiole glabrous or puberulous, slender or rather stout, (0–)5–27 × 0.6–3 mm, canaliculate above, many minute colleters densely packed together in the axils; blade dark green above, light green beneath, chartaceous or thinly coriaceous when dried, linear to obovate, 3–32 × (0.2–)1–12 cm, index 1.8–16(–47.5), apex acute, obtuse or shortly abruptly acuminate, acumen up to 10 mm long, base acute or decurrent onto the petiole, sometimes with slightly rounded base and then running down onto the petiole as a narrow wing, entire or sometimes sinuate, glabrous (rarely puberulous) above, glabrous or puberulous to velutinous beneath; midrib impressed above; secondary veins in 10–30(–40) pairs (rather obscure for the linear form), forming an angle of 60–80(–90)° with the midrib, 2–15 mm from each other; tertiary venation reticulate, sometimes scalariform, mostly conspicuous be-

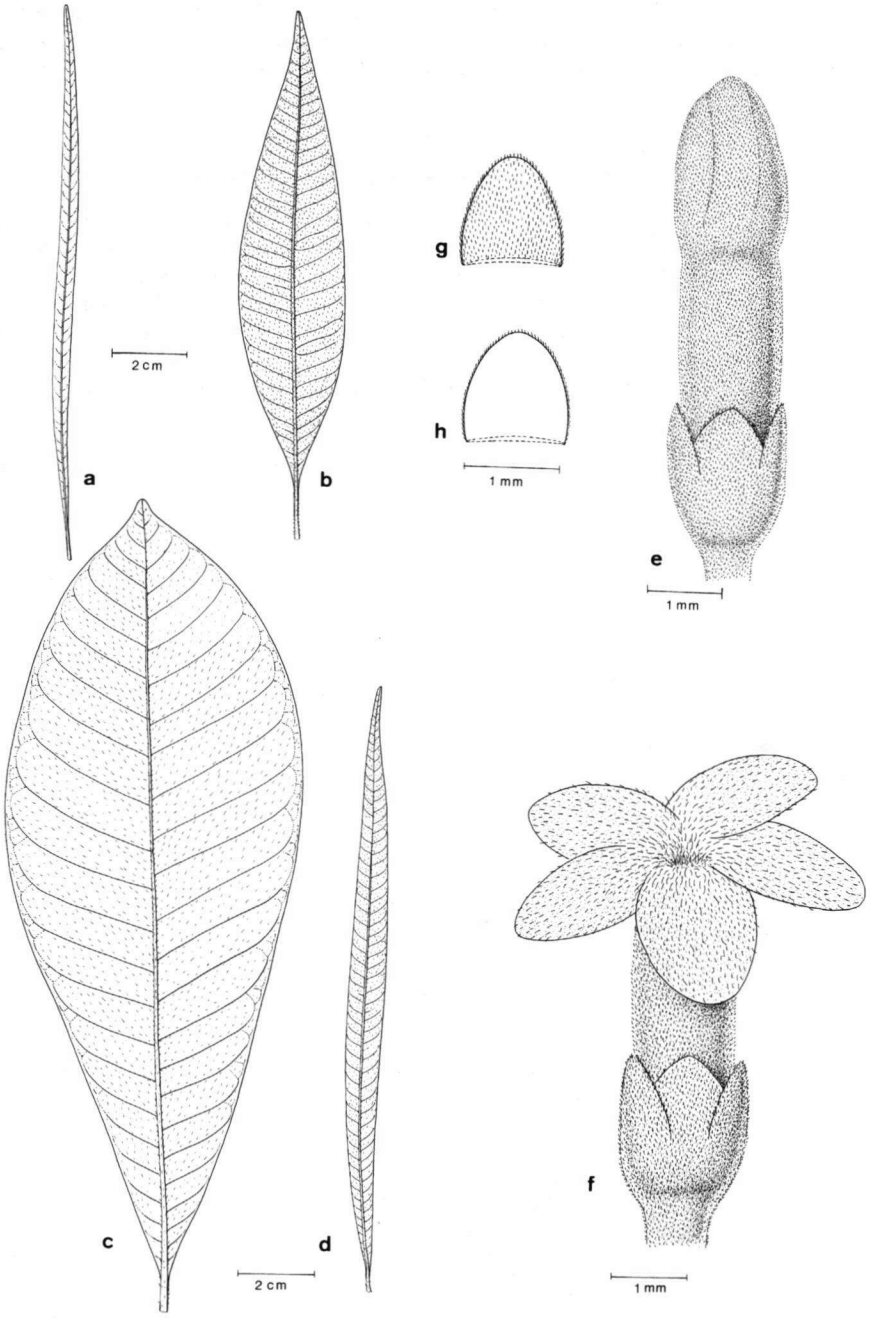


Fig. 5.40. *Alstonia spectabilis* R. Br. – a–d: Leaves; e: flower in bud; f: open flower; g: surface of sepals, outside; h: surface of sepals, inside (a: *Kenneally 7138*; b: *Hartley 14735*; c, e–h: *Schodde & Craven 4519*; d: *Kenneally 10893*).

neath (or sometimes on both sides). *Inflorescences* 2.5–11 cm long, in groups of 2–8, many-flowered, lax or congested and dense; peduncle slender, 1–7 cm long and 0.6–1.7 mm wide, mostly laterally compressed, glabrous or puberulous; pedicels 1–3 × 0.4–0.8 mm, puberulous or tomentose. *Bracts* and *bracteoles* scale-like, up to 1(–1.5) mm long, ovate or broadly ovate, acute or acuminate, ciliate, puberulous or pubescent outside, glabrous inside. *Flowers* fragrant. *Sepals* subequal, usually three of them larger than the other two, connate at the base for 0.3–1.2 mm, ovate, sometimes obovate or suborbicular, 1.1–3 × 1–1.8 mm, index 1.1–2.2, apex obtuse or rounded, sometimes mucronulate, erect, ciliate, pubescent outside, glabrous inside (less often laxly puberulous around the apex). *Corolla* white, cream or yellow, 4–7.5 mm in the mature bud and forming an ovoid head 1.2–3 × 0.8–1.5 mm when dried, puberulous or pubescent outside (except the basal part within the calyx which is glabrous), two densely hairy belts inside, the first belt pubescent from 1–2.2 mm above the base to the insertion of the stamens (0.7–1.3 mm wide), the second belt pilose starting from 0.2–0.5 mm below the mouth and covering the corolla lobes, around the stamens very sparsely hairy; throat wall much thicker; tube almost cylindrical or slightly widening around the stamens (above the middle), 3–5.5 mm long, 1–2 mm wide, 1.3–3.3 × as long as the sepals, 1.1–1.9 × as long as the lobes; lobes suborbicular or ovate, 2–3.5 × 1.2–2.8 mm, index 1–2.1 × as long as wide, ciliate, apex obtuse or rounded, auriculate at the base on the right side, spreading. *Stamens* with apex 0.5–1.3 mm below the mouth of the corolla tube, inserted at 0.46–0.64 of the length of the corolla tube (at 1.6–3.4 mm from the base); filaments short, 0.3–0.5 mm long, filiform; anthers ovate, 0.9–1.2 × 0.3–0.5 mm, apex acute, obtuse or sometimes mucronulate with a pointed tip. *Pistil* 0.8–2.1 × as long as the longest sepals, 1.9–3.8 mm long; ovary ovoid or broadly ovoid, 0.5–1 × 0.6–1 mm, usually slightly compressed, composed of 2 carpels, glabrous, with a disk-like thickening at the base, 0.2–0.4 mm high; style 1–2.1

