Plant Resources of South-East Asia

No 3

Dye and tannin-producing plants

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Pudoc Wageningen 1991

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Foreword

This book on dye and tannin-producing plants of South-East Asia is the third volume of the Prosea Handbook, the first two volumes being 'Pulses' and 'Edible fruits & nuts'. We shall welcome the publication of this invaluable book.

This volume concerns a group of plants whose economic prominence reached a record level in the 19th Century. Since then, there has been a gradual shift from natural to synthetic products, reducing the significance of natural dyes to almost nil at the end of the 20th Century. Natural tannins were more difficult to replace due to some of their characters which could not be equalled by syntans. As so often is the case, man aims at short-term profits, disregarding eventual harmful effects. However, the unrestricted use of synthetic dyes and tannins has now focused attention on the problem of their non-biodegradable waste products. A new shift towards natural products seems desirable.

A complete survey of dye and tannin-producing plants of South-East Asia has never been published before; therefore, this book is unique. Most of the species described are poorly known. It is hoped that the updated information presented here will help to prevent their complete disappearance from dyeing and tanning practices, and perhaps will induce a revival of their use and lead to a renewed appreciation of their role in human culture and history.

An international group of authors, mostly from South-East Asia, contributed to this volume. A number of specialists, including phytochemists and leather technologists, assisted with the writing of the introductory chapter. All contributors are gratefully acknowledged.

Jakarta, January 1991

Dr Aprilani Soegiarto
Chairman of the Prosea Foundation Board

1 Introduction

1.1 Choice of species described in this volume

This volume deals with plants producing substances used as dye or tannin in South-East Asia. Dyes and tannins are closely related. Certain plants (e.g. *Phyllanthus emblica* L.) contain substances that can be used for dyeing and others that can be used for tanning. As well as being used for tanning, tannins are often also used for dyeing or staining; for example, the dark-coloured extract obtained by boiling chips of the heartwood of *Acacia catechu* (L.f.) Willd. known as 'catechu' is employed both for dyeing and for tanning. The basic components of many vegetable dyes are chemically comparable with those of tannins. For these reasons vegetable dyes and tannins have been dealt with together in one volume.

The species (genera) described are primarily used as dye or tannin, and have some economic importance (at least locally). Mangrove species are perhaps primarily used locally for firewood, charcoal and timber, but because they play a major role in the tanning industry, they have also been included. Similarly, *Phyllanthus emblica* L. and *Terminalia catappa* L. have been included here, even though they are also important for their edible fruits. Some dye and tannin-producing plants are poorly known. Their use is occasional and very local, and they have been classified as 'dye and tannin-producing plants' because they have no other uses; most of these species are presented in this volume in Chapter 3 'Minor dye and tannin-producing plants'.

In some cases, plants that do not occur naturally or in cultivation in the Prosea region are described because they may have interesting prospects, or their products are used in the region, or, in one case (*Crocus sativus* L.) because the product is commonly confused with products of indigenous plants.

Many vegetable dyes and tannins are non-timber products of the forest, just like resins, gums, and latex. The latter products are often used in paints and inks. Examples include 'gum damars' from species of Dipterocarpaceae and 'karaya gum' from the Indian *Sterculia urens* Roxb. They do not have colouring properties, but are sometimes used as a thickening agent in solutions of dyes. These products are not dealt with in this volume, but will be treated in the volume 'Plants producing exudates'. Some exudates, however, have dyeing properties, e.g. the gum-resin from *Garcinia hanburyi* Hook.f.; hence this species is treated in this volume.

Chapter 4 lists species that have another primary use and have been or will be dealt with in other volumes of the Prosea handbook. However, because of their importance as dyes or tannins in South-East Asia, concise information is given in Table 1 (dyes) and Table 2 (tannins).

Table 1. Alphabetical list of important dye-producing plants with another primary use. Scientific name, family name, vernacular name, part of the plant used for dyeing, colouring substance and colour, and material suited for dyeing are given, where known. See Chapter 4 for commodity group and synonyms.

Anacardium occidentale (Anacardiaceae), cashew: bark and fruit used for the manufacture of marking ink and for colouring hair black.

Arcangelisia flava (Menispermaceae): stem, containing berberine, used for colouring cloth yellow.

Archidendron pauciflorum (Leguminosae): bark used for dyeing matting black and fruit for dyeing silk purple.

Areca catechu (Palmae), betel nut palm: nuts used for dyeing cotton and wool red-brown or black.

Artocarpus heterophyllus (Moraceae), jackfruit: heartwood, containing morin, used for dyeing cotton and silk cloth yellow.

Artocarpus integer (Moraceae), chempedak: heartwood used in the same way as for *A. heterophyllus*.

Baccaurea javanica (Euphorbiaceae), menteng: bark used for dyeing cotton and linen cloth and cigar boxes yellow–red or violet; also used as a mordant.

Baccaurea motleyana (Euphorbiaceae), rambai: bark used in the same way as for *B. javanica*.

Baccaurea racemosa (Euphorbiaceae), kapundung: bark used in the same way as for *B. javanica*.

Bischofia javanica (Euphorbiaceae), red cedar: bark used for dyeing matting red or black.

Carthamus tinctorius (Compositae), safflower: flowers, containing carthamin, used for dyeing silk, cotton and linen cloth yellow–red.

Clitoria ternatea (Leguminosae), cordofan pea: flowers used for dyeing food, matting and cloth blue-green.

Cocos nucifera (Palmae), coconut palm: nuts used for dyeing silk green, and fruit-stalk used for colouring teeth black.

Curcuma longa (Zingiberaceae), turmeric: rhizome, containing curcumin, used for dyeing food, cotton and silk cloth, matting and parts of the skin yellow-brown.

Dracaena angustifolia (Liliaceae), suji: leaves used for colouring food green.

Flemingia grahamiana (Leguminosae): glands on the pod, containing flemingin, used for dyeing silk orange.

Flemingia macrophylla (Leguminosae): glands on the pod used in the same way as for *F. grahamiana*.

Garcinia atroviridis (Guttiferae): fruit used as a mordant in dyeing silk.

Garcinia dulcis (Guttiferae): bark used for dyeing cloth and matting brown.

Garcinia mangostana (Guttiferae), mangosteen: fruit-rind used for dyeing cloth brown-black, bark for dyeing cloth yellow.

Hibiscus rosa-sinensis (Malvaceae), shoe flower: flowers used for colouring food red, and shoes and eyebrows black.

Mangifera indica (Anacardiaceae), mango: bark used for dyeing cloth and matting yellow.

Melastoma malabathricum (Melastomataceae), senduduk: roots used in mixtures for dyeing red, leaves in mixtures for purple; fruits used for dyeing cloth black; ashes used as a mordant.

Melastoma sanguineum (Melastomataceae): plant used in the same way as for *M. malabathricum*.

Psidium guajava (Myrtaceae), guava: leaves used in mixtures for dyeing silk and cotton cloth and matting black.

Pterocarpus indicus (Leguminosae), red sandalwood: wood, containing santalin, used for dyeing cotton cloth, wool, leather, bamboo and other woods red.

Pterocarpus santalinus (Leguminosae): wood used in the same way as for *P. indicus*.

Syzygium spp. (Myrtaceae): bark used for dyeing cotton cloth brown-black.

Tagetes erecta (Compositae), marigold: flowers, containing quercetagetin, used for dyeing silk and chicken food yellow.

Tagetes patula (Compositae), marigold: flowers used in the same way as for *T. erecta*.

Tamarindus indica (Leguminosae), tamarind: fruit-pulp used as a mordant.

Tectona grandis (Verbenaceae), teak: root-bark and leaves used for dyeing matting yellow-brown.

Table 2. Alphabetical list of important tannin-producing plants with another primary use. Scientific name, family name, vernacular name, part of the plant used for tanning, percentage tannin on dry weight basis, and material suited for tanning are given, where known. See Chapter 4 for commodity group and synonyms.

Acacia farnesiana (Leguminosae), fragrant acacia: fruit, containing ca. 23% tannin, used for tanning leather.
Adenanthera pavonina (Leguminosae), condori wood: bark, containing 25–30% tannin, used for tanning leather.
Albizia procera (Leguminosae), safed siris: bark, containing 12–17% tannin, used for tanning leather.
Archidendron clypearia (Leguminosae): bark, containing 20–22% tannin, used for toughening fishing nets.
Areca catechu (Palmae), betel nut palm: nut, containing 13–27% tannin, used for tanning leather and fishing nets.
Bischofia javanica (Euphorbiaceae), red cedar: bark, containing ca. 16% tannin, used for toughening nets and ropes.
Calophyllum inophyllum (Guttiferae), Alexandrian laurel: bark, containing 12–19% tannin, used for tanning leather and fishing nets.
Cassia fistula (Leguminosae), Indian laburnum: bark, containing 12–18% tannin, used for tanning leather.
Casuarina equisetifolia (Casuarinaceae), redwood tree: bark, containing 6–18% tannin, used for toughening fishing nets.
Heritiera littoralis (Sterculiaceae), looking-glass tree: bark, wood and fruit, containing 12–14% tannin, used for toughening fishing nets and sometimes for tanning leather.
Hopea odorata (Dipterocarpaceae), rock damar: bark, containing ca. 15% tannin, may be used for tanning sole leather.
Kandelia candel (Rhizophoraceae): bark, containing 17–20% tannin, used for tanning leather.
Lithocarpus pseudomoluccus (Fagaceae), pasang kajang: cupules of fruit, containing 20–25% tannin, useful for tanning leather.
Manilkara zapota (Sapotaceae), sapodilla: bark, containing ca. 20% tannin, used for toughening fishing tackle and sails.
Pithecellobium dulce (Leguminosae), Manila tamarind: bark, containing 12–37% tannin, well-suited for tanning leather and toughening nets.
Punica granatum (Punicaceae), pomegranate: fruit-rind and bark, containing 26–28% tannin, used for tanning leather.
Shorea negrosensis (Dipterocarpaceae), red lauan: bark, containing 9–10% tannin, may be used for tanning sole leather.
Sonneratia caseolaris (Sonneratiaceae): bark, containing 9–15% tannin, used for tanning leather and nets.
Symingtonia populnea (Hamamelidaceae): bark, containing ca. 11% tannin, used for tanning leather.
Syzygium spp. (Myrtaceae): bark, containing up to 28% tannin, used for tanning fishing nets.

1.2 Definition and chemistry of dyes

1.2.1 What is a dye?

Vegetable dyes are colouring agents originating from plants. They are extracted by fermentation, boiling, or chemical treatment from small quantities of certain chemical substances present in plant tissues.
Sometimes the colour of the dye is already visible in the living plant (e.g. saffron is extracted from the orange-coloured stigmas of *Crocus sativus* L.). However, some important vegetable dyes originate from plant components which are not

coloured in their original state or which are hidden in the plant (e.g. indigo from *Indigofera* species).
Substances are coloured because they absorb light that humans can see between about 400 and 800 nm wavelength (Singleton, 1972). Most colours can be obtained from plant products: for instance, blue from *Indigofera* spp. and *Haematoxylum campechianum* L., yellow from *Crocus sativus* L., red from *Rubia cordifolia* L., brown from *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne, and black from *Macaranga tanarius* (L.) Muell. Arg.; green is usually obtained by mixing blue and yellow vegetable dyes.

1.2.2 Chemistry

Plant pigments may differ substantially in their chemical structure. In general, major classes of plant pigments are chlorophylls, carotenoids, flavonoids, and quinones.

- Chlorophyll is a generic term for a number of closely related plant pigments responsible for the green colours that are so superabundant in vegetations. Chlorophylls are sometimes used for colouring foods and drinks.
- Carotenoids are characterized chemically by a long aliphatic polyene chain composed of isoprene units (Fig. 1). They have a bewildering variety of structures and intense characteristic colours: yellow, orange, red and purple. Examples of carotenoid pigments are bixin, obtained from *Bixa orellana* L. (annatto) and crocin found in *Crocus sativus* L. (saffron), *Nyctanthes arbortristis* L. and *Gardenia jasminoides* Ellis (Fig. 1).

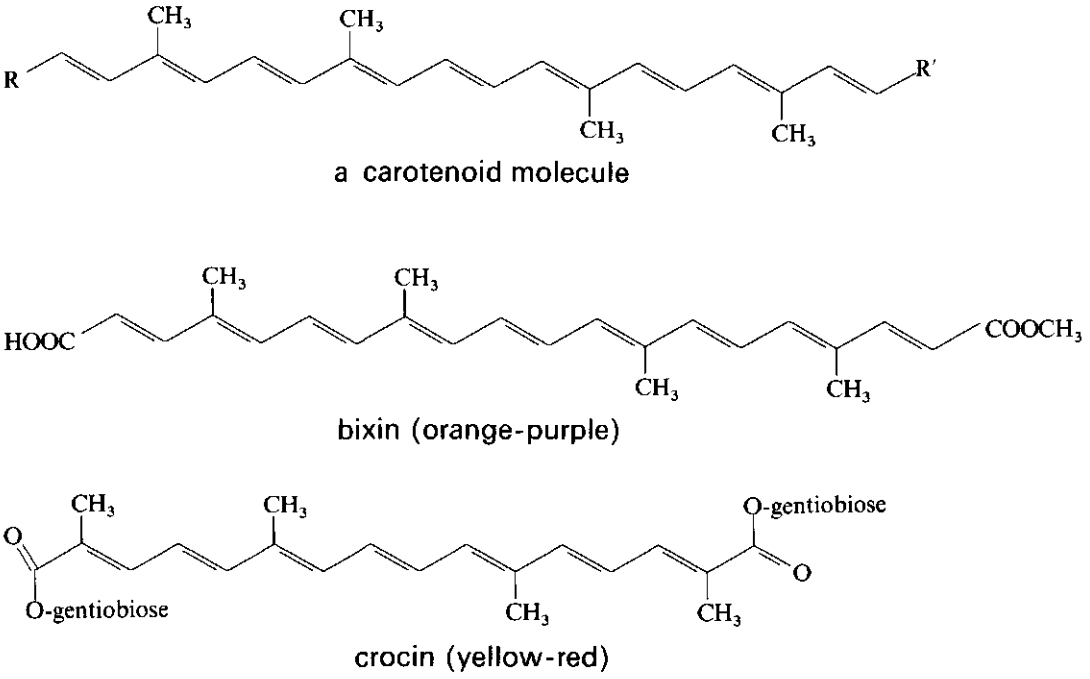


Figure 1. Basic structure of a carotenoid molecule, and 2 examples of carotenoid pigments: bixin and crocin.

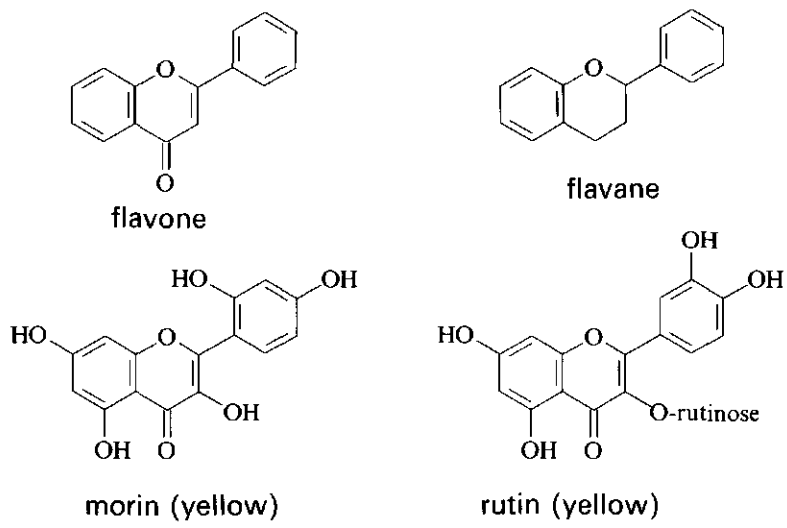


Figure 2. Basic structures (flavone, flavane) of most flavonoids, and examples of flavonoid pigments: morin and rutin.