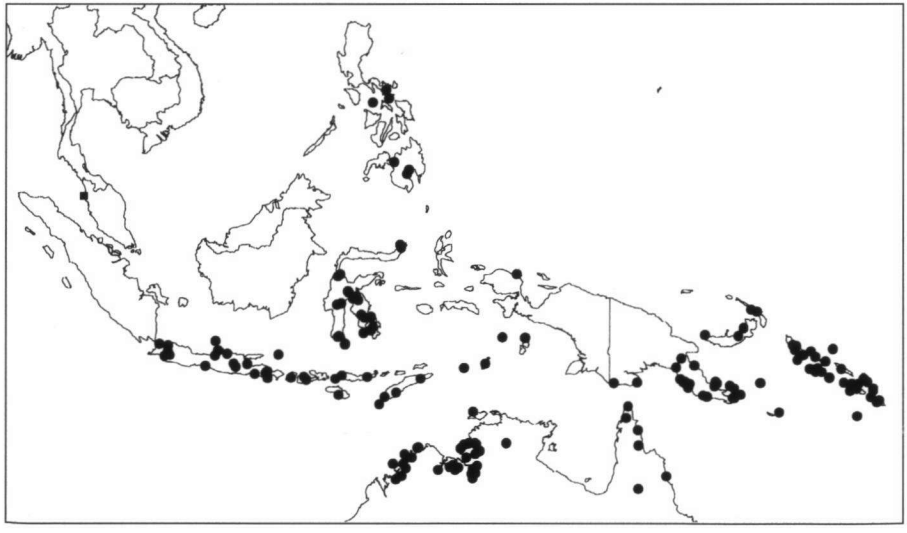


Fig. 5.41. Distribution of *Alstonia penangiana* Sidiyasa (■) and *A. spectabilis* R. Br. (●).

mm long, filiform; pistil head ovoid or funnel-shaped, 0.4–0.7 × 0.2–0.45 mm, composed of a thin basal ring up to 0.1 mm high, a conical central part 0.2–0.4 × 0.2–0.3 mm, and a cleft stigmoid apical part 0.1–0.2 mm high. *Fruit* a pair of follicles, (15–) 20–50 cm long, (2.5–)3–4 mm in diameter, glabrous, striate. *Seeds* elliptic or narrowly so, sometimes ovate, 5–9 × 1.5–2.7 mm, dark brown, mostly blackish at the margin, pubescent on both sides, one (adaxial) end short- or rather long-acuminate with an acumen up to 2.7 mm long (sometimes acute or cuneate), the other end rounded or obtuse; longest cilia 6–13 mm long, becoming gradually shorter towards the margins, hilum circular, c. 0.15 mm in diameter, or elliptic, up to 0.4 × 0.2 mm.

Distribution — Indonesia (except Sumatra and Kalimantan), Philippines, to Papua New Guinea (including New Britain), northern parts of Australia and the Solomon Islands.

Habitat & Ecology — Primary and secondary forests, coastal forests, on alluvial clay, limestone, or on lateritic soils with bedrock or coral ground covered by a thin layer of humus. Only *Ramlanto 206* annotated that this species grew in a swamp forest in Soroako, S Sulawesi. Altitude 5–800 m.

Vernacular name — Philippines, Luzon: *kuyau-kuyau* (Bic, Sorsogon Province).

Notes — *Alstonia linearis* Benth. and *A. spectabilis* subsp. *ophioxyloides* (F. Muell.) P.I. Forster could not be maintained here. The presence of a number of specimens with intermediate characters means that these taxa should be synonymised under *A. spectabilis*. Some of these intermediate specimens are: *Kenneally 10546 & Hyland 25153 RFK*, *Carr 4025*, *Lazarides 8556*, and *Kenneally & Hyland 10893* (these specimens often have narrow leaves, and are therefore closer to the type specimen of *A. linearis*). The last two specimens are similar to *Kenneally 10969*, *Brock 517 & 618*, *Dunlop 5759*, and *Russell-Smith & Brock 7568*, which are those specimens closer to *A. spectabilis* formerly called subsp. *ophioxyloides*. All the taxa which are combined here have the same flower characters.

Bentham (1869) described his new species *Alstonia linearis* without observing any flower characters, basing the taxon on the linear leaves. Similarly Forster (1992) recognised a subspecies, *ophioxyloides*, based on the pubescence of the leaves but later acknowledged that this character was not particularly useful due to the large variation.

Forster (1992) maintained *A. linearis* and mentioned that the species was characterised by opposite leaves. However, the type and other specimens have leaves in whorls of 3 or 4.

The Philippines plants usually have slightly larger and longer flowers.

Specimens studied: Philippines: 6 specimens. – Indonesia: Java: 83, Sulawesi: 46, Maluku: 13, Nusa Tenggara: 51, Irian Jaya: 2. – Papua New Guinea: 58. – Australia: 66. – Solomon Islands: 94.

39. Alstonia sphaerocapitata Boiteau — Fig. 5.42

Alstonia sphaerocapitata Boiteau, Adansonia sér. 2, 16 (1977) 474; Fl. Nouv. Caléd. et Dépend. 10 (1981) 191. — Type: *Vieillard 2947* (holo P; iso K), New Caledonia, Gatope, fl.

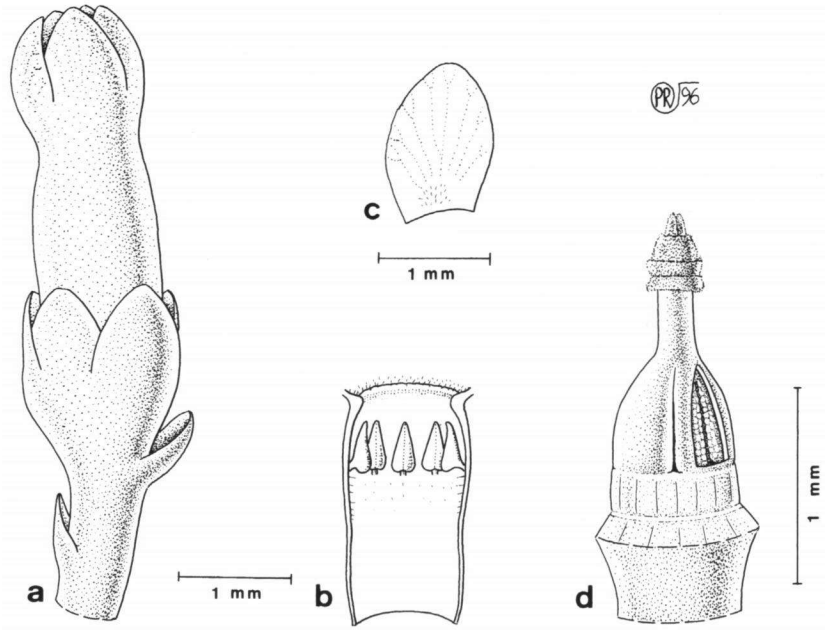


Fig. 5.42. *Alstonia sphaerocapitata* Boiteau – a: Flower, not fully open, also showing two bracteoles on the pedicel; b: dissected corolla tube; c: corolla lobe; d: pistil, showing an annular disk-like thickening at the base and numerous ovules from the dissected ovary (a–d: *MacKee 36174*).

Small or medium-sized tree, 4–20 m high; trunk 15–45 cm in diameter. *Bark* rather rough, brown or dark-brown with grey spots, with copious white latex from the inner bark. *Branches* slightly rough or shallowly longitudinally fissured, sometimes lenticellate; the branchlets terete, usually laterally compressed or angled when dried, glabrous, grey or dark brown. *Leaves* opposite, petiolate; petiole slender, 15–35(–50) × 0.6–1(–2) mm, glabrous, canaliculate above, widening at the base and more or less clasping the branchlets, few or many minute colleters densely packed together in the axils; blade chartaceous and dull dark brown when dried, rarely pale-brown, elliptic to narrowly elliptic, rarely narrowly obovate, 3.5–21 × 1.3–6 cm, index 2–3.8, glabrous on both sides, apex acute, obtuse or rounded, base acute or decurrent onto the petiole, sometimes slightly oblique, margin entire, slightly undulate and/or sinuate; midrib impressed above; secondary veins in (8–)10–16 pairs, almost straight or slightly arched, parallel or not and forming an angle of (50–)60–80° with the midrib, 3–15(–20) mm from each other; tertiary venation minutely reticulate, conspicuous beneath. *Inflorescence* 3.5–18 cm long, terminal, many-flowered; peduncle 1–7.5 cm long, slender, 0.6–1 mm wide, glabrous as on the branches; pedicel 1–3(–4) × c. 0.3 mm, glabrous. *Bracts* sometimes leafy, or more or less similar to the bracteoles, scale- or sepal-like, ovate or broadly ovate, c. 0.5 mm long, glabrous, not ciliate, obtuse or rounded (very often 1 or 2 bracteoles just below the calyx). *Flowers: Sepals* connate

at the base for 0.1–0.2 mm, ovate to broadly ovate, 0.8–1 × 0.8–1.1 mm, index 0.9–1.3, erect, glabrous on both sides, apex rounded, almost translucent around the margin, not ciliate, mostly the two outer ones larger than the inner three. *Corolla* yellow, 2.5–3.5 mm long in the mature bud and forming a subglobose head 0.2–0.3 of the bud length, 0.6–1 mm in diameter, with a rounded apex, glabrous outside, with two distinct hairy belts inside, the first belt shortly pubescent from c. 1 mm above the base to the insertion of the stamens (0.4–0.6 mm wide), the second belt villose starting with sparse hairs from 0.3–0.4 mm below the mouth, dense at the base of the corolla lobes, then reducing again to puberulous and/or glabrous towards the apex (around the stamens usually very sparse or glabrous); tube almost cylindrical, 2.5–3 mm long, 1 mm wide, 2.5–3.4 × as long as the sepals, 2.4–3 × as long as the lobes; lobes (broadly) ovate, 0.9–1.2 × 1–1.1 mm, index 0.9–1.2, auriculate at the base on the right side, minutely ciliate, spreading. *Stamens* with apex 0.6–0.8 mm below the mouth of the corolla tube, inserted at 0.5–0.6 of the length of the corolla tube (at 1.5–1.7 mm from the base); filaments 0.2–0.3 mm long, filiform; anthers ovate, 0.5–0.7 × 0.3–0.4 mm, obtuse or acute. *Pistil* 1.5–1.8 mm long; ovary glabrous, (broadly) ovoid, 0.8–0.9 × 0.6–0.7 mm, composed of 2 carpels, a disk-like thickening at the base 0.1(–2) mm high; style 0.3–0.5 mm long; pistil head 0.4–0.5 mm high, sparsely hairy around the apex, composed of a basal ring c. 0.1 mm high, a conical central part c. 0.2 × 0.2 mm, and a cleft stigmoid apical part up to 0.15 mm high. *Fruit* a pair of follicles, 18–35 cm long, 3–3.5 mm in diameter, striate, glabrous. *Seeds* 10–16(–19) mm long (main part elliptic, 3–5 × 1.5–2.3 mm), acuminate or caudate at both ends and with an acumen or cauda (2–)3–6 mm long, bifid or unequally lobed at the apex, and irregularly dentate at the margin, pubescent on both sides, cilia up to 2 mm long, gradually becoming shorter towards the margin, hilum circular, c. 0.15 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Forest galleries, on alluvial and serpentinic soils. Altitude from sea level up to 200 m.

Specimens studied : New Caledonia: 17 specimens.

40. **Alstonia stenophylla** Guillaumin — Fig. 5.43

Alstonia stenophylla Guillaumin, Bull. Soc. Bot. Fr. 88 (1941) 372. — Type: *Balansa 2823* (holo P), New Caledonia, south slope of Mt. Mou, Apr. 1870, fl.

Shrub, 2 m high. *Branches* smooth, lenticellate or not; branchlets terete or slightly angular when dried, glabrous, grey to dark brown. *Leaves* in whorls of 3, petiolate; petiole 3–10 × 0.6–1 mm (sometimes obscure due to the leaf margin which continues towards the base), longitudinally canaliculate above, not widened at the base, few or many minute colleters densely packed together in the axils; chartaceous or thinly coriaceous, grey-green, and greenish brown beneath when dried, very narrowly ovate to linear, 4–14.5 × 0.5–1 cm, index 6–20, glabrous on both sides, apex rounded, base decurrent onto the petiole, entire; midrib impressed above; secondary veins in 15–30 pairs, usually not parallel and forming an angle of (60–)70–90° with the midrib, 1.5–5 mm from each other, joining at the end and forming a minute submarginal

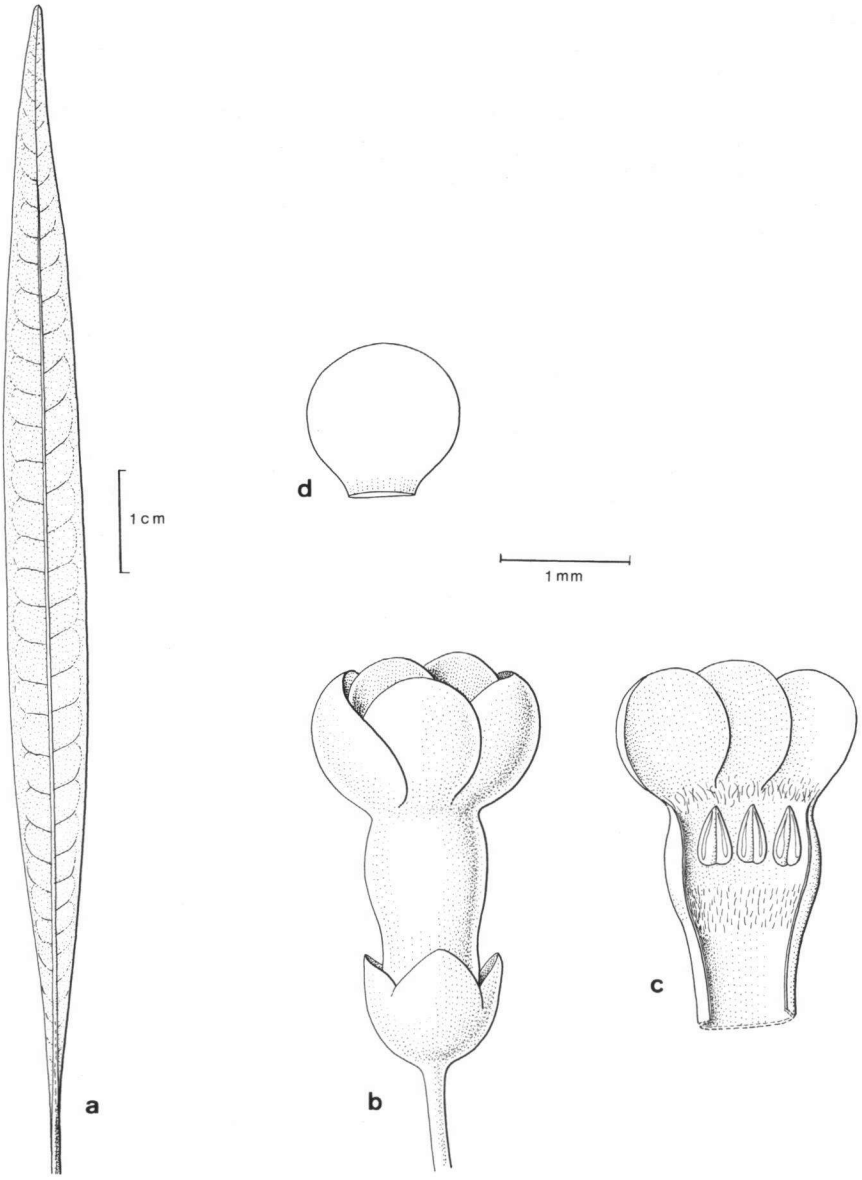


Fig. 5.43. *Alstonia stenophylla* Guillaumin – a: Leaf; b: not fully open flower; c: dissected flower; d: corolla lobe (a–d: *Balansa 2823*).