- Flavonoids comprise all compounds with structures based on flavone or flavane (Fig. 2). The major subgroups of flavonoids are chalcones, flavanones, flavones, flavonols, anthocyanins, and isoflavonoids. Examples of flavonoid pigments are morin (found in several species of Moraceae) and rutin (for example present in the flowers of *Sophora japonica* L.) (Fig. 2). Derivatives of flavonoid tannins often give a particular colour to leather as a secondary effect of the tanning process.
- Quinones include various compounds containing a quinone structure (Fig. 3). The colour is usually yellow to red. Major subgroups are benzoquinones,

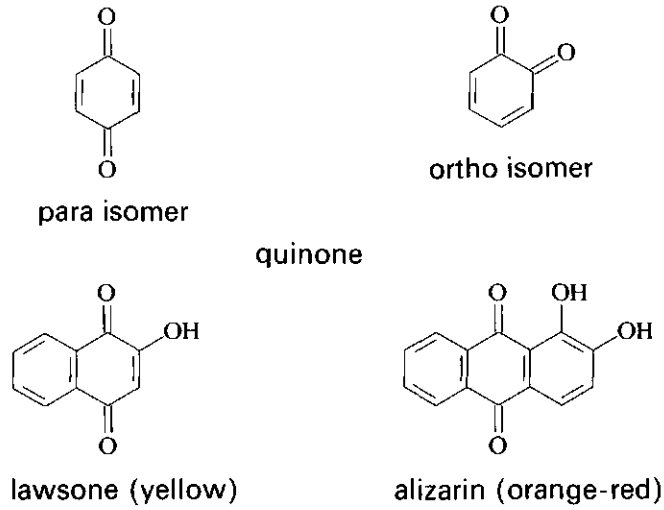


Figure 3. Structure of quinone, and an example of a naphthoquinone pigment (lawsone) and an anthraquinone pigment (alizarin).

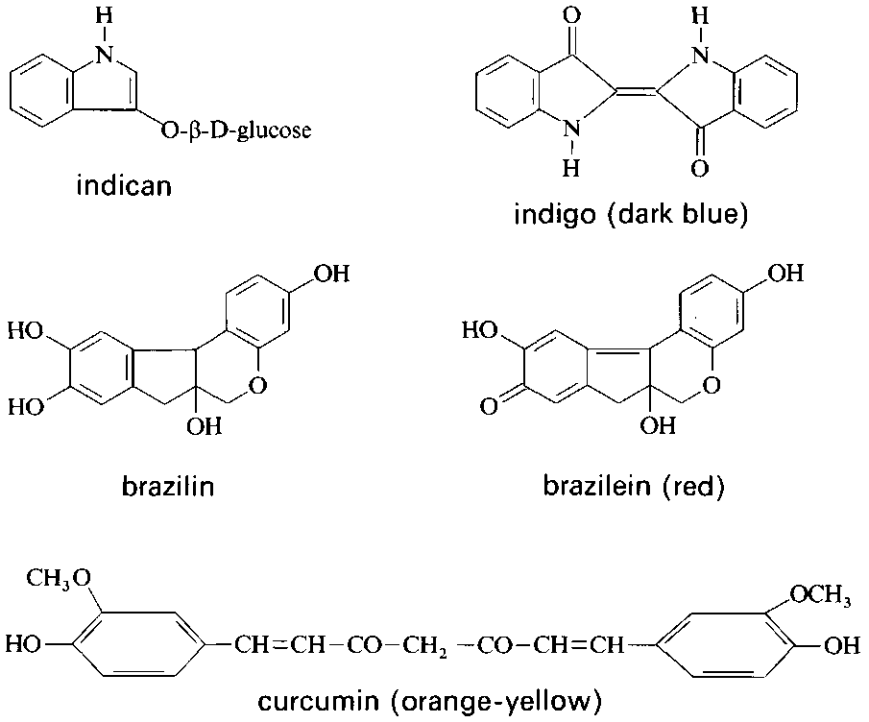


Figure 4. Structures of some important vegetable dyes and their precursors in the plant tissues.

naphthoquinones and anthraquinones. An example of a naphthaquinone pigment is lawsone from *Lawsonia inermis* L. (henna). Examples of anthraquinones are alizarin, morindin and purpurin found in species of Rubiaceae (Fig. 3).

- Other important vegetable dyes not included in the groups of pigments discussed above include the dark blue indigo, obtained by hydrolysis of the colourless indican present in plants such as *Indigofera* species and oxidation of the resulting indoxyl; the red crystalline dye brazilein, obtained by oxidation of the whitish phenolic compound brazilin which is present in the wood of *Caesalpinia* species; and curcumin, an orange-yellow crystalline compound which is the colouring principle of turmeric (from *Curcuma longa* L.); see Fig. 4.

1.2.3 Fastness of colours

The quality and importance of a dye are especially determined by the fastness of the colour. Most plant pigments are not permanent, the colours fading rapidly when exposed to detergents and sunlight, especially in the tropics. The vegetable dyes used for dyeing textiles can be classified into 4 types, according to the properties that determine their use:

- 'Direct dyes' form hydrogen bonds with the hydroxyl groups of the fibre; the dye is not fast (an example is curcumin).

- 'Acid and basic dyes' combine with the acid and basic groups respectively of wool and silk; cotton is not permanently dyed; examples include flavonoid pigments.
- 'Vat dyes' are regenerated in the fibre by a redox process; these dyes often display excellent fastness to light and washing (an example is indigo).
- 'Mordant dyes' dye textiles that have been mordanted with compounds of polyvalent metals; the dye can be very fast; examples are alizarin and morindin.

Specific substances called mordants increase the adherence of various dyes to fabrics. In ancient times dung or urine were often added to the dyeing bath as mordants. Nowadays the mordants are usually the salts of metals, e.g. from aluminium, iron, tin, or chromium; they form a chemical bridge between the dye and the fibre molecules. Some plant products are also still used as mordant, e.g. leaves and bark of *Symplocos* species. Mordants can also affect the final colour of a dye. To make the colour more permanent, coloured textile is often treated with a mixture of products like lime and sugar, or with vegetable dyes (e.g. flower buds of *Sophora japonica* L.) in a final fixing bath.

In some dye processes using alizarin-stain complexes, vegetable tannins are added to the solution together with proteins, in order to prevent white-coloured parts of the textile from becoming coloured differently by binding the stain that is lost from the coloured parts.

1.2.4 Food colouring

Some pigments naturally occurring in plants are used in food colouring. They are grouped into the following 4 main groups:

- Anthocyanins. These are intensely coloured water-soluble orange, red and blue pigments belonging to the larger group of flavonoid pigments. They are commonly found in fruits and vegetables, and usually consist of a combination of several pigments (often 4–6). These pigments are most stable under acid conditions and therefore must be kept in a rather acidic medium.
- Betanins. These form a small group of red and yellow pigments which are sensitive to pH, heat and light. The red beet (cultivar group of *Beta vulgaris* L.) is the most commonly used source of these pigments.
- Carotenoids. These yellow, red and orange pigments were discussed above. They are sensitive to oxidation; their stability in foods is maintained by limiting exposure to air.
- Chlorophylls. These green pigments were discussed above. They are sensitive to acid conditions and light.

Many plant pigments are still used to colour food, not only to make the food more attractive in appearance, but also to make it more palatable in combination with a certain flavour. However, vegetable dyes often give an undesired flavour or taste, they have poor stability, and they hardly produce a uniform colour. Moreover, they are often present in low concentrations in the plant tissues. In many cases, natural dyes are more expensive than synthetic dyes.

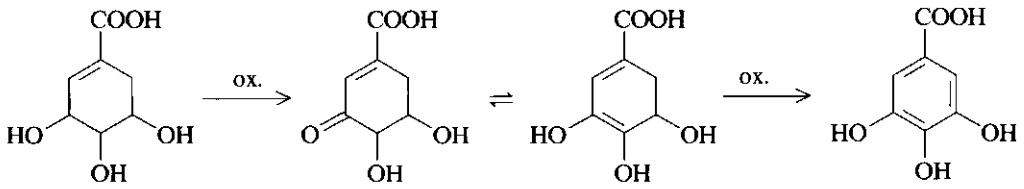
1.3 Definition and chemistry of tannins

1.3.1 What is a tannin?

Vegetable tannins are bitter and astringent substances in plants, often occurring as excretions in the bark and other parts (especially leaves, fruits, and galls). For tanning purposes, the excretions are either employed directly or used in a concentrated form by extraction of the tanning substance.
Tannins are able to react with proteins. After treatment with a tannin, a raw skin becomes stained and is protected against putrefaction. Vegetable tanning preserves the hide fibre from bacterial attack. It also builds into the fibre certain characteristics of fullness of feel and resilience which are not only characteristic to the type of skin, but also depend on the tanning materials and methods used. The result is leather with its multitude of uses.
In addition to the production of leather, tannins also serve to tan nets, ropes and sails. After tanning, fishing tackle becomes more resistant to sea water. Tannins are also used in glues, stains and mordants. For instance, proanthocyanidin tannins can be employed in the production of chipboard as an alternative to synthetic phenols, the production of which greatly depends on the oil price. Several tannin-producing plants are an ingredient of masticatories because of their astringent action, e.g. gambier from *Uncaria gambir* (Hunter) Roxb. Tannins are widely used for medicinal purposes. They are applied against diabetes, to regularize the balance of hormones excreted by the pancreas, as antiherpetic and as antibiotic. The tannins present in beverages like tea, coffee, wine and beer are essential for the flavour and aroma, and the concentration of tannins in several fruits is important for the fruit quality. Tannins are also used in ink manufacture, to remove boiler scale, and to reduce the viscosity of the drill mud when drilling deep oil wells.
According to specialists in leather technology like Thorstensen (1985) there is no such thing as a single tannin from a particular plant source. 'The material extracted not only contains many different tannins, but also starches, gums, and other materials. The extract is not a true solution but will contain suspended insoluble materials. These non-tannin materials also contribute to the leather-producing properties of the extracts. The structure of the vegetable tannins and the estimation of the tannin content of extracts have been a major field of work by leather chemists. The practical application of vegetable tanning has been primarily an empirical skill'.

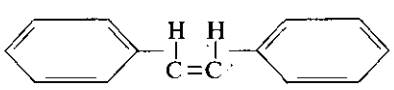
1.3.2 Chemistry

The chemistry of tannins is complex. According to Buchanan (1952) tannins can be defined as complex polyhydric phenols with a molecular size and shape which permits suitable solubility in water.
Research on the chemistry of tanning started long ago. In 1803, Davy hypothesized about the forming of complexes between the tanning polyphenols and the animal skin. Research on the chemical formulas of tanning materials has been in progress since the mid-19th Century. This field of research still exists and knowledge about tannins and about the reaction of polyphenols with proteins is increasing every year (Spencer et al., 1988). Interest is now based on the use

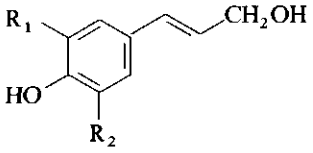


shikimic acid gallic acid

Figure 5. Biosynthesis of gallic acid by oxidation of shikimic acid.



stilbene



basic structure of lignans

Figure 6. Structure of stilbene and basic structure of lignans.

of tannins not only for the production of leather but also for many other products. Some important results about the chemistry of tannins have been published by Swain (1979) and Fengel & Wegener (1984).

The few basic chemical components found in tannins apart from sugars are gallic acid and its dimer ellagic acid, flavonoids (flavane-related components), lignans, stilbenoids and quinones.

Gallic acid is formed by oxidation of shikimic acid, which is an elementary reaction product in the metabolism of plants (Fig. 5).

For the basic structure of flavonoids, see Fig. 2; of quinones, see Fig. 3; and of stilbenoids and lignans, see Fig. 6.

Flavane-related components and compounds with gallic acid may be seen as the main constituents of tanning materials.

In the literature a separation has been made between hydrolysable tannins and condensed tannins. The criterion of the division was whether acids or enzymes could hydrolyse the components or whether they condensed the components to polymers. Although not absolutely correct, this separation corresponds merely to groups based on gallic acid and to groups based on flavane-related components.

The monomers may be polymerized to oligomers to give tanning material. They may also be linked with sugars in the tannins. In that case, the component is called a glycoside. Therefore, a glycoside consists of a sugar and a polyphenolic part which is called aglycon. As will be discussed later, the polyphenols have tanning effects if their molecular weight varies more or less between 500 and 3000 (Haslam, 1979; Hillis, 1987). For the bulk of flavonoid tannins this implies degrees of polymerization (DP) of 3 to 8. A complete list of all the tannins that have so far been determined would fill many pages. Only the major tanning

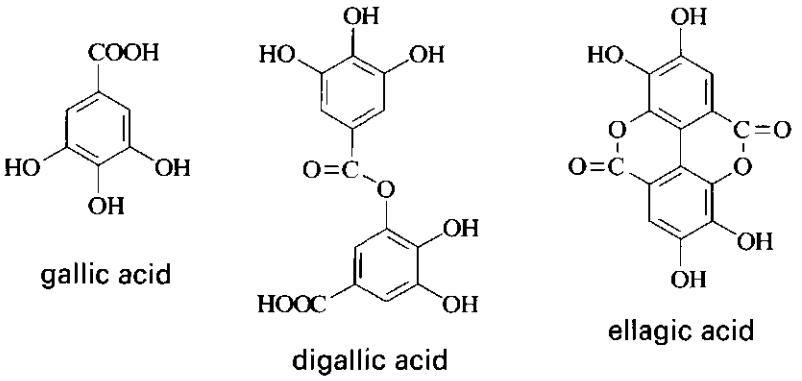


Figure 7. Constituents of gallotannins and ellagitannins.

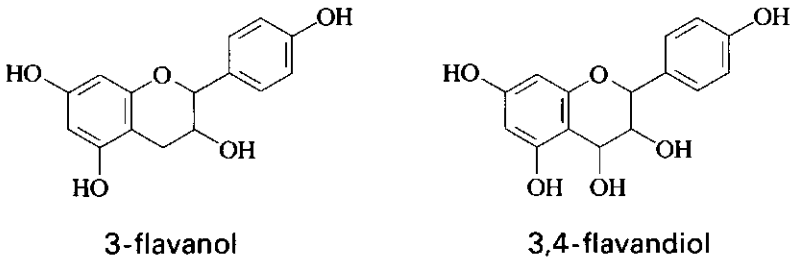


Figure 8. Basic structures of proanthocyanidins.

constituents of the most important groups of tannins are listed here, i.e. the group of gallotannins and ellagitannins, and the group of proanthocyanidins. Gallotannins and ellagitannins are esters of gallic acid or its dimers digallic acid and ellagic acid (Fig. 7) with glucose and other polyols.
Proanthocyanidins are oligomers of 3-flavanols (catechins) and 3,4-flavandiols (leucoanthocyanidins). See Fig. 8.

1.3.3 Tannin and animal skin proteins

Tanning is, by definition, the complex of reactions of tannins with proteins in hides and skins. Tanning as a chemical reaction may be found in other processes such as dyeing and medicinal processes (Oliver-Bever, 1986). Research on the tannin-protein complex is still in progress.
It is clear that hydrogen bonds play an important role in the forming of the complex (Fig. 9), but the necessity of a certain molecular weight for an effective tannin cannot be explained by them (Spencer et al., 1986). If hydrogen bonds were the only driving force in tanning, synthetic tannins could easily be made. The molecular structure of the tannin plays an important role. To understand new theories about tanning it is necessary to explain certain aspects of animal skin proteins. The part of the skin that is used for leather is the inner part of 3 layers and consists almost entirely (98%) of collagen. In proteins 4 struc-

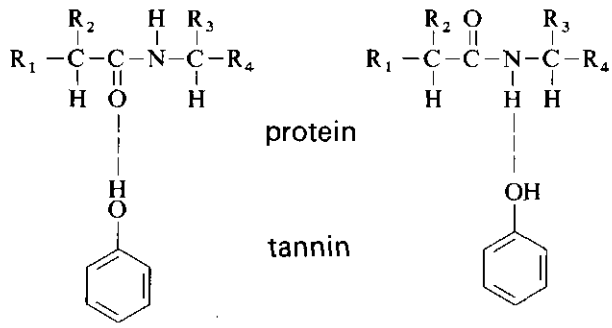


Figure 9. Reaction of tannin with protein.

tures are defined. The primary structure is the sequence of the amino-acids. The secondary structure concerns the spatial orientation of the peptide chain (e.g. a helix). The tertiary structure is defined by the spatial form of the secondary structure (e.g. a bent helix). The quaternary structure is the intermolecular arrangement in the form of complexes.
Because of the molecular and macroscopic structure of the proteins, it is clear that stereochemistry is important in relation to tanning. One of the characteristics of leather is its decreased hydrophilic property; another is its stability against rotting. These two may be linked. If the molecules of the tannin are too small (molecular weight M < 500) there is little or no reaction. The reasons for this are not clear. If the molecules of the tannin are too large (M > 3000) they physically prevent a complete reaction along the polyphenol molecule. Not all of the polyphenols with a molecular weight between 500 and 3000 have tanning properties because there must be a stereochemical resemblance between the tannin and the protein.