(looped) vein, rarely inconspicuous; tertiary venation inconspicuous. *Inflorescence* 6–8 cm long, 4 or 5 together, many-flowered; peduncle 3–5.5 cm long, slender, 0.8–1 mm in diameter, glabrous as on the branches; pedicels slender, 3–7 × 0.2–0.4 mm, glabrous, usually with 1 or 2 bracteoles around the middle. *Bracts* and *bracteoles*

scale- or sepal-like, ovate or triangular, up to 1.5 mm long, obtuse, glabrous on both sides, not ciliate; *Flowers: Sepals* connate at the base for 0.15–0.2 mm, ovate, triangular, or broadly ovate, 0.8–1 × 0.8–1.1 mm, index 0.9–1.1, erect, glabrous on both sides, apex obtuse, almost translucent margin, not ciliate, mostly three of them larger than the other two. *Corolla* white, 2.5–2.7 mm long in the mature bud and forming a broadly ovoid head 0.36–0.4 of the bud length, c. 1 × 1 mm, with an obtuse apex, glabrous outside, with two hairy belts inside, the first belt shortly pubescent starting from 0.7–0.9 mm above the base to the insertion of the stamens (0.3–0.4 mm wide), the second belt minutely pilose at the extreme base of the corolla lobes and surrounding the mouth of the corolla tube moustache-like; tube almost cylindrical, 2 mm long, c. 1 mm wide, c. 2 × as long as the sepals, 1.3–2 × as long as the lobes; lobes suborbicular or broadly ovate, 1–1.5 × 1.1–1.5 mm, index 0.8–1, auriculate at the base on the right side, not ciliate, spreading. *Stamens* with apex c. 0.3 mm below the mouth of the corolla tube, inserted at 0.6–0.7 of the length of the corolla tube (at 1–1.3 mm from the base); filaments 0.2–0.3 mm long, filiform; anthers ovate, 0.5–0.6 × 0.25–0.3 mm, obtuse. *Pistil* 1.2–1.35 mm long; ovary glabrous, ovoid, 0.5–0.6 × 0.6 mm, composed of 2 carpels, a disk-like thickening at the base 0.15–0.2 mm hight (rather obscure); style 0.3–0.6 mm long; pistil head 0.27–0.35 mm high, composed of a thin basal ring 0.05–0.08 × 0.25–0.3 mm, a cylindrical central part c. 0.1 × 0.1–0.2 mm, and a cleft stigmoid apical part up to 0.2 mm high. *Fruit* unknown.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Known only from c. 200 m altitude.

Note — This species was not mentioned by Monachino (1949) nor by Boiteau (1976) in their treatments of *Alstonia*. The species is very similar to *Alstonia lanceolifera* S. Moore in its small flowers and the broadly ovoid head of the corolla bud. It differs mainly in the arrangement of the leaves, which are in whorls of 3 instead of opposite, and in its narrower corolla lobes.

Specimens studied: New Caledonia: *Balansa 2823* (type) and *Le Rat 2871* (P).

41. Alstonia venenata R. Br. — Fig. 5.44

Alstonia venenata R. Br., On Asclepiad. (1810) 66; Mem. Wern. Nat. Hist. Soc. 1 (1811) 77. — *Blaberopus venenatus* (R. Br.) A. DC., Prodr. 8 (1844) 411. — Type: *Roxburgh s.n.* (holo BM; iso E), India, Bengal, fr.

Alstonia venenata var. *pubescens* Monach., Pacific Sci. 3 (1949) 156. — Type: *Gamble 13973* (holo K; iso HBG), India, Madras, Ganjam District, March 1884, fr.

Shrub or small tree, 2–3 m high. *Branches* smooth, lenticellate; branchlets terete, sometimes slightly sulcate when dried, glabrous, puberulous or densely pubescent, greyish, with a ring formed by the densely packed colleters at the nodes. *Leaves* in whorls of 3–6, petiolate; petiole (3–)5–10(–20) × 0.7–1(–1.3) mm, canaliculate above, glabrous or pubescent, colleters minute or linear (up to 3 mm long in var. *pubescens*) densely packed together in the axils; blade chartaceous or thinly coriaceous when dried, narrowly elliptic, sometimes elliptic, narrowly obovate or linear, 4–20 × 1–4.2 cm, index 3–9(–12), apex narrow and gradually acuminate, acumen up to 2 cm long

and with an acute point, base cuneate or decurrent onto the petiole (rarely acute), glabrous on both sides or puberulous above at least on the midrib and pubescent beneath, entire; midrib impressed above; secondary veins in (30–)50–100 pairs, parallel and forming an angle of 50–85° (sometimes starting at 90° and then slightly curving) with the midrib, 0.6–2 mm from each other, joining near the margin and forming a thin submarginal vein, very often confused with some thin interstitial vein; tertiary venation reticulate, inconspicuous. *Inflorescence* 5–12 cm long, terminal, many-flowered; peduncle (0.5–)1–3.5 cm long, 0.7–1.3 mm wide, glabrous or pubescent as on the branches; pedicels slender (2–)3–8(–11) × 0.3–0.5 mm, glabrous or pubescent. *Bracts* and *bracteoles* scale- or sepal-like, ovate or triangular, up to 2 mm long, obtuse or acuminate, ciliate, glabrous or pubescent outside, glabrous inside, and with some linear colleters in the axils (nodes of the inflorescence branching), leafy bracts sometimes present up to 3 cm long or only linear up to 0.5 cm long. *Flowers: Sepals* connate at the base for 0.2–0.3 mm, ovate, 1.5–2(–2.5) × 0.8–1.2(–1.7) mm, index 1.3–2.3, obtuse or mucronulate, rarely acute, almost translucent around the margin, glabrous or pubescent outside, glabrous inside, ciliate, erect, or slightly spreading when dried. *Corolla* white, 26–35(–40) mm long in the mature bud, forming a narrowly ovoid head 0.29–0.4 of the bud length, 8.5–12(–16) × 1.5–2 mm, with a blunt apex, entirely glabrous or with only a few hairs around the stamens and throat outside, two pilose belts inside, the first belt at the broader part of the tube, starting from 2.3–3 mm below the stamens (17–21 mm above the base) to 0.5–0.8(–1) mm below the mouth (5–6 mm wide), around the base of the stamens usually with very sparse hairs, the second belt surrounding the mouth or in a moustache-like belt c. 0.4 mm wide; tube (20–)23–28.5 mm long, 1–1.5 mm wide at the base, narrowing above to 0.8–1 mm, and again widening around the stamens, 1.7–2(–2.3) mm wide, (10–)12–18.2 × as long as the sepals, 1.7–2.6 × as long as the lobes; lobes lingulate or slightly oblique, 10–15(–19) × 4–5 mm, index 2.2–3.5(–4.8), obtuse, not ciliate, auriculate at the base on the left side, spreading. *Stamens* with apex c. 1 mm below the mouth of the corolla tube, inserted at 0.8–0.9 of the length of the corolla tube (at 19.5–25 mm from the base); filaments 0.7–0.9 mm long, filiform; anthers (narrowly) ovate, 2–2.5 × 0.6–0.8 mm, obtuse or acuminate. *Pistil* 20–25 mm long; ovary glabrous, ovoid, 1.7–2.4 × 0.8–1 mm, composed of 2 carpels; disk with 2 long lobes alternating with the carpels, narrowly ovoid, mostly shorter than the ovary (rarely longer), 1.2–2 mm long, mostly laterally compressed; style 17–22 mm long, filiform; pistil head pagoda-like, 1–1.3 mm high, composed of a basal membranous ring 0.1–0.25 × 0.5–0.7 mm, a woolly and wider central ring-like part 0.3–0.4 × 0.4–0.5 mm, then a ring 0.3–0.5 × 0.3–0.4 mm, and a robust short cleft stigmoid apex 0.1–0.2 × c. 0.2 mm. *Fruit* a pair of follicles, 5.5–13.5 cm long, 3.5–5 mm in diameter, slightly laterally compressed, stipitate and rostrate, stipe (5–)10–35 mm long, rostrum 4–25 mm long, minutely striate or almost smooth, glabrous, not spreading. *Seeds* elliptic, narrowly elliptic or slightly oblique, 8.5–12(–14.5) × 2–3.5(–4) mm, both ends rounded or obtuse, irregularly dentate or unequally lobed, and slightly so on the margins, glabrous and slightly ridged on the hilar side, mostly shortly pubescent and with sparse long hairs only near the margin on the other side, or glabrescent and forming a minute reticulate structure, grain usually located about the middle of the seed, cilia 4–10 mm long, usually tending to be shorter at the margins, hilum elliptic, 0.2–0.4 × c. 0.15 mm.

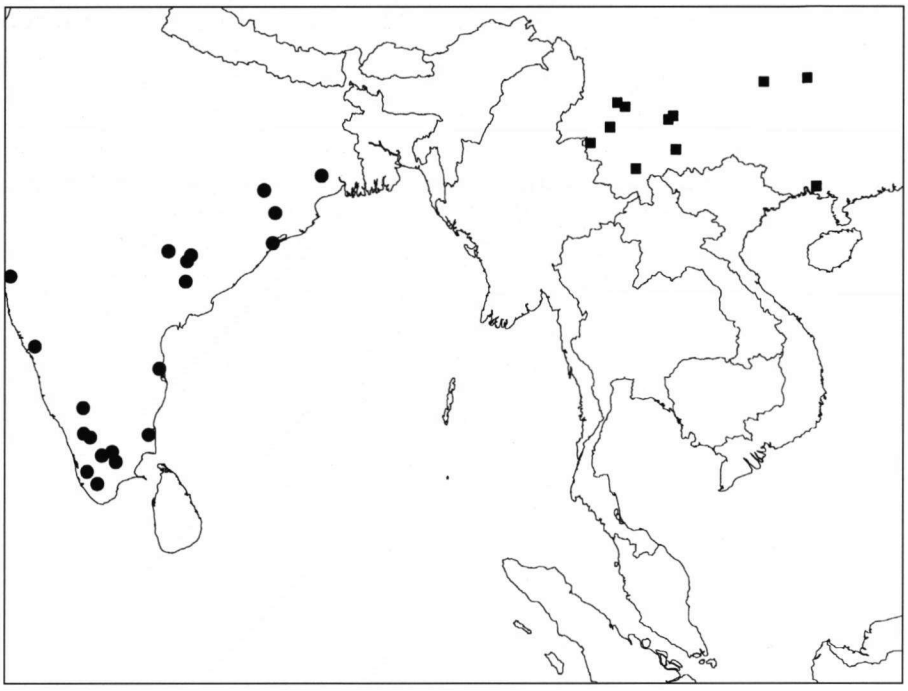


Fig. 5.44. Distribution of *Alstonia venenata* R. Br. (●) and *A. yunnanensis* Diels (■).

Distribution — India: from Madhya Pradesh to the south (Tamil Nadu, Karnataka, and Kerala). Cultivated in Botanical Gardens of Calcutta, Barbados, Trinidad, Kenya, Uganda, Malawi, Rhodesia, China, Singapore, and Brisbane.

Habitat & Ecology — Open woodlands or dry deciduous forests, in river vallies, and rocky slopes. The pubescent form is reported as growing together with *Murraya, Cleistanthus patulus, Gymnosporia*, and *Atalantia* (*H. F. Mooney 1053*). Altitude 500–1270 m.

Notes — *Alstonia venenata* var. *pubescens* Monach. could not be maintained here. There are two specimens which are intermediate between the glabrous and the pubescent form: *Voigt s.n.* (C) and *Haines 4043* (K).

The glabrous form is very similar to that of *A. neriifolia*. Vegetatively the taxa are very similar (see also under *A. sebusi*).

Specimens studied: India: 65 specimens.

42. Alstonia vieillardii Van Heurck & Müll. Arg. — Fig. 5.45

Alstonia vieillardii Van Heurck & Müll. Arg., Flora 53 (1870) 171; Monachino, Pacific Sci. 3 (1949) 169 (both as *vieillardi*); Boiteau et al., Adansonia sér. 2, 16 (1977) 469. — Type: *Vieillard 924* (holo AWH; iso G, GH, L, P, W, Z), New Caledonia, Sinu Tupili, fl.

Alstonia duerkheimiana Schltr., Tropenpfl. 7 (1903) 528. — Type: *Schlechter 14867* (holo K; iso A, B, G, HBG, L, M, W, Z), New Caledonia, Paita, 1 Oct. 1902, fl.

Alstonia vieillardii var *glaberima* Guillaumin, Bull. Soc. Bot. Fr. 88 (1941) 372; Boiteau et al., Adansonia sér. 2, 16 (1977) 469; syn. nov. — Type: *Balansa 236* (holo P), New Caledonia, 1868–1870, fl.

Shrub or small tree, 2–10 m high; trunk up to 25 cm in diameter. *Branches* smooth to rather rough, minutely horizontally fissured, lenticellate or not; branchlets terete, or slightly laterally compressed, mostly with rough leaf-scars, glabrous or puberulous, pale yellow or yellowish brown. *Leaves* opposite, petiolate; petiole glabrous or puberulous, (5–)10–37 × 1–4.5 mm, slightly flattened or longitudinally canaliculate above, widening at the base, forming an ocrea and more or less clasping the branchlets, few or many minute colleters densely packed together in the axils; blade dark green above, light green beneath, or grey-green or pale brown when dried, rarely reddish brown, thinly coriaceous, elliptic to narrowly elliptic or narrowly ovate (rarely obovate), 6–22(–37) × 1.5–14(–17) cm, index 1.6–4.7, glabrous above, softly pubescent or rare-

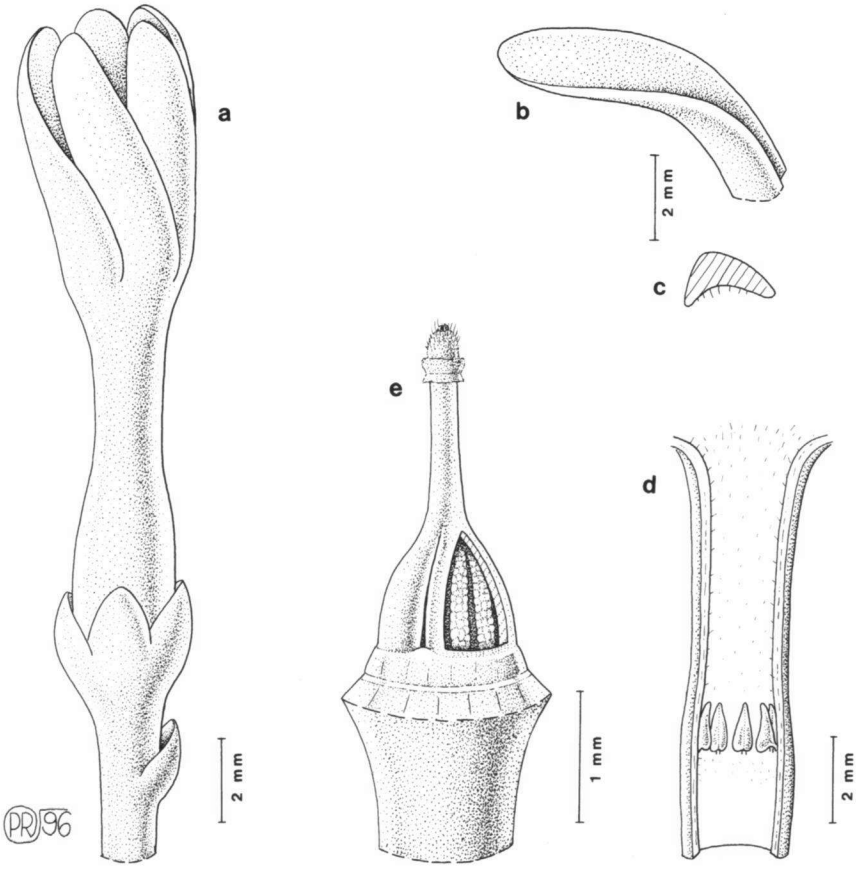


Fig. 5.45. *Alstonia vieillardii* Van Heurck & Müll. Arg. – a: Flower, not fully open; b: corolla lobe; c: cross section of corolla lobe; d: dissected corolla tube; e: pistil, showing numerous ovules from the dissected ovary (a–e: *MacKee 15751*).