1.3.4 Tanning practice

In the laboratory, extractions of tannins and other polyphenols are made with methanol. In the leather industry, warm water is used for extraction. The plant extracts consist of tanning and non-tanning components. The more the tannin content exceeds the non-tanning material in the extracts, the more suitable the plant is as a tannin supplier.
In general, gallotannins and ellagitannins are the most highly valued vegetable tanning materials. They often give leather of good quality with pale colours that do not fade in light. Examples are the myrobalans of *Terminalia* species and the tannins of Fagaceae species. Proanthocyanidins usually produce leather with a darker colour which is not fast to light. Plants containing proanthocyanidins are *Acacia* species (wattles), and mangrove species (Rhizophoraceae). However, the colour of the leather can also be improved by certain tanning techniques.

1.4 History and role of vegetable dyes

1.4.1 History and importance

From earliest times colours have played an important role in the life of man. Tens of thousands of years ago bodypainting was already part of the ritual connected with waging war and funerals. In southern Europe coloured drawings of hunting scenes have been found in caves used as shelter by men in the Stone Age, and coloured cloth and utensils have been found in ancient Egyptian and Indian tombs. In the beginning, minerals were often used to prepare dyes.
Vegetable dyes and their uses were known in ancient times. More than 2000 years ago plants such as woad (*Isatis tinctoria* L.), *Rubia* species, and indigo (*Indigofera* species) were known to contain substances that could be used for colouring cloth, implements, and utensils. The first recorded use of indigo in China is over 6000 years old. Samples of leather that had been dyed red, yellow and green 4000 years ago have been found in Egypt. The rind of the pomegranate (*Punica granatum* L.) may have been the source of the yellow dye, and madder root (*Rubia tinctorum* L.) of the red dye. The red dye from henna (*Lawsonia inermis* L.) was used by the ancient Greeks and Romans as a cosmetic, especially for giving human hair a red sheen. Indigo (*Indigofera tinctoria* L.) was cultivated on a large scale in India and South-East Asia in the 16th Century, but the plant and its product, the blue dye, is mentioned in Sanskrit records 4000 years old (Krochmal & Krochmal, 1974). Indigo and woad both produce a dark blue dye, and in Europe there was a competition between the dye from woad, which was cultivated mainly in France, Germany and Britain, and the indigo dye imported from India and South-East Asia. Indigo finally won, but only after a turbulent period in which there was severe punishment for marketing it.
The culmination of the use of many vegetable dyes was in the 19th Century. At the end of that century the vegetable dyes were largely supplanted by synthetic dyes, starting in 1856 with the preparation of mauveine, a basic violet dye obtained as the first synthetic aniline dye and used chiefly for dyeing silk. Alizarin, the substance from *Rubia tinctorum* L. used for dyeing red, was synthetized for the first time in 1869 in Germany (von Wiesner, 1927), soon followed by indigo, which has been produced synthetically in large quantities since 1897. In a short time vegetable dyes had been almost completely superseded because the synthetic dyes proved to be purer and cheaper to produce. The rapid decline is illustrated by the fact that in 1896 only natural indigo, originating mainly from British India, was used; by 1914 only 4% of the indigo was of vegetable origin. Since the beginning of the 20th Century most vegetable dyes have had local importance only.
Vegetable dyes were, and partly still are, used for colouring cloth (e.g. indigo, logwood), parts of the body (e.g. henna), objects of art, utensils, wood and wickerwork (e.g. *Caesalpinia sappan* L., *Phyllanthus emblica* L.), and food (e.g. annatto).

1.4.2 Textile dyeing

Dyes obtained from several plant species are employed in the batik process. In this process, wax is used to construct a pattern in the textile by protecting

certain patterns or designs from the watery solution of the dye. Batik is especially known from Indonesia, but comparable techniques are practised in other East Asian countries. In northern Thailand, northern Vietnam and southern China textiles are still coloured using wax. Techniques rather like batik are found in other parts of Asia, and also in Africa and Europe. The batik technique probably originated in China (Haake, 1984). In Indonesia the batik process seems to have been known for well over 1000 years; batik has certainly been practised for over 500 years.

The batik process is best perfected in Java, where batik is closely linked with culture. There are hundreds of named patterns, each pattern symbolizing the status of the person wearing the batik cloth. The Javanese usually use cotton cloth which is mostly produced locally from domestically grown cotton (often the coarser qualities), or imported from the Americas (the finer qualities). Silk clothes are nowadays rarely used, but they were used more often before the Second World War. Different qualities of cotton require different types of wax. Beeswax is of excellent quality, but it is expensive; commonly used waxes are paraffin and coconut oil. The wax is heated to a certain temperature above the melting point. Then it is fixed to the textile in a particular pattern by writing ('batik tulis') with a special device called a 'canting', or by stamping with a 'cap', a large copper stamp. The textile is then immersed in a cold solution of the dye because the wax would dissolve in a hot bath. This reduces the number of possible dyestuffs. The processes of waxing and dyeing are repeated many times so that several colours in different patterns can be given to the textile. The sequence of application of several dyes differs per method and determines the ultimate colours of the textile. Finally, the wax is removed by immersion in boiling water. The 'soga-batik' of central Java is famous, producing batik cloth of very fine quality.

Nowadays synthethic dyes are commonly used in the batik process. Only occasionally and very locally are vegetative dyes from *Indigofera* spp. (dark blue), *Morinda citrifolia* L. (red), *Ceriops tagal* (Perr.) C.B. Robinson, *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne (brown), and *Maclura cochinchinensis* (Lour.) Corner (yellow) applied.

1.4.3 Food colouring

For centuries people of South-East Asia have been using vegetable dyes to colour food. The rich flora of this region presents many sources of pigments to choose from. The use of plant pigments for colouring food, especially for traditional meals, is still widespread in South-East Asia, although the number of plant pigments used is quite limited. It is common practice to extract pigments directly from fresh materials, for instance yellow from the tubers of *Curcuma longa* L., green from the leaves of *Pandanus amaryllifolius* Roxb., *Dracaena angustifolia* Roxb. and *Sauropus androgynus* (L.) Merr., red from the leaves of *Iresine herbstii* Hook.f. and the fruits of *Capsicum annuum* L., and brown from the sugar extracted from palms such as *Arenga pinnata* (Wurmb) Merr., *Borassus sundaica* Becc. and *Cocos nucifera* L. Besides the colour, people often also appreciate the typical flavour and taste given to the food by the plant product. For the choice of their food, people are often attracted by the colour first, then the flavour, followed by the structure, and at last by the nutritional value.

The medium and large-scale food industries use almost exclusively synthetic food colourings. Synthetic dyes are not always harmless for human beings. To protect the safety and health of consumers most countries in the world have gazetted regulations on the use of food colourings. However, a food colouring permitted to be used in one country may be prohibited in other countries. In general, the use of vegetable dyes is considered safer than the use of synthetic dyes, although they are usually subjected to the same scrutiny prior to approval for use in foods. Whereas, for example, chlorophylls are permitted for colouring foods and drinks in the European Communities (EC), these pigments are not approved in the United States (Freund et al., 1988). Extracts from the fruit of cape jasmine (*Gardenia jasminoides* Ellis) are commonly used in Japan for colouring boiled beans, fish eggs, cakes, liquor, sweets, ices, noodles and candies, but they are not approved for food use in the United States. Annatto (*Bixa orellana* L.) and turmeric (*Curcuma longa* L.) are vegetable dyes commonly used in the large-scale food industry.

1.4.4 Wood-tar and hosts of lac insects

In many cultures it is a custom to blacken the teeth. For this purpose wood-tar from species such as *Cocos nucifera* L., *Eugenia tumida* Duthie, *Tamarindus indica* L., *Fagraea racemosa* Jack ex Wallich, and many others is usually used. Sometimes the juice from the plant is used, e.g. from *Rothmannia macrophylla* (Hook.f.) Bremek.

Lac insects (e.g. *Laccifer lacca*), which are tiny scale lice that produce lac, are found from India to Thailand. Lac is the source of shellac, a purified lac resin that is used chiefly in varnishes, binding and stiffening agents and for electric insulators, but it is also the source of the scarlet lac dye. Some plant species are important as host for lac insects: these include the Leguminosae species such as *Butea monosperma* (Lamk) Taubert, *Tamarindus indica* L., *Caesalpinia crista* L., *Acacia farnesiana* (L.) Willd., and *Pongamia pinnata* (L.) Merr., as well as *Ficus religiosa* L. (Moraceae), *Litchi chinensis* Sonn. (Sapindaceae), *Macaranga gigantea* (Reichb.f. & Zoll.) Muell. Arg. (Euphorbiaceae), and *Zizyphus jujuba* Miller (Rhamnaceae). In this way these plant species play an important role in the production of a dye of animal origin.

The wood-tar producing plants for blackening teeth and the hosts of the lac insects are not dealt with specifically in this volume.

1.5 History and role of vegetable tannins

1.5.1 History and importance

The history of tannins probably goes back to prehistoric times. Animal skins were used as warm clothes and as footwear, and made it possible to combat the cold in the temperate regions of the earth. Dry hides are not flexible and they rot when they get wet. To overcome these problems, the hides were probably initially treated with smoke from fires and later with oils, fats, and salts. How, when and where early man learned to make strong, flexible leather out of dry skins is not known (FAO, 1960). Probably it was a serendipity. Archaeological investigations of ancient civilizations in northern Germany dating back

to 12000 years ago have proved the existence of leather and of leather tanning at that time. In Egypt jars containing pods of *Acacia nilotica* (L.) Willd. ex Del. and pieces of leather have been found in the remains of a tannery dating about 7000 years ago (Howes, 1953). Almost 2000 years ago Plinius and Dioscorides reported the occurrence of astringent substances in some plants which could be used to tan hides and to heal certain diseases. *Acacia* species were mentioned for this purpose, together with oak (*Quercus* spp., 'acorn cups'), pine (*Pinus* spp.), alder (*Alnus* spp.), sumach (*Rhus* spp.), and gallnuts (plant galls, especially from *Quercus, Rhus, Tamarix* and *Pistacia* spp.). The ancient Greek and Romans were competent tanners and produced large quantities of leather of good quality.

During the Middle Ages the Middle East was the centre of production of fine leathers. The Arabs took their tanning skills to India; however, although they ran a flourishing trade with Java during the 15th to 17th Centuries, they never introduced these skills there.

The use of mangrove bark for tanning purposes is known with certainty from the 13th Century in Persia (Wind, 1924). In the 19th Century, wattles (*Acacia* species) from Australia were introduced in British India and in South Africa, and later also in Java. The practical value for tanning of the South American quebracho trees (*Schinopsis quebracho-colorado* (Schldl.) F. Barkley & T. Meyer and other *Schinopsis* species) was not discovered until 1870. Quebracho is now one of the major sources of vegetable tannins, especially in America and Europe.

For a long time tanneries were run as one-man industries, but from the second half of the 19th Century large tanneries were established in Europe and North America. In most South-East Asian countries there was no real tanning tradition before the 16th Century. The South-East Asian tanning agents often proved superior to those from Europe, where oak and chestnut barks were traditionally used. Only catechu and gambier were already known in the 16th Century in Europe, although the origin of these tanning materials was unknown to most tanners.

Asia, Africa, and South America exported their raw material (i.e. the tannins and hides) to Europe and the United States where the leather was produced and sold. Efforts were made to develop a viable leather industry to export leather and leather goods. The modernization in the industrializing nations in South-East Asia is progressing rapidly, and not step by step as in Europe and North America decades ago. Thailand is one country which is rapidly extending its leather industry. In 1988 no less than 126 tanneries produced more than 18000 t of leather per year, and 40% of the processed hides were imported. That is still not enough to meet demand. Malaysian shoe manufacturers are also rapidly expanding their facilities to cope with the massive recent surge in export demand.

The most important vegetable tannins on a world scale besides quebracho (from *Schinopsis* species in South America) are mimosa (from *Acacia mearnsii* De Wild., especially from South Africa) and chestnut (*Castanea sativa* Miller from Europe). An overview of the extract shipments in the years 1950–1988 shows that the amounts of vegetable tannins shipped fell by 50% or more (Table 3).

In 1851 chrome tanning was discovered, and this rapidly took a major place in the commercial world. In chrome tannage the animal skin is impregnated

Table 3. Tannin-extract shipments (in 10^3 t) of quebracho, mimosa and chestnut in the years 1950–1988.

	Quebracho	Mimosa	Chestnut	Total
1950	224.2	140.3	76.3	440.8
1960	167.4	140.5	72.9	380.8
1970	108.5	128.8	51.0	288.3
1980	101.9	106.8	32.5	241.2
1984	77.7	94.4	32.4	204.5
1988	66.9	82.3	30.4	179.6

Source: Tanning Extract Producers Federation, Harrow, Middlesex, Britain.

with chromium salts. Later, with the development of the chemical industry and the knowledge of organic synthesis, it became possible to build molecules into synthetic tannins, which have a more specific activity and are more predictable and controllable in the tanning process. The use of synthetic tanning materials such as syntans, resin tannages and aldehyde tannages, has increased rapidly since 1950. The synthetic tannins allow the tanner to obtain special effects in processing or leather quality (Thorstensen, 1985). In the United States about 85% of all leather is tanned by mineral processes and about 15% by vegetable-tanning processes (Seigler et al., 1986).

In large tanneries vegetable tannins are especially used for 'heavy leathers' such as soles, belts, straps and mechanical leathers. The processes involved are time-consuming. It can take 2 months or more to tan sole leather (Thorstensen, 1985). The vegetable tannin imparts the property of mouldability to sole leather and gives more physical weight and better durability. The major vegetable tannins are available as powders. In large tanneries, they are usually mixed with syntans.

Chrome tanning is preferred for many types of leather, mainly because chrome-tanned leather is more heat-proof, stronger and more supple and elastic, is more water-repellent, and is easier to dye (van Herwijnen, 1956). Chrome tannins are therefore used for shoe upper leather and light leathers. The chrome tanning for upper leather is a rapid process taking only a few days. However, vegetable re-tannage of chrome-tanned leather is often necessary to produce usable leathers, and numerous light leathers are subjected to vegetable tanning to develop special characteristics.

1.5.2 The production of leather

Leather is remarkable for possessing a combination of properties: it can be hard and tough, but also soft and flexible; it has a porous structure which enables it to 'breathe'; it is easy to work and cut. Many attempts have been made in recent decades to produce substitutes for leather, but none of the products equals the particular properties of leather.

Leather has for millenia not only been used for clothing; it has also been made (and is still made) into all kinds of tackle and gear such as saddles and reins.

It is used to make bags for carrying liquids, and for luggage, purses and wallets, and also as ornament or decoration. Leather-covered furniture is currently fashionable in many prosperous countries.

The properties of the hides as well as the tannins are important for the production of good quality leather. Many types of hides and skins can be used: cattle hides, goatskins, sheepskins, pigskins, skins of reptiles like snakes, lizards, crocodiles and alligators, and sometimes even the skins of sharks, kangaroos, camels, elephants, and ostriches. Each type has its own application. For instance, the heavy hides of bulls are used for sole leather, pigskins for suede shoe leather and gloves, sheepskins for garment suede leather, goatskins for durable types of shoes and gloves, and skins of reptiles for hand bags.