ly glabrous beneath, apex obtuse or shortly acuminate with a blunt acumen up to 1 cm long, base acute or obtuse, margin entire, slightly undulate or revolute; midrib impressed above; secondary veins in 10–21 pairs, straight and forming an angle of (50–)60–70(–90)° with the midrib, 4–12(–15) mm from each other; tertiary venation scalariform and between steps reticulate, mostly conspicuous. *Inflorescence* 5–22 (–26) cm long, terminal, many-flowered; peduncle rather stout, 5–12 cm long; first branches umbellate, 1–6 cm long, glabrous or puberulous as on other branches; pedicels (2–)4–11 × 0.5–0.7 mm, glabrous or laxly puberulous. *Bracts* sometimes leafy, narrowly ovate or narrowly elliptic, up to 4 × 1.2 cm, and mostly more or less similar to the bracteoles, scale- or sepal-like, ovate, triangular or broadly triangular, up to 1 mm long, glabrous or laxly puberulous outside, glabrous inside, not ciliate, apex obtuse or acute. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.3 mm, ovate or broadly ovate, 1.7–2(–2.2) × 1–2 mm, index 0.9–2, erect, or slightly spreading when dried, glabrous on both sides, apex obtuse, almost translucent around the apex and margin, not ciliate, the two outer ones often larger than the inner three. *Corolla* yellow, 11–13 mm long in the mature bud and forming an ellipsoid or cylindrical head 0.33–0.46 of the bud length, 4–6 × 1.5–2 mm, with a rounded apex, glabrous or minutely hairy around the stamens outside, with two distinct hairy belts inside, the first belt pubescent from 1.5–2 mm above the base to the insertion of the stamens (1–1.4 mm wide), the second belt sparsely villose starting from 0.5–1 mm above the stamens and then covering most of the corolla lobes (mostly reducing gradually towards the apex), around the stamens very sparsely hairy or almost glabrous; tube almost cylindrical or slightly widening around the stamens, 7–9.8 mm long, 1.5–2 mm wide, 4–5.4 × as long as the sepals, 1.2–1.7 × as long as the lobes; lobes ovate or lingulate, oblique or sometimes slightly falcate, 5–7.1 × 1.5–2.2 mm, index 2.7–4.2, thick, auriculate at the base on the right side, not ciliate, spreading. *Stamens* with apex 4–6 mm below the mouth of the corolla tube, inserted at 0.3–0.4 of the length of the corolla tube (at 2.8–3.5 mm from the base); filaments 0.4–0.5 mm long, filiform; anthers ovate, 1–1.3 × 0.4–0.5 mm, obtuse. *Pistil* 2.5–3.5 mm long; ovary glabrous, ovoid or broadly ovoid, 0.9–1 × 0.8–1 mm, mostly slightly laterally compressed, composed of 2 carpels, a disk-like thickening at the base c. 0.1 mm high; style 1–1.8 mm long; pistil head 0.5–0.7 mm high, sparsely hairy around the apex, composed of a basal ring 0.1–0.25 mm high, a sparsely hairy conical central part 0.2–0.4 × 0.2–0.3 mm, and a cleft stigmoid apical part up to 0.1 mm high. *Fruit* a pair of follicles, (15–)20–35 cm long, 2.5–3 mm in diameter, with pointed apex, striate, glabrous. *Seeds* 5.5–8.5 mm long, main part elliptic, 2.8–3.5 × 1.6–2 mm, one end bifid or sometimes with unequal lobes, the other end obtuse or cuneate with a blunt apex, pubescent on both sides, longest cilia 1 mm long and gradually becoming shorter towards the middle of the margins, hilum circular, c. 0.1 mm in diameter.

Distribution — Endemic to New Caledonia.

Habitat & Ecology — Primary or secondary forests, riverine areas, on rocky streambeds or ultrabasic rocks. Altitude 10–500 m.

Specimens studied: New Caledonia: 59 specimens.

43. Alstonia yunnanensis Diels — Fig. 5.44

Alstonia yunnanensis Diels, Notes Roy. Bot. Gard. Edinburgh 5 (1912) 165; Monachino, Pacific Sci. 3 (1949) 158; Li et al., Fl. China 16 (1995) 155. — Type: *G. Forrest 592* (holo E), China, Yunnan, Feb. 1909, fl. & fr.

Alstonia esquirolii H. Lév., Cat. Pl. Yunnan (1915) 10. — Type: *Esquirol 740* (holo E), China, Kweichow (= Guizhou) Province, 1905, fl. & fr.

Acronychia esquirolii H. Lév., Fl. Kouy-Tcheou (1915) 374. — Type: *Esquirol 3212* (holo E), China, Kweichow (= Guizhou) Province, June 1911, fl.

Shrub or small tree, (0.7–)1–3 m high. *Branches* smooth or ringed, lenticellate; the branchlets terete, slightly angular or sometimes sulcate when dried, puberulous or glabrescent, greyish. *Leaves* in whorls of 3–4(–6), exceptionally opposite or alternate found only at the end of the flowering branches, sessile, colleters narrow or linear and densely packed together in the axils and then continuing as a ring around the nodes; blade chartaceous or thinly coriaceous when dried, narrowly elliptic or narrowly obovate, 4–17 × 1–3.6 cm, index 3–5.8, apex acute or narrowly acuminate with an acute acumen up to 2 cm long, base acute or decurrent, rarely obtuse, glabrous or glabrescent above, sparsely hairy or densely pubescent beneath at least on the venation, entire; midrib flat or impressed above; secondary veins in 15–30 pairs, sometimes not parallel and forming an angle of (45–)60–80° with the midrib, 1.2–4 mm from each other, slightly arched and joining near the margin forming a thin submarginal vein, very often confused with some thin (shorter) interstitial veins; tertiary venation reticulate, mostly inconspicuous. *Inflorescence* 2–5 cm long, terminal, many-flowered; peduncle 0–1 cm long, puberulous; pedicels slender (1–)2–5(–7) × 0.3–0.4 mm, puberulous. *Bracts* sometimes leafy or similar to the bracteoles scale- or sepal-like, narrowly triangular or linear, up to 1 mm long, puberulous, many colleters at the base and in the axils. *Flowers* fragrant. *Sepals* connate at the base for 0.2–0.3 mm, narrowly triangular, (2–)2.4–3.3(–4) × 0.8–1 mm, index (2–)2.3–3.3(–4), erect, glabrous or minutely hairy at the base outside, glabrous inside, ciliate. *Corolla* pink or red, 10–14.5 mm long in the mature bud and forming an ovoid head 0.2–0.3 of the bud length, narrower than the widest part of the tube, (2.5–)3–4 × 1–1.7 mm with a blunt apex, glabrous or very sparsely hairy only around the throat and at the lobe-margins outside, with a densely villose belt inside starting from 4–5.6 mm above the base to the mouth of the corolla tube (5–6.3 mm wide); tube 9.5–12 mm long, widening around the stamens and 2–2.5 mm wide, 3–4.7 × as long as the sepals, 2–3 × as long as the lobes; lobes ovate or lingulate, 3.5–5 × 2–2.5 mm, index 1.7–2, obtuse or rounded, sometimes mucronulate, ciliate, auriculate at the base on the left side, spreading. *Stamens* with apex 1–1.6(–2) mm below the mouth of the corolla tube, inserted at (0.61–)0.63–0.75 of the length of the corolla tube (at (4–)6.7–8 mm from the base); filaments 0.7–0.8 mm long, filiform; anthers ovate or narrowly ovate, 1.9–2.2 × 0.6–0.8 mm, obtuse. *Pistil* (4.5–)7–8.2 mm long; ovary glabrous, ovoid, 1.7–2.1 × 0.7–1 mm, composed of 2 carpels; disk with 2 long lobes alternating with the carpels, narrowly ovoid or linear and mostly longer than the ovary, 1.8–2.5 mm long, mostly slightly laterally compressed; style (1–)4–4.7 mm long; pistil head pagoda-like, 1.2–1.7 mm high, woolly in the middle, composed of a membranous basal ring 0.2–0.35 × 0.8–1 mm, a woolly wider central ring-like part 0.2–0.5 × 0.7–0.9 mm, again a ring

0.2–0.3 × 0.4–0.8 mm, and a robust cleft stigmoid apex 0.5–0.7 × 0.2–0.4 mm. *Fruit* a pair of follicles, 2.5–5.3(–6.7) cm long, (2.5–)3–4 mm in diameter, stipe absent (if present then usually very short or obscure), rostrum 3.5–7 mm long, smooth, glabrous, not spreading. *Seeds* elliptic or oblong, rather thick, 4.6–6.5(–8.5) × 2–2.6 × 0.5–0.8 mm, flat on the hilar side, ends rounded, surfaces rough, warty, and with some silky hairs up to 4 mm long, cilia on the margins sometimes not persistent, hilum circular and 0.1–0.2 mm in diameter or linear and 0.2–0.3 mm long.