The properties of vegetable tannins differ and co-influence the characteristics of the leather obtained. Gambier extract is very mellow and gives a buff-coloured leather; bakau extract from mangrove trees and cutch or cachou are more astringent and produce red leather, whereas myrobalans from *Terminalia chebula* Retz. give a greenish tinge to the leather. Good tanning needs a skillful balance of pH, temperature, and concentration (Thorstensen, 1985).

Buyers estimate the value of leather largely by the colour: light-coloured rather than dark-coloured leather is preferred.

The tannins must be extracted from the vegetable tissues (often barks). In the past tannins were extracted in open tanks by allowing hot water to percolate through the bark. The resulting tan liquors were diluted. This made it unpractical to transport extracts over great distances, and consequently tanneries were often located near clusters of tannin-producing plants. Nowadays the liquors can be concentrated and solidified, and shipping is much easier.

For industrial production of sole leather the hides are first trimmed, soaked, and, if necessary, remnants of flesh are removed. Then they are placed in lime to remove the hair; this usually takes about a week. After treatment with deliming and detergent materials, the hides are ready for tanning. Usually a series of rockers is employed in which the concentration of the tanning materials starts out low and is gradually increased as the tannage proceeds. This takes about 3 weeks. The 'butt' (i.e. the thick part of the hide corresponding to the animal's back and sides after trimming off shoulders and belly) is the most valuable part of the skin for sole leather, and is cut off and halved into 'bends'. The bends are tanned again for some weeks and then cleaned and bleached. Finally, the leather is treated with certain oils and chemicals, rolled with a heavy cylinder, and sponged with wax coating materials and dried.

The activities connected with the tanning processes can be environmentally destructive. Mangrove forests have been destroyed in several regions for the production of tannins and firewood, and wild populations of quebracho in South America have been locally overexploited. Tanneries produce large amounts of waste solids and chemicals; effluent treatment is now often one of the major considerations in the design and operation of a tannery.

1.6 Botany

1.6.1 Dyes in plants

Dyes can be found in many different parts of the plant: roots (e.g. the red dye from *Rubia cordifolia* L.), rhizomes (the orange-yellow dye from *Curcuma longa* L.), bark (the black substance from *Terminalia catappa* L.), gum-resin of the bark (the yellow dye from *Garcinia hanburyi* Hook.f.), wood (sappanwood, logwood), leaves (indigo), fruits (the purplish-black dye from *Terminalia bellirica* (Gaertner) Roxb.), seeds (annatto), flowers (safflower), and stigmas (saffron).
The functions in plants of substances used as dye depend on their chemical structure and location in the plant. Chlorophylls are involved in the light conversion step in photosynthesis. The functional aspects of these substances are still not wholly understood. The most plausible proposal for the universal function of carotenoids is that they protect cells from photo-oxidative damage caused by the incidental absorption of visible light (Burnett, 1976). Leaf flavonoids might have a protective role as a deterrent in plant–animal interactions, and may have an even more important protective role as a light screen against damaging ultraviolet radiation (Harborne, 1976), comparable with carotenoids. In general it is assumed that the presence of pigments in flowers subserves important roles in attracting insects, birds or bats for pollination. Coloured fruits and other parts of plants attract birds and other animals and favour dispersal of seeds and sometimes also vegetative fragments. The functions of plant components which are not coloured in their original state but can be converted into dyes are often obscure.

1.6.2 Tannins in plants

The role of tannins in plants is still not clarified. Sometimes tannins are considered waste products, but a deterrent effect on herbivores and a sterilizing effect on microbes have also been postulated. The latter opinions are supported by the fact that tannins are often found nearby essential and vulnerable parts such as the cambium in dicotyledonous plants. The deterrent effect on herbivores is also supported by the fact that plants with high tannin content are frequent in open vegetations in tropical and subtropical regions with heavy grazing pressure, as with *Acacia* species in the savanna. Although tannins may be an effective defence against herbivores, it is likely that their major role in evolution has been to protect plants against fungal and bacterial attack. To support this opinion, the high concentrations of tannins in nonliving cells of many trees (heartwood, bark), which would otherwise readily succumb to saprophytes, have been cited (Swain, 1979). It has also been suggested that the leaf tannins are active metabolites used in the growing tissues (Darnley Gibbs, 1974). However, tannins in different plant species probably have different functions.
Tannins are absent or only found in small quantities in lower plants (algae, mosses, lichens, fungi, ferns). They are comparatively rare in monocotyledons (except in palms). Tannins are common in dicotyledons, and their occurrence is scattered over many families. However, in some families tannins do not occur or are very rare, e.g. in Cruciferae and Labiatae, but in others (e.g. in Rosaceae and Guttiferae) they are almost invariably present. In a few families many spe-

cies contain tannins in large quantities, e.g. Rhizophoraceae and Combretaceae. On a world scale the most important species for tannin production belong to Leguminosae (e.g. black wattle, *Acacia mearnsii* De Wild.), Anacardiaceae (e.g. quebracho, *Schinopsis* spp.) and sumach (*Rhus* spp.), Rhizophoraceae (species of several genera), and Combretaceae (e.g. myrobalans from *Terminalia* spp.). Studies of the distribution of tannins in higher plants indicate that numerous families with a large number of tanniferous species are commonly considered primitive. It seems '... that the capacity to synthesize tannin is a primitive character that tends to become lost with increasing phylogenetic specialization.' (Bate-Smith & Metcalfe, 1957).
It has also been pointed out that there exists a remarkable relation in plants between the presence of types of flavonoids to which many tannins belong, and woody habit (Bate-Smith, 1957, 1963). This relation will remain unexplained as long as the chemistry of the processes concerned in lignification is not well understood.

1.7 Prospects

The great importance of vegetable dyes such as indigo and madder in the 19th Century contrasts enormously with the application of vegetable dyes nowadays. Some are hardly used any more, others remain of local importance only. However, the demand for natural products is increasing slightly in the world. Some synthetic dyes have proven to be carcinogenic. Others used in foods have been associated with behavioural disturbances such as hyperactivity and learning disorders in children. Moreover, their waste products cause environmental pollution. These facts may improve the market for vegetable dyes, especially for those used in foods and drinks.
For centuries dyes of vegetable origin have been used in the manufacture of the brown-coloured 'soga' batiks, especially in central Java. The colours symbolize grandeur and have been greatly appreciated. Fine soga batiks have been worn by Javanese people in various traditional ceremonies, and they are still worn, but almost exclusively by middle-class to rich, noble and older people. The use of vegetable dyes may only be revived if much effort is made to increase the demand for fine traditional batiks by stimulating the interest and developing the appreciation of young people to the well-developed culture of their country. This will not be easy because of the still increasing influence of Western and Middle-Eastern cultures in Indonesia.
Vegetable tannins are still important, but in the future, a gradual shift in favour of synthetic tanning materials is expected. Chrome tanning is most important at present, and is employed in many modern tanneries. The waste products of this type of tanning can be very detrimental to the environment. This has been demonstrated in some European countries, and as a consequence, dumping of the waste products is regulated by law. Similar pollution can be expected when aluminium and titanate tanning methods are employed. These problems should be taken into account when extension of tanning industry is considered. Vegetable tannins decompose easier and are thus less dangerous for the environment – provided their waste products are not dumped in too large quantities. Renewed phytochemical research on vegetable tanning might reveal tanning methods and possibilities that are competitive with synthetic methods, especially if the

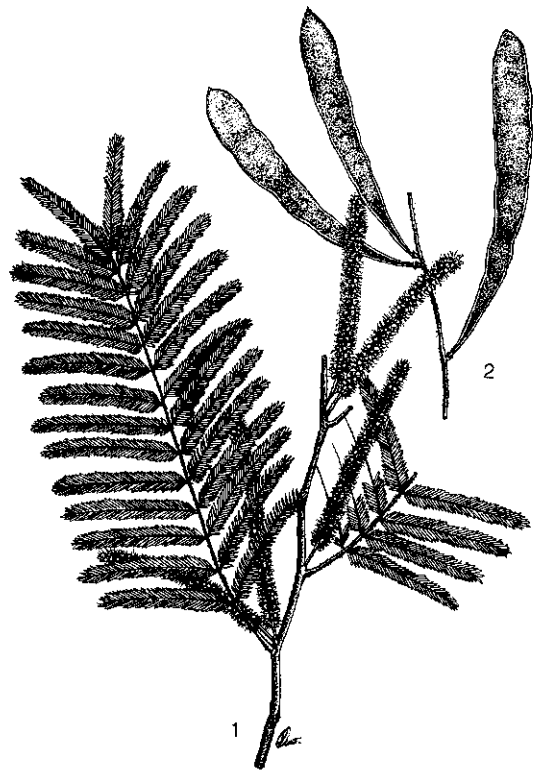
costs of dumping waste products are also considered.
The prospects for growing tannin-producing plants in the tropics should not be neglected. Multipurpose crops should have priority, producing other products such as oils, dyes, timber, firewood and edible fruits, and providing protection against erosion at the same time. For example, in many places, artificial regeneration of mangroves – including selection of better tannin-yielding species – has been shown to be possible.

R.H.M.J. Lemmens, N. Wulijarni-Soetjipto, R.P. van der Zwan & M. Parren

2 Alphabetical treatment of species

Acacia catechu (L.f.) Willd.

Sp. Pl. 4th ed., Vol. 4(2): 1079 (1806).
LEGUMINOSAE
$2n = 26$
Synonyms *Acacia chundra* Willd. (1806).
Vernacular names Cutch tree, catechu tree (En). Acacie au cachou (Fr). Burma: sha. Thailand: seesiat nua (central), sa-che (Shan, Mae Hong Son), seesiat (northern).
Origin and geographic distribution Cutch tree is distributed in the southern Himalayas of Pakistan, northern India and Nepal, south to Andhra Pradesh in India, and east to Burma and Thailand. It is sometimes planted in Indonesia (Java), Thailand, Burma and India.
Uses A substance called cutch, which is marketed as a solid extract, can be isolated from the heartwood. Depending on the way of processing, several products for different purposes can be obtained from crude cutch. In India and Burma the dark 'catechu' or 'Pegu cutch' is used to tan heavy hides into sole leather, often in a mixture of tanstuffs. Catechu extract is also used for preserving fishing nets and ropes, and for dyeing cotton, silk, canvas, paper and leather a dark-brownish colour, and also as viscosity modifier in on-shore oil wells. The crystalline portion of a concentrated decoction of the wood, called 'katha' or 'kath', is much used in betel chewing together with the leaf of *Piper betle* L., and as an astringent for medicinal purposes. A third form of cutch is the crystalline deposit sometimes found in cavities of the wood, known in India as 'khersal'. It is used for medicinal purposes, especially for the treatment of cough and sore throat. The bark is said to be effective against dysentery, diarrhoea and in healing wounds. The seeds have been reported to have an antibacterial action.
The wood is a useful timber, used for house posts, agricultural implements, wheels, etc. It is very strong, hard, durable and not attacked by white ants or teredos. The wood is an excellent firewood and one of the best woods for charcoal. Spent chips left over after the extraction of katha and cutch can be used for the manufacture of hardboards. The tree is a host for lac insects. Fresh leaves and small lower branches are eaten by cattle.
Production and international trade A trade in cutch between India and China existed from the earliest days of seaborne trade. As 'terra japonica', a product thought to be a mineral, cutch was imported in the 17th Century in Europe for medicinal purposes.
In India and Burma, the cutch tree is considered as a valuable tree; there is a great demand for cutch and katha. Statistics on the production of katha and cutch are not easily obtained, and vary greatly from 7000–9000 t/year in 1976, to as much as 40000 t/year in 1974 in India. Exports from India were estimated as 215–430 t per year in the 1970s. In Thailand crude cutch is produced on a small scale for local uses and for export. In Indonesia (Java) about 24000 ha of land was made available for cutch tree plantations in 1959, but there is no information on how much was really planted with this species. In Thailand plantations cover about 3300 ha.
The name 'cutch' is also used for mangrove extract, and figures on production and international trade of cutch sometimes also refer to this product.
Properties The average yield of katha is 3–4.5% of the weight of the heartwood, and the average yield of cutch is 6–8%. The tannin content of cutch is usually 55–60%. When used alone the tannin yields a harsh leather apt to contain yellow stains. Cutch contains 25–35% catechutannic acid, 2–10% catechin ($C_{15}H_{14}O_6$), and small proportions of catechu red, quercetin and gum. Katha predominantly consists of a mixture of catechin isomers; the catechin content averages 55% in katha of good quality. Catechin is also found in gambier from *Uncaria gambir* Roxb., which provides a similar product used in betel chewing in South-East Asia.
The tannin has shown algicidal activity when tested in ponds. Cutch has been found to be effective against liver diseases; this property has been attributed to the presence of the d-form of catechin called (+)cyanidanol-3.
The sapwood is sharply distinct from the heartwood, and is yellowish-white or yellow. The heartwood is light red to reddish-brown, darkening on exposure and is very strong and hard. The volumetric mass range is 810–1210 kg/m^3. The timber is characterized by brown tracts of paratracheal parenchyma, distinct narrow lines of terminal parenchyma and by the presence of white specks of a crystalline deposit. The timber needs long seasoning, and is fairly difficult to saw.
Seed weight is about 65 g/1000 seeds.
Description A small or medium-sized thorny tree, up to 15 m tall. Bark dark grey or greyish-brown, peeling off in long strips, or sometimes in narrow rectangular plates, brown or red inside. Branches slender, puberulous when young but glabrescent, with 2 curved, ca. 8 mm long prickles at the base of each petiole. Leaves bipinnately com-



Acacia catechu (L.f.) Willd. – 1, flowering branch; 2, branchlet with fruits.

pound with 9–30 pairs of pinnae, and a glandular rachis; leaflets 16–50 pairs, oblong-linear, 2–6 mm long, glabrous or pubescent. Flowers in 5–10 cm long axillary spikes, 5-merous, white to pale yellow, with a campanulate 1–1.5 mm long calyx, and a 2.5–3 mm long corolla; stamens numerous, far exserted from the corolla with white or yellowish-white filaments. Fruit a strap-shaped pod, 5–8.5 cm × 1–1.5 cm, flat, tapering at both ends, shining brown, dehiscent, 3–10-seeded. Seeds broadly ovoid.

Growth and development Germination starts 5–7 days after sowing. The tree starts flowering and producing pods when 5–7 years old. In Burma and Thailand it usually flowers in August and September, and the pods become mature in January and February.

Investigation on growth in Nakhon Ratjasima Province in Thailand showed a mean annual increment in girth of the bole of 2.5–4 cm. In India a mean annual increment of 3.2 cm has been reported in Himalayan trees and 4.3 cm in trees from Darjeeling Tarai.

Other botanical information *Acacia chundra* is sometimes considered as a separate species, sometimes as a variety of *A. catechu*, differing from the typical *A. catechu* in having glabrous leaves, calyces and rachises and in having heavier wood. Sometimes var. *catechuoides* Prain is distinguished, having glabrous calyces but puberulous rachises and also heavy wood.

Ecology Cutch tree occurs naturally in mixed deciduous forests and savannas of lower mountains and hills, up to 1500 m altitude. It is especially common in the drier regions on sandy soils of river banks and watersheds. It can be grown in the more humid climates of South-East Asia at altitudes from sea-level to about 300 m, as cultivation in Java shows, but it is intolerant of clay soils.

Propagation and planting Plants can easily be propagated by seed and by cuttings. Before sowing it is recommended to put the seeds in boiling water and to leave them to cool in the water for 24 hours. In India seeds may be sown in early summer, in a 0.5 cm deep seed-bed. The beds should be watered thoroughly. Usually the seedlings are transferred to plastic bags, and planted in the field when they are 3–6 months old or 30–50 cm high. Plant spacing is 4 m × 6 m or 2 m × 4 m. In wet regions the seed may be sown directly in the field.

Husbandry Weeding is essential, especially when plants are still young. Protection against fire is necessary, especially in the drier parts of India, Burma and Thailand. The plants should also be protected against grazing animals.

Diseases and pests In India, parasitic plants of the genus *Cuscuta* L. may kill plants, and hemiparasitic plants of the genus *Loranthus* Jacq. may damage trees. Root rot can be caused by the fungus *Ganoderma lucidum*. Other fungi may cause rot, too. Insects reported to attack cutch tree in Thailand include *Bothogonia* spp., seed-boring beetles such as *Bruchidius terranus* and *Bruchus billineatopygus*, and the leaf-eating insect *Dasychira mendosa*. Rodents are also reported to damage trees.

Harvesting Trees with a girth of 60–120 cm are generally preferred for cutch production. The wood can be harvested when the trees are 30 years old in good sites, 50 years old in moderate sites, and 60 years old in poor sites. The trees are felled and transported to factories.

Yield For maximum heartwood production there should be about 560 trees/ha at 10 years of age. In 60-year-old plantations in India the yield of heartwood in good sites is 75 m^3/ha, in moderate sites 63 m^3/ha, and in poor sites 50 m^3/ha. In these plantations the yield of cutch can be estimated at 6 t/ha,

5 t/ha and 4 t/ha, respectively.

Handling after harvest The wood of freshly felled trees yields more cutch than dried wood. After felling, the bark and sapwood are removed, and the heartwood is converted into chips. In India the chips are extracted with water in extractors made of copper or wood, but vessels of aluminium and stainless steel are also suitable. After heating for about 2 hours, the chips are removed and extracted in a new bath of water. Then the extract is evaporated and cooled for crystallization of katha, which is separated by filtering. To obtain cutch the aqueous liquor is further concentrated in evaporators to a consistency at which it solidifies on cooling. In this way advantage is taken of the fact that cutch is soluble both in cold and hot water, whereas katha is only sparingly soluble in cold water. Cutch and katha are marketed in the form of tablets.

In Thailand the chips are extracted by boiling in vessels 7 times; this takes about 9 hours. Concentrated extract of correct consistency is rolled into balls and dried.

In dyeing cotton, the material is steeped for about one hour in a boiling solution of cutch, to which copper sulphate has been added. Afterwards it is transferred to a bath containing sodium bichromate. The dye is very fast to light, acids and alkalies.

Prospects In India, the number of katha factories has been increasing rapidly in the period 1980–1990. Sustained supply of the raw material is a problem. In Thailand, the demand of tanning agent is very high, and although cutch does not hold a high position as a tan-stuff, cutch tree is easy to grow and might be promising. As a multipurpose tree, it deserves more study to verify the possibilities for cultivation in the wetter climates of South-East Asia.

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W. Subansenee

Acacia leucophloea (Roxb.) Willd.

Sp. Pl. 4th ed., Vol. 4(2): 1083 (1806).

LEGUMINOSAE

$2n$ = unknown

Synonyms *Mimosa leucophloea* Roxb. (1800).

Vernacular names Indonesia: pilang (Javanese, Sundanese), opilan (Madura), pelang (Madura, Bali). Burma: ta-noung. Thailand: chalaep daeng (central), phayaa mai (Kanchanaburi). Vietnam: a bu, a kawa (Thuan Hai).

Origin and geographic distribution *A. leucophloea* is native to large parts of South and South-East Asia, where it is found in India, Nepal, Pakistan, Sri Lanka, Burma, Thailand, Vietnam, Indonesia (Java, Timor, Sumbawa).

Uses The tannin-containing bark was used in the leather industry in Indonesia, and less so in India, until the 1950s. Until the 1940s the tree was cultivated in commercial plantations in Indonesia mainly for this purpose. The bark is also used to prepare fine beverages (arak); its strong fibres are used locally to make fishing nets. The wood of *A. leucophloea* is used for indoor construction and, although a little hard to work, for furniture. It is also highly appreciated as firewood and is very suitable for making charcoal.

The consumption of cooked, germinated seeds as vegetable (hale) is reported from Java. Stem and roots produce a gum which is used for medicinal purposes. The pods and foliage are a protein-rich fodder source. In Tamil Nadu (India) farmers cultivate *A. leucophloea* for soil improvement. The trees are also planted around timber plantations as fire protection.

Production and international trade In former times *A. leucophloea* was grown commercially for tannin production. Nowadays, the species is no longer considered commercially interesting and production figures are difficult to obtain. There is no international trade.

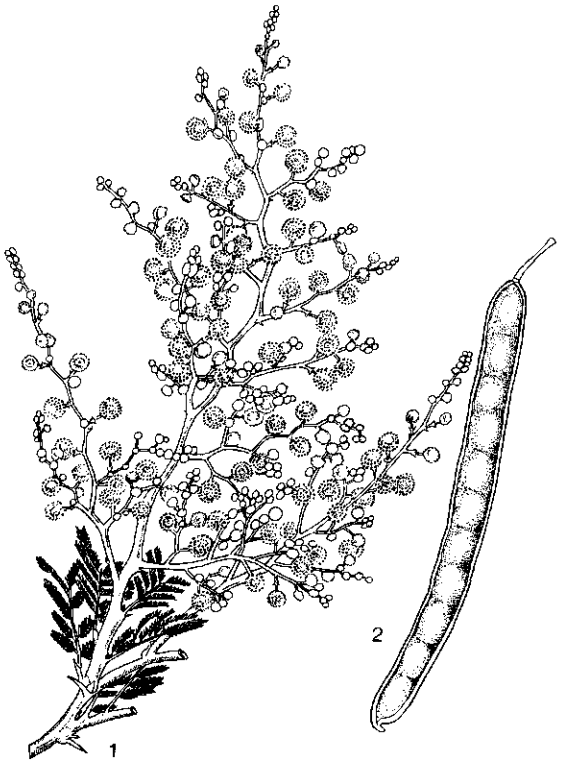
Properties The bark contains 11–20% tannin, with an average of 15%; the tannin content is highest in older trees. The tannin is difficult to extract, and so the tanning process is slow. Because of its small content of sugar-like components, the tannin has hardly any acid-forming properties. The tannin is of the proanthocyanidin type, and colours leather red; the red colour darkens easily in light. In tanneries pilang bark was often used mixed with trengguli bark (*Cassia fistula* L.). In Indonesia pilang bark was replaced by the better tanning bark of *Acacia mearnsii* De Wild. (black wattle) after the Second World War.

The fodder (leaves and pods) contains 1.9% digestible fats, 7.1% digestible proteins and 12.4% digestible carbohydrates. Its hydrocyanic acid content varies during the year. In India, values ranging from zero (December) to 240 mg/kg hydrocyanic acid (May/June) have been measured in the leaves, and values over 400 mg/kg in the pods from October to April (with a maximum of almost 1000 mg/kg in November). Whenever the hydrocyanic acid content exceeds 200 mg/kg, the fodder should not be used as the sole source of animal feed.

The roots bear nodules with nitrogen-fixing microorganisms. Seed weight is small, about 37000 seeds weighing 1 kg.

The heartwood is beautifully red, the sapwood is grey white. The wood is strong (class II in Indonesia) and durable (class III in Indonesia) when used indoors. In contact with moist soil, it decays quickly. Volumetric mass is 710–890 kg/m^3.

Description Deciduous tree or erect shrub, 10–35 m tall, with deep taproot, few secondary roots, pale bark and broadly umbelliform crown.



Acacia leucophloea (Roxb.) Willd. – 1, flowering branch; 2, fruit.

Young trees are often densely beset with thorny suckers; lower branches armed with paired straight or faintly curved stipular thorns, usually dark brown or black, less often white, up to 2.5 cm long. Leaves bipinnate, pinnae 4–13 pairs, rachis 3.5–8.5 cm long; leaflets in 6–30 pairs, linear, 3–11 mm × 0.5–1.7 mm. Inflorescences yellowish-white subglobose heads, ca. 1 cm in diameter, in large terminal densely hairy panicles up to 30 cm long; peduncles 0.4–1.3 cm long. Flowers sessile, calyx 0.8–1.2 mm, corolla 1.2–2 mm long; stamens 20–25. Fruit a linear, slightly curved or straight pod, 6–15(–20) cm × 7–11 mm × 3 mm, woody, glabrescent, dark brown, 5–12(–20)-seeded, indehiscent. Seeds very variable, orbicular, ellipsoid or trapezoid, 5.5–6.5 mm × 4–5 mm, compressed, greyish-brown.

Growth and development Only a small proportion of the seeds germinates. Pretreatment of seeds with hot water improves germination. In Indonesia pretreated seeds have taken up to 75 days to germinate. Flowering is at the end of the rainy season/beginning of the dry season. Leaf fall occurs for a very short period at the beginning of the rainy season. There is some disagreement in the literature as to whether the trees bear fruit every year.

Ecology The ecological range of *A. leucophloea* is wide: it occurs in areas with a pronounced East Monsoon, under semi-arid (rainfall 600 mm/year) to humid (2000 mm) conditions, at altitudes ranging from sea-level to 550 m, on sandy-marl to heavy clay-marl soils. The plants need much light and space to develop into mature trees. In the wild, the tree occurs individually and sometimes in groups in heterogeneous, deciduous forests on soils with a moderate to poor fertility. It is never found in evergreen, closed forests on fertile soil. *A. leucophloea* tolerates soils that are periodically very dry, and soils with compaction features, because of the adaptibility of its root system to poor oxygen availability. It does not survive on poorly drained sites.

Propagation and planting Plantations of *A. leucophloea* are established by sowing seeds directly, using 10–12 seeds per hole, at 2 m × 1 m. If enough space and light are available, abundant natural regeneration has been observed in Tamil Nadu (India) with 1000 seedlings/ha. It is advisable to plant in combination with a creeper that gives effective soil cover, or to intercrop with other species that provide more shade in the youth phase. In mixed plantations, however, accompanying species should be carefully selected because *A. leucophloea* is easily suppressed on account of its slow growth when young. When combined with other

species it should be planted in small groups.

Husbandry In monoculture plantations, *A. leucophloea* needs intensive and expensive maintenance to suppress the heavy undergrowth that develops because the trees provide little shade.

Diseases and pests Seedborne rust infections by *Hapalophragmiopsis ponderosum* cause amorphous, tumorous galls. The seed of *A. leucophloea* may be seriously infested by a small weevil of the genus *Caryoborus* and by a bruchid beetle. Caterpillar plagues have also been observed. The species is fire resistant and the bark recovers easily.

Harvesting For tannin production, the bark is stripped at the beginning of the growing season because then the high water content facilitates the process. The bark is cut into pieces of 50 cm × 10 cm, and dried in the sun for 2–3 days. During drying the bark loses one-third of its original weight.

Yield Production figures from plantations in Indonesia with a rotation of 12 years indicate an annual dry bark production ranging from 8 kg/tree for diameter class 10–14 cm to 81 kg/tree for diameter class 30–35. The annual wood production is ca. 15 m^3/ha (whole tree), 11 m^3/ha thick wood (diameter breast height > 7 cm) and 9 m^3/ha clear bole. Under wide-spaced conditions in an agroforestry system in India (Tamil Nadu), an annual yield of 100 kg pods/tree and a 20–23% increase in height growth and dry-matter yield of fodder sorghum cultivated under the trees has been reported.

Handling after harvest After the bark has been air-dried at the factory, it is chopped into small pieces and put in the tanning extraction vats. Only 3–4 days may elapse between harvesting and extraction, because fungal infections degrade the colour and quality of the extract. After continuous countercurrent extraction first with cold, then with warm water (below 60°C), the resulting extract is concentrated in a triple effect evaporator and finally in a copper vacuum evaporator until it has the desired moisture content. The extract is stored in containers.

Prospects *A. leucophloea* is a promising species for agroforestry and especially for silvopastoral purposes. It can be used in sites that suffer from compaction as a result of overstocking. It produces good fodder that is rich in protein, and enriches soils by nitrogen fixation. Its open crown transmits enough light to permit crop cultivation under the trees. Nevertheless, *A. leucophloea* has not yet received much attention in agroforestry and silvopastoral research.

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L.M. Berenschot

Acacia mearnsii De Wild.

Pl. Bequaert. 3: 61 (1925).

LEGUMINOSAE

$2n = 26$

Synonyms *Acacia decurrens* (Wendl.) Willd. var. *mollis* Lindley (1819), *Acacia decurrens* auct., non Willd. (1806), *Acacia mollissima* auct., non Willd. (1809).

Vernacular names Black wattle, tan wattle (En). Acacie noir (Fr).

Origin and geographic distribution Black wattle is native to south-eastern Australia (New South Wales, Queensland, Victoria and Tasmania), but it has been introduced throughout the tropics. Large plantations are found in southern and East Africa, Brazil and India. In Indonesia the first trials with the species started at the end of the 18th Century, but better results were obtained with trials started in 1911. In 1933 the Forest Service started planting the species on commercial scale in mountainous areas of Java and by 1941 an area of around 12000 ha had been planted. Additional plantations were established in southern Sulawesi, around Lake Toba on Sumatra and on Bali. On a smaller scale, plantations have been established in Peninsular Malaysia and in the Philippines.

Uses Black wattle is primarily cultivated for tannin and wood production. The species is the principal source of the world's tanbark; the bark contains up to 40% of excellent tannin especially fitted for use in the manufacture of heavy leather goods. In addition, the powdered bark extract is used to prepare tannin formaldehyde adhesives for exterior grade plywood, particle board and laminated timber. The wood of the tree is widely used as fuelwood for domestic use and village industries

(e.g. tobacco curing in central Java), or for charcoal production (e.g. in Kenya and Brazil). The wood may also be used for local construction material, mine props, wooden tools, joinery, flooring and hardboard. It is also used for rayon and paper pulp. The species has also been planted for erosion control and soil improvement, as shelterbelt or firebelt, as a shade tree in tea plantations, and as an ornamental. The leaves are sometimes used for fodder, but are relatively unpalatable and can best be mixed with other feeds.

Production and international trade The maximum area of black wattle plantations was reached around the 1960s. Since then, a fall in demand for tannin has led to a considerable reduction in area, e.g. from 325000 ha to 160000 ha in South Africa and from 27000 ha to 14000 ha in Zimbabwe. Around 1980 the estimated plantation area was about 350000 ha, of which 160000 ha were in South Africa, 125000 ha in Brazil, 30000 ha in East Africa (Zimbabwe, Kenya, Tanzania, Rwanda, Burundi), and 20000 ha in India. In Indonesia the plantation area is estimated at 15000 ha (mostly Forest Service plantations); in addition, locally (Dieng Plateau and the slopes of Merapi volcano in central Java, southern Sulawesi) the tree is also grown by farmers in rotation with agricultural crops. In several countries tannin industries based on the species have been developed; the main exporting countries are South Africa (150000 t/year of bark), Kenya (25000 t/year) and Tanzania, and the main importing countries are Great Britain, Australia and the United States.

Black wattle is currently the world's major source of vegetable tannin, closely followed by quebracho (*Schinopsis* spp.).

Properties The bark of black wattle contains 30–40% high-quality tannin on dry weight basis. The tannin belongs to the proanthocyanidins, and is a complex mixture of some 40 components; among the main constituents are (+)catechin, (–)robinetinidol and (+)gallocatechin. The tannin penetrates the hide fast, and gives a firm and durable leather with a light colour, unlike other proanthocyanidin tanning materials (e.g. mangrove extracts) which give a reddish colour. It does not precipitate in acid solution, which influences positively the quality of the leather. It is especially suited for the manufacture of sole leather.

The tannin content varies with bark thickness, age of the tree and average annual rainfall, and decreases from the base of the trunk upwards, the bark of the branches having a low tannin content. Black wattle extract contains 60–65% tannin. Extracts, usually called 'mimosa extract', are commercially available in several forms, each giving different qualities to leather. Some firms in Europe specialize in treating the pure extract for this purpose. Usually the extract is mixed with syntans for use in the leather industry.

The wood is yellowish to light red. It is fairly light, 550–850 kg/m^3 (in Indonesia 600–700 kg/m^3), depending on site conditions, moderately hard to hard, durable, and fairly tough and strong. It has an energy value of about 19700 kJ/kg and ash content of ca. 1.5%. The energy value of charcoal is about 32000 kJ/kg.

Seed weight is low; 1 kg contains 50000–80000 seeds.