Distribution — Endemic to China..

Habitat & Ecology — Open woodlands on mountains, in bamboo forests and rocky slopes. Altitude 1000–2300 m.

Uses — The roots are used to cure hypertensis and the leaves to treat haemostasis and fractures. The seeds yield up to 18% industrial oil (Li et al., 1995).

Specimens studied: China (Yunnan, Guizhou, and Guangxi Provinces): 42 specimens.

5.5. *Incompletely known taxon*

Alstonia spectabilis var. *bantamensis* Blume, Bijdr. Fl. Ned. Ind. 16 (1826) 1037, non *A. spectabilis* R. Br. — Type: "montanis Provinciae Bantam (= Banten)", Java.

I have been unable to obtain a specimen of this taxon, but I agree with Monachino (1949) that from the description it seems to be close to *A. angustiloba*, rather than *A. spectabilis*.

5.6. *Nomina nuda*

Alstonia coriacea Pancher ex Guillaumin, Ann. Inst. Bot.-Geol. Colon. Marseille 2, 9 (1911) 195 = ***Alstonia coriacea*** Pancher ex S. Moore.

Alstonia filipes Schltr. ex Guillaumin, Ann. Inst. Bot.-Geol. Colon. Marseille 2, 9 (1911) 195 = ***Alstonia lenormandii*** Van Heurck & Müll. Arg. See: Boiteau, Adansonia sér. 2, 16 (1977) 478.

Alstonia moui Pancher, Notice Bois Nouv. Caléd. (1874) 186 = ***Alstonia lenormandii*** Van Heurck & Müll. Arg. See: Boiteau, Fl. Nouv. Caléd. et Dépend. 10 (1981) 183.

Alstonia oleandraefolia Lodd. ex Loudon, Hort. Brit. 67 = ***Alstonia scholaris*** (L.) R. Br.

Amblyocalyx borneensis Benth. & Hook., Gen. Pl. 2 (1876) 698 = ***Alstonia angustifolia*** Wall. ex A. DC.

Echites venenata Roxb., Hort. Bengal (1814) 20 = ***Alstonia venenata*** R. Br.

5.7. *Excluded species*

Alstonia ciliata Benth., Pl. Hartweg. 48 (1840). — Type: *Hartweg 366* (holo G), Mexico = ***Symplocos coccinea*** var. ***benthamii*** (Gürke) Brand (Symplocaceae). See: Brand in Engler, Pflanzenr. 4 (242), Heft 6 (1901) 80.

Alstonia costulata Miq., Fl. Ind. Bat., Suppl. (1860) 556. — Type: *Diepenhorst s.n.* (holo L), Indonesia, Sumatra Utara, Priaman (= Pariaman) = ***Dyera costulata*** (Miq.) Hook. f. See: Monachino, Lloydia 9 (1946) 190.

Alstonia edulis G. Benn., J. Linn. Soc. Bot. 5 (1867) 156 = ***Parsonsia esculenta*** Pancher ex Baill. See: Guillaumin, Bull. Soc. Bot. Fr. 88 (1941) 370.

Alstonia eximia Miq., Fl. Ind. Bat., Suppl. (1860) 555. — Type: *Teijsmann s.n.* (holo L), Indonesia, Sumatra, Bangka = ***Dyera costulata*** (Miq.) Hook. f. See: Monachino, Lloydia 9 (1946) 190.

Alstonia ficifolia S. Moore, J. Bot. 61, Suppl. (1923) 32. — Type: *Forbes 74* (holo K), New Guinea, Sogere = ***Ochrosia ficifolia*** (S. Moore) Markgr. See: Markgraf, Bot. Jahrb. Syst. 61 (1927) 190.

Alstonia grandifolia Miq., Fl. Ind. Bat., Suppl. (1860) 555. — Type: *Teijsmann s.n.* (holo L; iso K), Indonesia, Sumatra, Palembang = ***Dyera costulata*** (Miq.) Hook. f. See: Monachino, Lloydia 9 (1946) 190.

Alstonia lucida D. Don, Prodr. Pl. Nepal (1825) 131. — *Blaberopus lucidus* (D. Don) A. DC., Prodr. 8 (1844) 411. — Type: *Wallich 1675* (holo K-W), Nepalia = ***Trachelospermum lucidum*** (D. Don) K. Schum. See: Monachino, Pacific Sci. 3 (1949) 179.

Alstonia micrantha Ridl., J. Straits Br. Roy. Asiat. Soc. 79 (1918) 95. — Type: *Kloss s.n.* (holo K), Malaysia, Selangor, Rantau Panjang = ***Chilocarpus*** cf. ***embelioides*** King & Gamble.

Alstonia pacifica (Seem.) A.C. Smith, Fl. Vitiensis Nov. 4 (1988) 72. — Type: *Seeman 314* (holo BM) = *Tabernaemontana pacifica* Seem. = ***Tabernaemontana pandacaqui*** Poir. See: Leeuwenberg (1991).

Alstonia polyphylla Miq., Fl. Ind. Bat., Suppl. (1860) 556. — Type: *Teijsmann s.n.* (holo L), Indonesia, Sumatra, Bangka = ***Dyera lowii*** Hook. f. See: Monachino, Lloydia 9 (1946) 194.

Alstonia schumanniana Schltr., Bot. Jahrb. Syst. 39 (1906) 236 — Type: *Schlechter 15442* (holo Z; iso L, P, W), New Caledonia, "Auf den Bergen bei Oubatche" = ***Rauvolfia schumanniana*** (Schltr.) Boiteau. See: Boiteau et al., Adansonia sér. 2, 16 (1976) 56.

Alstonia theaeformis L. f., Suppl. (1781) 264. — Type: *J.C. Mutis 3229* (holo ?US), Columbia = ***Symplocos theaeformis*** (L. f.) Gürke. See also: Brand in Engler, Pflanzenr. 4 (242), Heft 6 (1901) 81.

Tonduzia macrophylla Kuhlm., Arch. Jard. Bot. Rio de Janeiro 5 (1930) 208 = ***Laxoplumeria macrophylla*** (Kuhlm.) Monach. See: Monachino, Phytologia 3, 2 (1949) 68.

IDENTIFICATION LIST

The numbers in **bold** refer to the species numbers as given in the descriptions in Chapter 5. Dates or sheet numbers (especially of Leiden specimens) are used if the number of the collection is not available or unknown. If only the year is known, it is placed between brackets.

Dewulf 342: **7** — Diawara 1: **7** — Dickason 6671: **35**; 6830: **35** — Difor 1473: **7** — van Dijk (all bb) 30273: **23**; 30288: **23**; 30363: **23**; 30492: **23**; 30499: **35**; 30525: **35**; 30573: **23**; 30664: **35** — Dobremez 1789: **35** — Dockrill 528: **1**; 878: **1** — Doggrell 16/12/1929: **25** — Domin 7855: **25**; 7856: **25**; 7857: **25** — Donis 3394: **7**; 3395: **7**; 3418: **7**; 3426: **7** — Donnat 38137: **35** — Dorantes DO 13391: **22** — Dorst iP 505: **30**; iP 511: **30**; iP 512: **30** — Drake 20: **35**; 371: **13**; 921: **18** — Dubois 90: **10**; 166: **7** — Ducloux 137: **43**; 2350: **43**; 5413: **24** — Dumas 1533: **2** — Dummer 4473: **7** — Dunlop 5260: **38**; 5759: **38**; 9209: **38**; CD 531: **11** — Dunlop & Wightman 6466: **38**; 6852: **38** — Durand 4609: **35**.