Description A small to medium-sized evergreen tree, 6–25 m tall, with straight trunk to 50 cm in diameter and a spreading rounded crown of feathery, dark green foliage (if cultivated in plantations erect and slender); bark brownish-black, fissured, but in younger stems grey-brown and smooth; twigs unarmed, angled, grey, densely hairy, tinged with golden yellow when young. Leaves alternate,

Acacia mearnsii De Wild. – 1, flowering branch; 2, branchlet with fruits.

bipinnately compound, 8–15 cm long, with 8–20 pairs of pinnae 2–5 cm long; rachis with glands at base of each pair of pinnae on upper surface; leaflets very numerous, 20–70 pairs crowded on each pinna, narrowly oblong and small, 1.5–4 mm × 0.5–0.8 mm, blunt, with dense soft hairs, dark olive green. Flowers minute and numerous in pale yellow globose heads, 5–8 mm in diameter, arranged in axillary racemes or panicles, very sweet-scented, 5-merous, with numerous stamens and a pistil with long slender style. Fruit a narrowly oblong or linear, flat pod, (3–)5–15 cm × 0.5–1 cm, constricted between the seeds, pubescent, dark brown to blackish when ripe, dehiscent along one suture, 3–14-seeded. Seeds ovoid, 3–5 mm × 2–3.5 mm, smooth and black.

Growth and development Seeds stay viable for many years, especially when stored in air-tight containers. Seeds can remain in the ground for a long time and start to germinate after a forest fire, but seedlings are susceptible to fire. After germination the radicle grows vertically downwards to form a taproot of about 1 m. After a few weeks a relatively extensive network of lateral roots starts to develop; at a later stage these lateral roots may develop sinkers. Nodules of nitrogen-fixing bacteria are readily formed at the tips of the lateral roots. The plumule starts to develop somewhat later than the radicle; it has an erect growth. Black wattle is a light-demanding species with rapid early stem growth. Growth rates of up to 3 m/year are reached after 3–5 years. Trees start to flower when about 2 years old. The flowers are insect (bee) pollinated. Copious fruiting normally occurs after 5–6 years, and fruits mature in 12–14 months. The total lifespan is 15–20 years.

In some areas such as Hawaii and parts of South Africa the species has become a noxious weed due to its aggressive colonization of denuded areas, especially if fires occur.

Other botanical information There has been considerable confusion about *A. mearnsii* and some closely allied species: *A. decurrens* (Wendl.) Willd. (green wattle) and *A. dealbata* Link (silver wattle). These species have been considered for a long time as conspecific with *A. mearnsii*, although usually distinguished as varieties. They are now usually thought to represent distinct species. The name *A. mollissima* has often been used erroneously for *A. mearnsii*. In fact, *A. mollissima* Willd. is a synonym for *A. pubescens* (Vent.) Ait.f. This makes literature on these species very confusing. In Indonesia, the name *A. decurrens* is still commonly used for *A. mearnsii*. However, although unlikely, it cannot be completely ruled out that the true *A. decurrens*, which also has a high tannin content in the bark, has also been introduced in Java.

Black wattle can be crossed with green wattle (*A. decurrens*). Hybrids show more sterility than their parents.

Ecology In its natural area of distribution (35–44°S latitude), black wattle occurs in the understorey of tall open forests, in fringes of closed forests or in dense thickets on recolonized lands. Its range is from sea-level to 900 m, but its main occurrence is from near sea-level to about 200 m in areas with a warm subhumid to humid climate. The mean maximum temperature of the hottest month is 21–28°C, the mean minimum of the coolest month 1–7°C, with up to 20–40 frost days. Annual rainfall varies between (440–)625–1000 (–1600) mm. The species is sensitive to severe drought and to frosts of –4°C or lower.

In tropical countries plantations occur under hotter and wetter conditions than in the natural area of distribution. These plantations are found in the highlands (1500–2500 m) with mean annual temperature 12–20°C, coolest month minimum temperature 2–8°C, hottest month maximum temperature 18–24°C and mean annual precipitation 700–2000 mm. In Indonesia the species has been planted at 1000–2000 m altitude with annual rainfall of 1000 mm or more. In South Africa (Natal) the species is cultivated in areas at 300–1000 m altitude where ecological conditions are intermediate between the tree's native conditions and tropical conditions.

Black wattle can grow on a variety of soils. The best soils are moist but well-drained, relatively deep and light-textured with pH 5–6.5. The species tolerates moderately heavy or shallow soils with moderate to poor fertility. It does not grow on poorly-drained, calcareous or very infertile sites.

Propagation and planting Black wattle is usually propagated by seeds, which are either directly sown in the field, or in containers when raised as nursery stock. In Java direct seeding at 3 m × 1 m distance with 5 seeds per hole is most common. Germination is rapid if seeds have been pre-treated with very hot water (90°C). Sometimes scarification is used. Seeds retain their viability for several years. Vegetative propagation is not very successful. Normally no inoculation with *Rhizobium* is needed.

Standard nursery practices can be used to raise seedlings in the nursery. Plantation sites should be well prepared by ploughing or soil ripping. Nor-

mally black wattle is not mixed with other species because its rapid growth hinders the development of other species. In Indonesia and other countries, young plantations are sometimes temporarily intercropped with food crops. In such cases in Indonesia, *Leucaena leucocephala* (Lamk) De Wit or *Cestrum* spp. are interplanted along the contours to control erosion.

Husbandry During the first year plantations should be weeded. To maintain vigorous growth, thinning should start as early as the 2nd or 3rd year, and should be repeated regularly. The degree of thinning depends on the management objectives; severe thinning favours stem diameter growth and the related bark production; denser stands are needed for good timber production. In Indonesia optimal bark production is obtained by reducing the early tree density of around 3000 trees/ha to 200–380 trees/ha at 8 years of age, depending on the quality of the sites. Such thinning allows the most productive trees to be selected and trees with gummosis to be removed. Normally no pruning is needed.

Because of the short rotations and high biomass harvest it is important to replace nutrients by fertilization. Proper care should be taken to control erosion, especially when plantations are burnt (e.g. to promote natural regeneration). But if properly managed, black wattle may help to enrich soil nitrogen as a result of rhizobial nitrogen fixation, and rehabilitate degraded lands. Good results are obtained in the Wonosobo region (Central Java) where local farmers have cultivated the species in rotation with vegetable crops and tobacco for many years.

Diseases and pests In its native range the species is not cultivated because of serious damage by indigenous insects including the fireblight beetle *Pyrgo orphana*; sometimes severe damage may occur in Brazil, too. But in most tropical countries, disease and pest attacks are generally not serious, although attacks by various insects including defoliators (e.g. wattle bagworm, *Acanthopsyche junode*), stem-borers (e.g. *Platypus solidus*) and caterpillars (e.g. wattle looper caterpillar, *Achaea lienardi*) may occur. Sometimes a physiological disorder, called 'gummosis' occurs whereby gum is exuded in the absence of any obvious injury.

In Indonesia, most damage occurs from fungal attacks of *Armillaria*, *Corticium*, *Fomes* and *Phytophtora* spp. under humid conditions with more than 3000 mm annual precipitation.

Harvesting Plantations for tannin bark are usually harvested after (7–)8–10(–12) years, when trees are more than 18 m tall and have a diameter of at least 15 cm. The bark is harvested by ripping the bark at several points near the base of the stem with a hatchet or short iron bar flattened at the end; the loosened strips of bark are pulled from the stem. After stripping the bark is cut to bundle length. Trees are cut according to normal practices.

Yield In South Africa typical yields of fertilized plantations are 15–25 m^3/ha per year of wood and 1.5–2 t/ha of dry bark. In other tropical regions yields range between 25–35 m^3/ha per year of wood and 0.9–2 t/ha of dry bark. In Indonesia mean wood yields are 14–21 m^3/ha per year and 11–16 m^3/ha per year in plantations of 8 and 12 years old, respectively. Dry bark production is 1.2–2 t/ha per year and 0.9–1.5 t/ha per year in plantations of 8 and 12 years old, respectively. At the best sites 60–65 % of the yield consists of first grade bark from stems of at least 15 cm diameter, on poorer sites this is only 40–50 %.

Handling after harvest The harvested bark may be transported immediately or first dried locally. Drying should be done in partial shade; the inner bark darkens if exposed to direct sunlight. The bark discolours if it is re-wetted after drying. To obtain good bark quality kiln drying is practised sometimes. In Indonesia and elsewhere trials have been done on portable charcoal-burning drying kilns in which the bark can be completely dried in about 60 hours. During drying the bark curls inwards; these 'sticks' are bundled for transport. At processing plants the bark may either be extracted or prepared for marketing as dry bark. Fresh bark is preferred for extraction. Dry bark is graded according to thickness, maturity, lightness of colour, absence of corkiness and freedom from mould. It is marketed as chopped bark, ground bark or sometimes as dust, in pressed bales or in bags.

In small tanneries in Indonesia, chopped bark is used directly for tanning hides in pits in the ground. The bark is cut into chips about 5 cm long, which are soaked in water for 10 days. Cow hides are immersed in the solution for a period of about 6 weeks.

Genetic resources It is thought that the seed used for black wattle plantations outside Australia derived from a limited part of the natural range and further provenance testing should be carried out. Germplasm collections exist at the CSIRO Division of Forest Research (Canberra, Australia) and at the Wattle Research Institute (Pietermaritzburg, South Africa).

Breeding Major breeding objectives are trees with enhanced vigour, better bark quality and stem form, and resistance to pests and diseases. Trials in South Africa to hybridize black and green wattle have not given promising results.

Prospects Due to the substitution of leather by plastics and the subsequent decline in the importance of tannin since the 1960s, black wattle cultivation has decreased in importance. In Indonesia several wattle plantations have been transformed into timber or clove plantations, and in central Java the cultivation of black wattle in rotation with agricultural crops has also diminished with the advance of artificial fertilizer and commercial vegetable production. Nonetheless, the species deserves more attention because of its multipurpose functions and its adaptability to a wide range of ecological conditions including degraded sites. It is a potential substitute for the synthetic tannins, which are now so widely used in the tanning industry and which cause problems for the environment. Special consideration should be given to using black wattle for combined production of bark and fuel or local construction material, and for soil rehabilitation in local land use systems.

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K.F. Wiersum

Acacia nilotica (L.) Willd. ex Del.

Fl. Aegypt. Ill.: 79 (1813).
LEGUMINOSAE
$2n = 52, 104$

Synonyms *Acacia arabica* (Lamk) Willd. (1806).

Vernacular names Babul acacia, Egyptian thorn (En).

Origin and geographic distribution Babul acacia is a native of tropical Africa, from Egypt south to Mozambique and Natal, extending to south-western Asia (Iran, Pakistan), and east to India. It is widely distributed in India, wild, cultivated, as well as naturalized, and it was introduced to Sri Lanka, Burma, Indonesia (Java in 1850, Lesser Sunda Islands) and tropical Australia.

Uses The bark produces tannin which in India is used for tanning and dyeing leather black or various shades of brown. Babul acacia bark is the most commonly used tanning material in northern India. The tannin produces a heavy leather which is firm and durable but hard. If combined with myrobalans (from *Terminalia* spp.) the tannin produces excellent leather. Dried mature pods are used in local tanneries in Sudan and rarely in India to produce a pinkish-white leather of good quality. The wood produces Indian gum which is sweet and of poorer quality than gum arabic obtained from *Acacia senegal* Willd. Indian gum is used for printing and dyeing calico, as a sizing material for cotton and silks, and also in the manufacture of paper. It is also useful as an emulsifying and suspending agent. The gum from the pods is used for dyes and inks in India. The young pods, young leaves and shoots are used as vegetables and as fodder. The seeds are used as cattle feed. In eastern Java sprouted seeds are consumed as a vegetable, and well-roasted seeds are mixed with coffee.

The trees make good hedges, e.g. to protect plantations against grazing animals. They are also used as fire-breaks, e.g. in the Baluran National Park in East Java. In Sudan they are used to afforest inundated areas. Babul acacia is a valuable species for reclamation of waste lands, especially on alkaline soils. In some places in India babul acacia serves as a host for lac insects.

The bark, gum, leaves and pods are used in various traditional medicines. An extract of the root is a potential inhibitor of tobacco mosaic virus.

The timber is harder than teak and is used for making agricultural implements, boat handles, brake blocks, cart-wheels, planks, tent pegs, etc. The wood is valuable as fuel and for the production of charcoal. The wood shavings are used as raw mate-

rial for paper. Young bark is used as fibre for toothbrushes.

Production and international trade No recent statistics are available on production and trade of this species. The various products made from the tree are used locally but do not enter international trade.

Properties The tannin content of the bark varies with the age of the plant. Older trees have more tannin than younger ones. The content of tannin in the bark varies from 7% to 23%, with an average of 12%, on a dry weight basis. In India the tannin content of mature pods is 12–19%, and 18–27% in de-seeded pods. However, de-seeded pods in Sudan may contain 40% tannin.

Besides tannin, the bark also contains colouring matter. Babul acacia bark tans slowly and gives a dark-coloured leather. These undesirable properties may be modified by the use of myrobalans or by the use of modern methods such as controlling the pH of the tan liquor. The tannin of the bark belongs to the proanthocyanidin type.

The tanning material from the pods has the disadvantage that it tends to ferment easily. The percentage of sugar-like components and soluble non-tannins is too high to be of any value for making tannin extracts. The tan-stuff is a mixture of several tannins of the group of gallotannins and ellagitannins. Tannins from fallen pods penetrate the soil and are hydrolized, producing gallic and ellagic acids which are allelopathic to grasses and other herbs.

The pods provide an excellent tanning material, producing a light-coloured leather, especially when young pods are used. The leather is durable and has a high reputation for book binding. In Africa the pods are used in tanning, whereas in India the bark is used and little attention is paid to the pods.

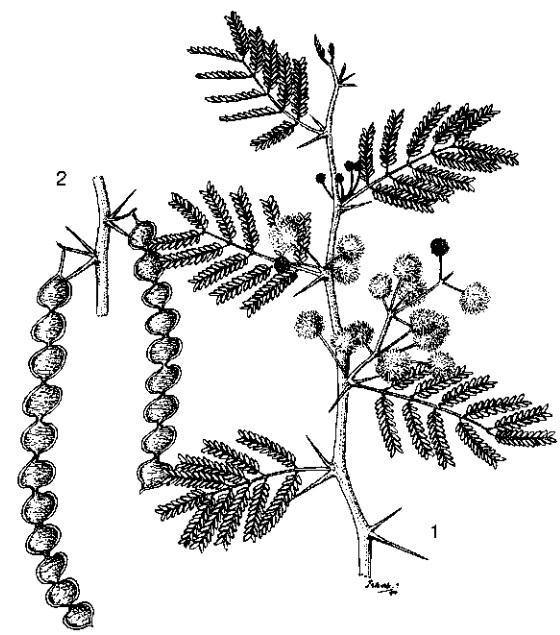
On a dry weight basis the pods contain 11–16% crude protein, and the leaves 14–20%.

The gum of babul acacia varies in colour from pale yellow to reddish-brown or almost black depending on the age of the tree and climate at harvesting. It is soluble in water and its aqueous solutions are very viscous. The darker gum contains tannin and is less soluble in water. It has a moisture content of ca. 13% and is slightly dextrorotatory. It is composed of galactoaraban which hydrolysizes to give l-arabinose and d-galactose. The quality and composition of the gum depends on climate and methods of collection.

Babul acacia timber is strong and fairly heavy with an air-dry weight of 650–850 kg/m^3. The sapwood is soft, yellowish-white, decays rapidly and is soon destroyed by insects. The heartwood is pale red, mottled with darker streaks, turning to reddish-brown when exposed to light, and it is not readily attacked by insects. The timber is very durable if it is well-seasoned. However, during the dry season it is liable to split. The energy value of the wood varies from 20160–20790 kJ/kg.

On a dry weight basis the seeds contain 4% lipid, 39.5% triglyceride, and 9.6% hydrocarbon-wax-ester. Seed weight is small, 1 kg containing 7000–11000 seeds.

Description A shrub or small to medium-sized, spiny and evergreen tree, usually less than 10 m tall, but sometimes attaining 20 m tall; bole short, straight or bent, with diameter up to 60(–80) cm, crown umbrella-shaped; bark dark brown, longitudinally deeply fissured, 1–1.5 cm thick; branches ascending, branchlets smooth, densely grey pubescent when young, at each leaf-base provided with 2 stipular spines 1–5 cm long, straight, sharp-pointed and white; sometimes spines are absent. Leaves alternate, bipinnately compound with 3–6 pairs of pinnae, rachises 3–10 cm long, pubescent, glandless or with several glands; leaflets (8–)10–15(–20) pairs per pinna, membranous, elliptic or narrowly oblong, 3–6 mm × 1–2 mm, rounded and oblique at base, obtuse at apex,



Acacia nilotica (L.) Willd. ex Del. – 1, flowering branch; 2, branchlet with fruits.

entire, usually glabrous, subsessile. Flowers very small, 5-merous and arranged in 1–3 cm long peduncled, globose heads; heads 1–2 cm in diameter, 1–6 per leaf axil, with ca. 50 flowers per head, dark yellow and sweet-scented; subtending leaves of upper nodes reduced or not yet developed. Fruit a usually dehiscent oblong-linear and flattened pod, 7.5–15 cm × 1–2 cm, constricted between the seeds, distinctly stalked, densely tomentellous, becoming black when ripe, 5–12 seeded. Seeds ovoid-circular, flattened, ca. 5 mm × 4 mm, black. Germination epigeal, seedling with petiolate circular-ovate cotyledons and very short epicotyl; first leaves alternate, sometimes opposite.

Growth and development Seedlings and young plants thrive best in open places with sufficient moisture. They prefer loose soils and absence of grasses and weeds.

Babul acacia is fast-growing, but the productivity varies according to environment. In India, trees in plantations along canals grow much faster than trees in natural stands. The mean heights of trees in plantations 5 and 10 years after planting are about 5 m and 25 m respectively, whereas in natural stands of the same ages, mean heights of 3 m and 5.5 m respectively, have been reported. In savanna land in Baluran National Park in East Java 17-year-old trees reach an average height of 6 m. Here the species, formerly planted as a hedge crop and firebreak in 1969, has become a noxious weed colonizing a large part of the grazing area of the savanna.

Other botanical information *Acacia nilotica* is an extremely variable species. It has been divided into a considerable number of subspecies and varieties. The specimens planted and naturalized in Java are usually considered representative of subspecies *indica* (Benth.) Brenan.

Ecology Babul acacia occurs from sea-level to 1300 m altitude. It thrives in areas with an annual rainfall of 400–2300 mm. It will tolerate drought or flooded conditions for several months. Natural stands often occur along river banks which are subject to periodic inundation. Babul acacia is reported to tolerate annual mean temperatures of 19–28°C, but it can grow at extreme conditions of temperature and in soil with various characteristics, including heavy clay soils and saline sites with pH 5.0–8.0. Babul acacia prefers alluvial soil. It does not tolerate frost or shade when young. This plant is suitable for marginal lands with extremely high or low temperatures.

Propagation and planting Babul acacia is propagated by seed. The seeds can be sown directly in the field, or they can first be sown in nurseries and the seedlings transplanted to the field later. The seeds should be scarified and soaked in warm water for several hours before sowing to obtain good germination. For direct sowing, ridge-sowing is recommended, with a sowing rate of 1 kg per ha. Seeds collected from goat and sheep dung germinate more easily.

Husbandry When planted for the production of tannin and gum, babul acacia plants should have sufficient space (4 m × 4 m) so that each tree receives enough light. Thinning is necessary to maintain optimum growth of the stand. In India thinning is started at the age of 10 years and is repeated at intervals of 5–6 years. Plants tolerate pruning well, which makes them useful as hedge plants. Since in a suitable environment the dispersal of the species may be very fast, regular monitoring of the stands is necessary.

Diseases and pests Two beetle species have been recorded as the most destructive insect pests of babul acacia in India, i.e. *Coelasterna scabrata*, a root-borer beetle, and *Psiloptera fastuosa*, which strips the bark from shoots and branches. Some plant parasites such as *Dendrophthoe falcata* (L.f.) Ettingsh. and *Loranthus* spp. have been reported on babul acacia. Damping-off in seedling stands, root rot, and heartwood rot caused by fungi have been reported.

Harvesting For harvesting bark for tanning, the trees are felled and the bark is separated from the logs by beating them with wooden mallets. The strips obtained are then sun-dried, chopped into small chips and sent to tanneries. The bark is often only a by-product; the trees are primarily felled for timber and fuel.

In harvesting gum, trees are wounded by removing a part of the bark and bruising the surrounding bark. Good-quality gum is reddish in colour, almost completely soluble in water and tasteless. Usually it is traded in ball form.

Yield In India a plantation of about 600 plants per ha produced ca. 12 t of bark after 15 years of planting. In Sudan a babul acacia tree yields about 18 kg of de-seeded pods per year, and the yield of gum is up to 0.9 kg/year but usually much less. The yield of gum decreases as a tree gets older.

Prospects For many years babul acacia has been used for various purposes in India. It has potential in South-East Asia as a source of tannin, gum, timber, fodder and fuel. The species is fast-growing, easy to propagate, and tolerant of dry conditions and poor soils. Babul acacia is one of the species worth considering for reclamation of

wasteland, especially in areas where supply of fuel is critical.

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N. Wulijarni-Soetjipto & R.H.M.J. Lemmens

Albizia lebbekoides (DC.) Benth.

Hook. London J. Bot. 3: 89 (1844).
LEGUMINOSAE
$2n = 26$

Vernacular names Indonesia: tarisi (Sundanese), kedinding, tekik (Javanese). Malaysia: siris, koko. Philippines: haluganit (Tagalog), maganhop-sa-bukid (Bisaya). Cambodia: châmri:ek (Kampot), kântri:ek (Kompong Thom). Laos: kh'aang, h'uung. Thailand: kang (northern), chamari dong, chamari pa (central). Vietnam: câm trăng, sóng răń.

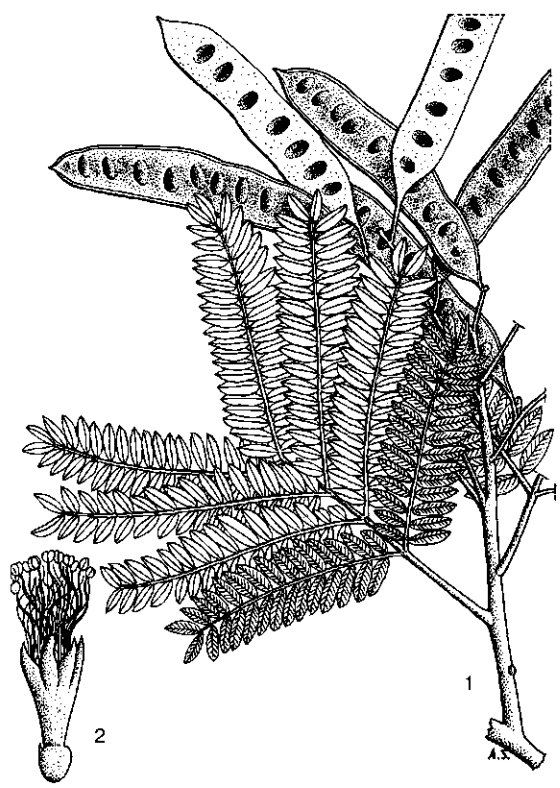
Origin and geographic distribution *A. lebbekoides* is widely distributed in South-East Asia, where the species is found in Thailand, Laos, Cambodia, Vietnam, the Philippines, southern Sulawesi, Java and the Lesser Sunda Islands. It has been collected once in Papua New Guinea.

Uses In Java the bark is occasionally and locally used to tan hides and fishing nets. Moreover it provides a red dye, formerly used for colouring cloth and known as 'soga tekik' in eastern Java. In the Philippines it is frequently used in the manufacture of a fermented drink made from sugar cane, just like the bark of *Macaranga tanarius* (L.) Muell. Arg., which also yields tannin. The timber is suited for indoor construction, and in Cambodia paddy mills are constructed from the wood. The bark is used medicinally just like many other tannin-yielding barks, e.g. as a remedy for colic in Cambodia. *A. lebbekoides* is sometimes planted as a shade tree.

Production and international trade Production of bark and timber is exclusively for local use and production data are not known.

Properties Information on properties is extremely limited. In an analysis of the bark of 10 trees from Java with a trunk diameter between 15 and 40 cm, the tannin content ranged between 12.5% and 17%. A tanning extract was prepared containing 67–74% tannin. It is known that the bark contains a toxic alkaloid.
The wood is dark brown, little attacked by insects, but is reported to season poorly.

Botany A small to medium-sized tree, 8–15(–32) m tall, trunk up to 40(–80) cm in diameter; branches terete, glabrous, with greyish bark. Leaves alternate, minutely stipulate, bipinnately compound with 5–13 cm long rachis provided with glands near base and top; petiole 2.5–6 cm long; pinnae in 3–8 pairs, with glandular axis, 5–15 cm long; leaflets (5–)15–25(–35) pairs per pinna, (narrowly) oblong, 6–20 mm × 2–6 mm, asymmetric and truncate at base, mucronate at apex, sessile. Flowers in axillary up to 18 cm long panicles composed of 10–15-flowered heads; calyx narrowly campanulate, very small; corolla tubu-



Albizia lebbekoides (DC.) Benth. – 1, fruiting branch; 2, flower.

lar, 3.5–5 mm long, 5-lobed; stamens numerous, 7–10 mm, filaments united into a tube; ovary superior, sessile and glabrous. Fruit a strap-shaped dehiscent pod, 7–15(–20) cm × 1.5–2 cm, glabrous, chartaceous and dark brown. Seeds up to 12 per pod, obovate or suborbicular, 4.5–7 mm × 3.5–5 mm × 1–1.5 mm, areolate.
Specimens aberrant with regard to the width of the pod (up to 2.8 cm), and the size of the leaflets (up to 27 mm × 14 mm) occur on the Lesser Sunda Islands, but no varieties are recognized.

Ecology *A. lebbekoides* occurs commonly in deciduous forests in dry localities, less commonly in savanna and evergreen forests. The species prefers open locations, such as forest margins, road-sides, along streams, and in forest clearings. More rarely it is found in shaded habitats. The species grows from sea-level to an altitude of 800 m, both on red volcanic soil and limestone.

Prospects Not much is known about the potential uses of this species. Long ago it was already being recommended as a source of tanning material. According to the results of provisional experiments the bark contains a fair amount of tannin, and extracts with a favourable tannin content can be prepared from it. However, the properties of the tannin and the quality of the leather produced with it are still obscure and warrant research.

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J.M.C. Stevels

Aporosa frutescens Blume

Bijdr.: 514 (1825).
EUPHORBIACEAE
$2n$ = unknown

Synonyms *Aporosa fruticosa* (Blume) Muell. Arg. (1866), *Aporosa similis* Merr. (1914), *Aporosa banahaensis* (Elmer) Merr. (1923). *Aporusa* Blume is considered as an orthographic variant of *Aporosa* Blume.

Vernacular names Indonesia: kayu malam (Bangka), sasah (Sundanese), berih (Javanese). Malaysia: mesekam, rukam utan. Thailand: khruen (Trat).

Origin and geographic distribution *A. frutescens* is distributed from lower Burma and south-eastern Thailand through Malaysia, to the Philippines and Indonesia (Sumatra, Java, Kalimantan, Sulawesi and the Moluccas).

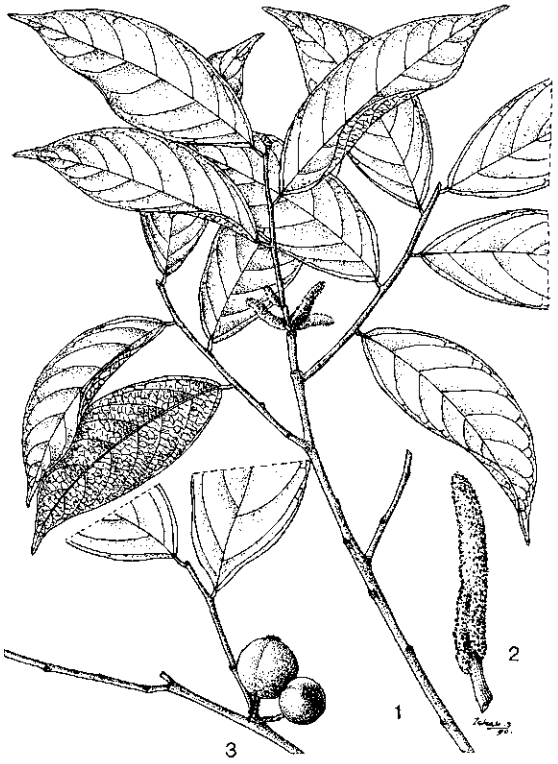
Uses The bark, called 'sasah' was formerly used in the batik industry in Java as a mordant, for fixing the red dye of *Morinda citrifolia* L., similarly to the bark of *Symplocos* Jacq. Sometimes the leaves were used for that purpose. The bark was also occasionally used to prepare a black dye.
The wood is considered second-class and is sometimes used for building houses and making tools.

Properties The bark is probably rich in aluminium, which explains the action as a mordant. No chemical analysis of *A. frutescens* is available, but accumulation of aluminium is reported as common in the genus *Aporosa*. Crushed leaves smell of alum, and the yellowish colour of dried leaves also indicates a high content of aluminium. The wood is hard, yellow-brown, and radially striate.

Description A small, conical, dioecious tree up to 16 m tall and 35 cm in diameter, but usually much smaller; bark thin, finely flaky, pale brownish. Leaves alternate, simple, papery to thin-leathery, oblong to lanceolate, 6–20 cm × 2–6(–9) cm, acuminate, bearing 8–13 small glands along the margins; petiole 6–12 mm long. Flowers unisexual, minute; male flowers in densely flowered axillary, almost sessile, up to 2.5 cm long spikes, each flower with 2(–3) stamens; female flowers in fascicles, each flower with an ovoid-globose ovary. Fruit a subglobose capsule, 1–1.5 cm in diameter, shortly stalked, green to red, usually 3-seeded. Seeds flattened, surrounded by orange-red pulp.

Ecology *A. frutescens* grows in rain forest and occurs up to 1700 m altitude. It often grows in more open places in the forest and on wet ground, and is locally common.

Prospects The supposed high aluminium con-



Aporosa frutescens Blume – 1, branch with male inflorescences; 2, male inflorescence; 3, fruiting branch.

tent makes this plant a suitable mordant in combination with mordant dyes, and a good alternative to chemicals such as metallic salts which cause more injurious waste products of the dye bath.

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C.C.H. Jongkind

Bixa orellana L.

Sp. Pl. 1: 512 (1753).
BIXACEAE
$2n = 14, 16$

Vernacular names Annatto (anatto, arnatto) tree, lipstick tree (En). Rocouyer, annato (Fr). Indonesia: kesumba (general), galuga (Sundanese). Malaysia: jarak belanda, kesumba, kunyit jawa. Philippines: echuete (Tagalog), sotis (Bisaya), achuete (Ilokano). Cambodia: châm'-puu, châm'-puu chrâluëk'. Laos: kh'am, satii, sômz phuu. Thailand: kam tai, kam sêt. Vietnam: diêù nhuôm.

Origin and geographic distribution Annatto tree is native to Central America, and tropical South America. It is widely planted and naturalized in the tropical regions of the world, including South-East Asia.

Uses The main product of trade obtained from annatto tree is an organic dye present in the fruits, commercially called 'annatto'. It is widely used in the food industry for colouring rice, candy, margarine, oils, butter, ice-cream and bakery products. It owes its success in the dairy sector to the comparative instability of equivalent certified synthetic materials in these applications. It is also used in the cosmetic industry in the production of nail gloss, hair oil, lipstick, soap and home improvement products like floor wax, furniture polish, shoe polish, brass lacquer and wood stain. The dye is used to paint the body as a decoration, for instance in Papua New Guinea, and when used in this way it is believed to repel insects. Annatto has also been used for dyeing cotton, silk and wool, giving an orange-red colour which becomes more yellow if the fabric is passed through a weak solution of tartaric acid, a colour popular with oriental and Buddhist monks since early days. For colouring textiles, annatto has largely been replaced by synthetic dyes, because it is not a fast dye. Exposure to light soon causes fading. However, the dye is resistant to soap, alkalies, and acids. Formerly in Indonesia bamboo matting and rattans were dyed with it. Sometimes annatto is used in mixtures with other vegetable dyes such as curcumin (from *Curcuma longa* L.).