Ebalo & Conklin 1327: **23** — Edaño 34440: **38** — Eddowes & Kumul NGF 13125: **38**; NGF 36056: **1**; NGF 36080: **23** — Edinburgh Roy. Bot. Gard. 1845: **35** — Edwards, J.B. 448: **22** — Edwards, J.P. 3890: **37**; 36667: **37** — van Eechoud bb 31086: **35** — Eggling 1547: **7** — van Eijnatten 1706: **7** — Elbert 354: **35**; 355: **38**; 3860: **35**; 3874: **38**; 3917: **35** — Elgincolin 28857: **35** — Elias 85: **7** — Elmer 5640: **35**; 6876: **28**; 8165: **35**; 9690: **28**; 10840: **38**; 12157: **23**; 12929: **23**; 13167: **17**; 14468: **38**; 15515: **38** — Elsener H 201: **3** — Emwiogbon FHI 65923: **7** — Endert E 823: **37**; E 831: **3**; E 1004: **3**; E 1065: **3**; E 1186: **37**; E 1962: **17**; E 2177: **35**; 28 E iP 418: **30**; 28 E iP 502: **30**; 28 E iP 505: **30**; 28 E iP 511: **30**; 28 E iP 512: **30**; 28 E iP 536: **30**; 28 E iP 537: **30**; 28 E iP 545: **30**; 174 E iP 919: **3** — Enti FE 1350: **7**; R 897: **7** — Enti & Cudjoe FE 1934: **7** — Equipe 413: **7**; 2291: **7** — Erlanson 5310: **35** — Ern 3173: **7** — Espinoza (For. Bur.) 6410: **23** — Esquirol 740: **43**; 3212: **43** — Essing & Lelean LAE 55042: **35** — Estrada (1951): **26** — Everist 12/10/1960: **11**; 796: **11**; 2156: **11** — Evrard 692: **35**; 734: **7**; 975: **10**; 1342: **10** — Eyma 2823: **35** — Emanuel-Rapière 1548: **35**.

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SAMENVATTING

Alstonia is het soortenrijkste en meest wijd verspreide geslacht van bomen en struiken in subtribus Alstoniinae, tribus Plumeriae, van de familie der Apocynaceae. Veel soorten van *Alstonia* groeien uit tot grote bomen en leveren waardevol hout. Verder worden plantendelen van enkele soorten benut als traditionele geneesmiddelen. Het geslacht komt voor in Centraal Amerika, tropisch Afrika en vanaf de Himalaya en China tot New South Wales in Australië. Het grootste aantal soorten komt voor in Malesia, het gebied dat de staten Malaysia, Singapore, Brunei Darussalam, Indonesië, de Filippijnen, en Papua Nieuw Guinea omvat.

Dit onderzoek heeft tot doel om een bijdrage te leveren aan de nog steeds gebrekkige kennis van de tropische biodiversiteit en voorziet in een uitgebreid overzicht van de macromorfologische en pollenmorfologische biodiversiteit binnen het geslacht *Alstonia* (Hoofdstuk 2), een cladistische analyse gebaseerd op deze diversiteit (Hoofdstuk 3), een vergelijkend houtanatomisch onderzoek aan drie van de vijf secties, met een analyse van de ecologische verbanden en fylogenetische signalen in de houtanatomische variatiepatronen (Hoofdstuk 4) en tot slot een volledige taxonomische revisie van het gehele geslacht (Hoofdstuk 5).

In de taxonomische revisie worden 43 soorten herkend; vijf hiervan zijn nieuw voor de wetenschap, waaronder één soort die voorheen als de variëteit *annamensis* van *A. angustifolia* werd beschouwd. De vijf nieuwe soorten zijn: *A. annamensis*, *A. beatricis*, *A. breviloba*, *A. penangiana* en *A. rubiginosa*. Verschillende soorten en taxa onder het soortsniveau zijn bij elkaar gevoegd. Zo blijken *A. brassii* Monach. en *A. glabriflora* Markgr. bijvoorbeeld synoniemen te zijn van *A. macrophylla* Wall. ex G. Don, en *A. montana* Turrill, *A. reineckeana* Lauterb., *A. roeperi* Van Heurck & Müll. Arg., *A. vitiensis* Seem. en A. *marquisensis* M. L. Grant synoniemen van *A. costata* (G. Forst.) R. Br. Geen enkel taxon beneden het soortsniveau blijft gehandhaafd. Er worden determinatiesleutels per gebied en een verkorte sleutel van alle soorten gepresenteerd. De soortbeschrijvingen bevatten ook de volledige synonymie, de geografische distributie, standplaatsinformatie en ecologische gegevens. Bij de meeste soorten zijn ook opmerkingen toegevoegd om kenmerkvariatie binnen de soort te verklaren en /of om aan te duiden wat de verschillen met andere taxa zijn. Wanneer bekend, zijn ook het nut (vooral medicinaal) van de soort en de lokale namen toegevoegd. Een identificatielijst van alle c. 4.200 bestudeerde herbarium exemplaren is bijgevoegd.

De cladistische analyse, gebaseerd op 68 kenmerken (61 macromorfologische en 7 pollenkenmerken), met het nauw verwante geslacht *Dyera* als buitengroep, levert één kortste (= meest parsimone) boom op. Deze boom laat vijf verschillende monofyletische groepen zien. Deze groepen onderbouwen de vijf secties die in deze studie herkend worden, nl.: *Alstonia, Blaberobus, Tonduzia, Monuraspermum* en *Dissuraspermum. Tonduzia*, voorheen gezien als een apart geslacht (Pittier, 1908), is in het cladogram genesteld en wordt hier daarom behandeld als een sectie binnen het geslacht *Alstonia*. Het cladogram is aanvaard als hypothese voor de verwantschappen binnen *Alstonia*. De kenmerksveranderingen die geleid hebben tot de huidige morfologische diversiteit worden besproken.

Drie secties zijn houtanatomisch onderzocht, nl.: *Alstonia, Monuraspermum* en *Dissuraspermum*. De houtanatomische kenmerken ondersteunen de indeling binnen het geslacht, gemaakt op basis van de macromorfologische en pollenkenmerken. Het aantal vaten, de gemiddelde tangentiale vatdiameter, de lengte/breedte verhouding van de vatleden, de straalfrequentie, de aan- of afwezigheid van melksapbuizen, de parenchymverspreiding, de dikte en stippeling van de vezelwanden zijn allemaal, tot op verschillende hoogte, diagnostisch om de groep met lichter hout binnen *Alstonia* (= sectie *Alstonia*) te kunnen onderscheiden van de groep met zwaarder hout (de twee andere bestudeerde secties). De sectie *Monuraspermum* en *Dissuraspermum* worden onderscheiden door verschillen in vatfrequentie en vatdiameter.

Binnen de groep met licht hout hebben de in moeras groeiende soorten lagere stralen dan de soorten die niet op drogere bodems groeien en waarschijnlijk wortelen in goed doorluchte grond. Binnen de groep met zwaarder hout (sectie *Monuraspermum* en *Dissuraspermum*), tonen de struiken en kleine bomen een grotere vatfrequentie, smallere vaten, kortere vezels, een hogere straalfrequentie en hogere stralen dan de soorten die uitgroeien tot grote bomen. Dit bevestigt een goed gedocumenteerd algemeen verband tussen microscopische houtstructuur en boom- of struikgrootte (inclusief stamdiameter). Wederzijdse correlaties van kenmerkenparen, zoals onder andere vatdiameter en vatfrequentie, zijn eveneens onderzocht en vergeleken met bevindingen in andere houtachtige families; ook hier bevestigen de gegevens voor *Alstonia* algemeen geldende verbanden.

CURRICULUM VITAE

Kade Sidiyasa was born on October 12, 1956 in Jembrana, Bali, Indonesia. In 1963–1968 he attended the elementary school in Bali, and in 1970–1975 the primary and secondary high schools in Southeast Sulawesi. He started his graduate study at the Department of Forestry of the Hasanuddin University in Ujung Pandang, South Sulawesi in 1976, and earned his Ir. degree in March 1982.

From May 1982 until 1994 he served as a forest botanist at the Forest Research and Development Centre, Bogor. From 1989 he also served as a staff member of the International MOF-Tropenbos Kalimantan Project in East Kalimantan. In 1994 he was officially transferred to the Forestry Research Institute of Samarinda, East Kalimantan.

In the framework of the International MOF-Tropenbos Kalimantan Project he came to the Netherlands in October 1993 to embark a PhD study at the Rijksherbarium / Hortus Botanicus, Faculteit der Wiskunde en Natuurwetenschappen, Leiden University, under the supervision of Prof. Dr. P. Baas, Dr. A.J.M. Leeuwenberg (Wageningen), and Dr. M.C. Roos.

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