The fibres extracted from the bark are used for cordage. The gum extracted from the bark is similar to gum arabic. The wood from the aged tree makes good firewood. Annatto is often planted as an ornamental in home gardens and public parks, valued for its beautiful white and pink flowers and red fruits. The seeds and leaves have been used in

traditional medicine. The dye from the seeds is reported to purge gently, the leaves are said to be febrifugal.

Production and international trade The main commercial producers are countries in South America (especially Peru), Central America, the Caribbean, and also India and Sri Lanka. In South-East Asia annatto is produced on a rather small scale in Malaysia and the Philippines. Production statistics are not usually available, and besides they would not provide a reliable guide to international trade since many of the producing countries utilize significant quantities domestically. However, the available statistics suggest that the world market for internationally traded annatto during the 1970s was 2000–3000 t/year of seed. In recent years, the volume of trade has been slowly increasing as a result of increased consumption of the products in which annatto is used, and may well exceed 3000 t/year by now.

The main market for annatto is the United States, with 1500–2000 t/year, followed by western Europe, the Soviet Union, Puerto Rico and Japan. Some 70% of the product is used in the importing countries in cheese-making.

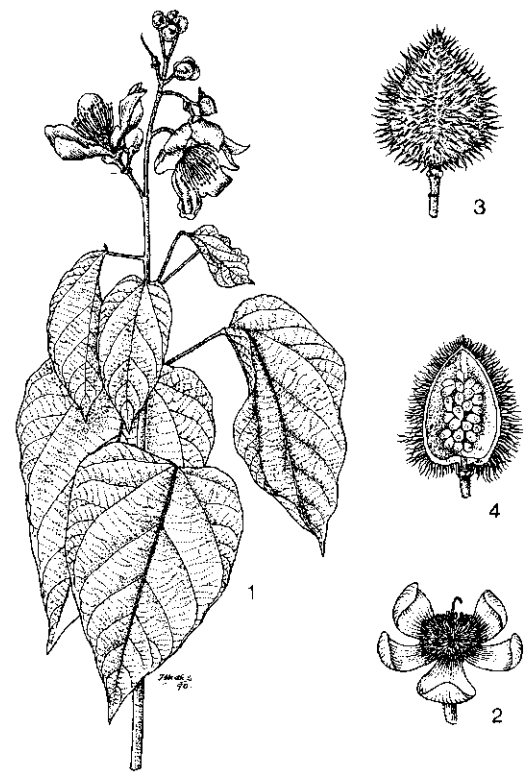
Properties The principal colouring matter present in the seeds is bixin, $C_{25}H_{30}O_4$, a carotenoid carboxylic acid, and a harmless organic dye. The ethyl ester of bixin, $C_{27}H_{34}O_4$, is used as a suspension in vegetable oil for colouring foods. It imparts a golden yellow colour. The dye is sensitive to light and contains sulphur dioxide, which limits its use in food products and beverages. It has no provitamin A activity, and is therefore not much used for colouring margarine. The remainder of the pigment mass surrounding the seed (20–30%) consists mainly of an uncharacterized yellow pigment with little tinctorial strength, and small quantities of related compounds including norbixin.

Annatto is prepared as a solution in vegetable oil, as an aqueous solution of norbixin, as bixin crystals, and as a spray-dried water-soluble powder.

The bixin content of the seeds is 1.6–5.3% on an oven-dry basis in Papua New Guinea, but elsewhere contents up to 12% have been reported. The proportion of bixin present in annatto varies considerably, and depends on the nature of the product. Norbixin concentrations of commercially available spray-dried annatto powder ranges from 7.5% to 15%; a solution in vegetable oil usually contains 0.2–5% bixin. The seeds contain a small amount of fatty oil (5%), and about 13% of protein. The seed-coat contains a wax-like substance which acts as a vermifuge. A very poisonous substance has been found in the embryo. The fruit-wall contains tannin. Ellagic acid and cyanidin have been isolated from the leaves.

The wood is soft, light (air-dry weight about 400 kg/m^3), yellowish to light brown, porous, and not durable.

Description An evergreen shrub or small tree, 2–6(–8) m tall, trunk up to 10 cm in diameter. Bark light to dark brown, tough and smooth, sometimes fissured, lenticellate; inner bark with orange sap. Branches greenish and densely rusty-scaly when young, later becoming dark brown, ringed at nodes. Leaves spirally arranged, simple, herbaceous, stipulate, ovate, 7.5–24 cm × 4–16 cm, shallowly cordate to truncate at base, long-acuminate at apex, dark green above, greyish or brownish-green beneath, scaly when young but glabrescent; petiole terete, thickened at both ends, 4.5–12 cm long. Flowers in terminal, 8–50-flowered panicles, fragrant, 4–6 cm across; pedicel scaly, thickened at the apex bearing 5–6 large glands; sepals 4–5, free, obovate, 10–12 cm long, caducous; petals (4–)5–7, obovate, 2–3 cm × 1–2 cm, pinkish, whi-



Bixa orellana L. – 1, flowering branch; 2, flower; 3, fruit; 4, halved fruit showing seeds.

tish or purplish tinged; stamens numerous, anthers violet; ovary superior, unilocular, style 12–15 mm long, thickened upwards. Fruit a spherical, or broadly to elongated ovoid capsule, 2–4 cm × 2–3.5 cm, flattened, 2-valved, more or less densely clothed with long bristles, green, greenish-brown or red when mature, many-seeded. Seeds obovoid and angular, 4–5 mm long, with bright orange-red fleshy seed-coat. Germination epigeal, seedling with thin, ovate, nervate cotyledons, a fairly long hypocotyl, and alternate, cordate first leaves.

Growth and development Mature seeds taken directly from fresh fruits germinate readily in 7–10 days under moist conditions. The harvested, cleaned, sun-dried seeds retain viability for over one year, but fall to 12% in 3 years. Pollination is by insects; honeybees are observed in plenty around the plant. Fruits mature 5–6 months after pollination. Seed-grown plants take longer to flower and do so sparingly; they are very tall and exhibit much variation. Plants propagated by cuttings, which allows selection of high-yielding, rapidly growing cultivars, flower early and profusely and bear fruit within two years. These plants are also more uniform in growth and external characteristics.

Other botanical information The variation in shape and colour of the fruits of different forms of annatto tree is considerable. The shape varies from spherical to ovoid, broad-topped and shortly acuminate to elongate-ovoid and long-acuminate. The colour varies from white to green and red. The form with ovoid, broad-topped and shortly acuminate fruits is reported to have a lower bixin content than the forms with spherical or elongated fruits, and is consequently considered inferior. Forms with white flowers occur, but pink-flowered plants are much more common. The species is not subdivided into cultivars.

Ecology Annatto tree requires a frost-free, warm, humid climate and a sunny location. It can grow in a wide variety of tropical to subtropical climates and needs little care, though in places where rainfall is not distributed equally throughout the year, irrigation may be necessary. It grows on almost all types of soils, with a preference for neutral and slightly alkaline soils. It grows into a larger tree when planted in deeper and more fertile soil, rich in organic matter. It does well on limestone, where the topsoil is only a few centimetres thick and overlies a coral base. In Indonesia it is planted up to 2000 m altitude.

Propagation and planting Annatto tree can be propagated from seeds or stem cuttings. Seeds are sown directly in the field, 2–5 seeds per hole in well prepared beds, usually in the beginning of the rainy season. After germination only one seedling per hole is retained. The seeds may be raised in planting trays, and transferred to 1 kg bags containing soil mixture and raised in the nursery for 3–4 months before they are transplanted. Hardwood cuttings of 0.75 cm or more in diameter readily root when any of the commercial root hormones for hardwood cuttings is used. Roots are produced in abundance in 7–9 weeks. Rooted cuttings are first transferred into pots or bags and kept protected in the nursery and can be transplanted to the field after 3 months. For commercial production, annatto tree should be planted in rows 3–4 m apart, with plants spread 2–3 m within the row, depending on soil and climate.

Husbandry Weeding is necessary only in the initial stages of plant growth. Once the canopy is formed periodic slashing the weed cover, light pruning to remove the dead, dried and weak stems and to balance the shape of the plant are required to increase economic yield. Lower branches are either tied or pruned to ease farming operations. Apical pruning is done to encourage branching and to reduce plant height for ease of harvest. Suckers arising from the roots need to be removed. Earthing up the plants after application of fertilizer will help rejuvenation as a ratoon crop. No artificial pollination is required, but if bees are kept, seed yield may increase.

Annatto tree grows easily and does not exhibit any nutritional deficiencies. Artificial fertilizers are not usually applied. The trash is usually collected and burnt outside the field and the ash is added to the field along with poultry or farmyard manure. However, application of NPK fertilizer enriched with boron and molybdenum encourages faster early growth and higher yield.

Diseases and pests Annatto tree is sometimes infested by powdery mildew caused by *Oidium bixae* and *Oidium heveae*; the latter fungus causes powdery mildew on rubber, too. A foliar disease of minor importance, caused by a fungus (*Phyllosticta bixina*) has been recorded for Guam.

Insect pests are of minor importance. The pests include spiralling whitefly (*Aleurodicus dispersus*), pink wax scale (*Ceroplastes rubens*), transparent scale or coconut scale (*Aspidiotus destructor*), Seychelles scale (*Icerya schellarum*), and red banded thrips (*Selenothrips rubrocinctus*). In Indonesia, annatto tree is reported liable to be attacked by tropical mirid bugs of the genus *Helopeltis*.

Harvesting The capsules should be harvested after they start to turn brown and before they split open. The harvested pods are dried in the shade and threshed by gently beating with a stick. The seeds can then be collected, dried again, cleaned to remove dust and other plant parts, and stored. Fruits harvested when not too ripe, or when allowed to stay on the plant long after maturity reduce the quality of the product.

Yield No reliable statistics are available. Seed yield is reported to be as high as 3–5 t/ha, but in Sri Lanka yields of only 625 kg/ha have been reported. Usually seed yield is 800–1200 kg/ha. From 1 kg of seed 20–50 g of dye can be obtained.

Handling after harvest Seeds that have been properly harvested, dried and threshed retain their quality for a long time provided they are cleaned and dried adequately to about 4–6% moisture and stored in a cool and dry place.

The dye is extracted from seeds by soaking them in water and squeezing to dissolve the aril which contains the dye. It is only partially soluble in water and produces a turbid solution. The solution of bixin is concentrated by heating and subsequently cooled to form red crystals. The solution may also be allowed to ferment for about a week, and the dye that has settled at the bottom of the vessel is then separated and dried into cakes. A third method of extracting the dye is to boil the seeds with sodium carbonate solution, filter, and acidify the filtrate, after which the dye is coagulated by boiling with salt, and is then filter-pressed, washed and dried.

Annatto seed is usually exported in sacks containing 50–80 kg. Processed annatto is packed in polythene bags if powder or crystals, and in high density cans or drums if liquid.

For dyeing cotton, annatto is dissolved in boiling water and a solution of carbonate of soda. The cloth is left in this solution for about 20 minutes, then squeezed dry and washed in acidulated water or alum solution and dried in the shade. For dyeing silk, a solution is made of equal proportions (by volume) of annatto and sodium carbonate in water; soap is usually added and the dyeing is continued at 50°C for about an hour (longer duration gives a darker colour). Wool is dyed at about 90°C in the water solution of annatto, without addition of other compounds. For 100 g of wool 100 g of annatto is needed.

Prospects Many natural dyes have been superseded by chemical dyes. However, there is still a demand for annatto in the food and cosmetic industry because of the reported carcinogenic activity of many synthetic dyes. Although ß-carotene with its vitamin A activity competes with annatto to some extent in household margarine, the lower price and the lesser complexity associated with the use favour annatto. The major use of annatto is in the cheese-making industry, and the prospects are dependent on the growth of this industry. However, the existing exporters of annatto which are located outside South-East Asia appear to be capable of servicing any conceivable level of demand for the foreseeable future, and opportunities for new suppliers seem to be limited. The scope for rapid improvement in this crop is still considerable.

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R. Rajendran

Bruguiera gymnorhiza (L.) Savigny

Lamk, Encycl. Méth. Bot. 4: 696 (1798).

RHIZOPHORACEAE

$2n = 36 (+ 1B)$

Synonyms *Bruguiera rheedii* Blume (1827), *Bruguiera cylindrica* (non Blume) Hance (1879), *Bruguiera conjugata* Merr. (1914).

Vernacular names Black mangrove, Burma mangrove (En). Indonesia: tanjang (Java), putut (Sumatra). Malaysia: tumu, bakau besar (Peninsular), putut (Sarawak). Papua New Guinea: mangoro (Pidgin). Philippines: pototan (Tagalog, Bisaya), bakauan (Tagalog), siap (Ilokano). Singapore: tumu merah. Cambodia: prâsâk' nhii, prâsâk' tôôch. Thailand: pasak, pang kâ hûa sum. Vietnam: vẹt dzù, vẹt den, du'óc' hông.

Origin and geographic distribution Black mangrove is distributed from tropical southern

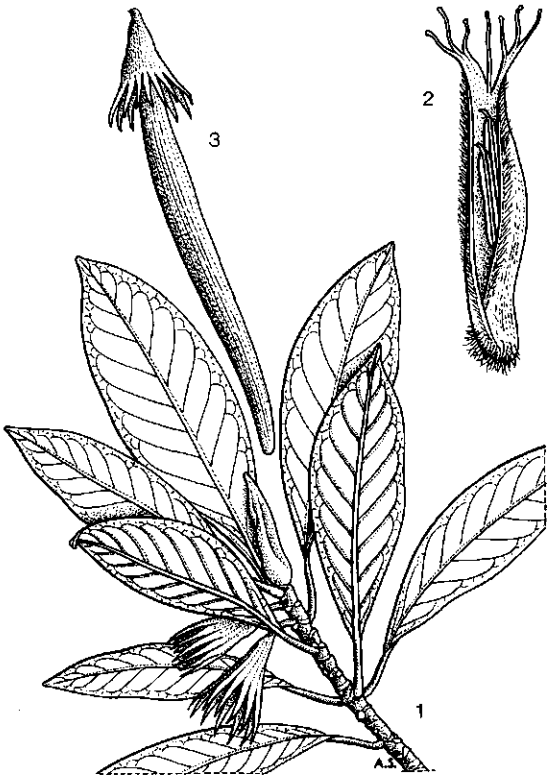
and East Africa and Madagascar, through South and South-East Asia (throughout Malesia), to north-eastern Australia, Micronesia, Polynesia and the Ryukyu Islands. The South and South-East Asia area probably represents the centre of origin.

Uses The bark is suitable for tanning leather and fishing nets as it contains up to 35% tanning substance in air-dry bark. A phlobaphene colouring matter from the bark is sometimes used as a dye in Malaysia and Vietnam for black or dark-brown colour, but this use is considered as minor.
Planks up to 7 m long can be obtained from the bole of this species, but the wood will withstand attacks by termites and teredos only up to 8 years. The timber is used for firewood and charcoal, less so for piles, house posts, rafters, fishing stakes, and telegraph poles. Poles have a life of about 10 years. The wood can be used for the paper industry, but the paper is of poor quality.
The bark is used also as condiment and adhesive, and as an astringent medicine against diarrhoea and sometimes malaria. The fruits are sometimes used as an astringent in betel quid when nothing better is available and they are suitable as an eye medicine, too. The leaves and peeled hypocotyls are eaten in times of scarcity in the Moluccas after having been soaked in water and boiled. In Jakarta, formerly the starchy central part of the hypocotyl was treated with sugar for food.

Production and international trade The main countries producing tannin from black mangrove are East African countries, Indonesia (Kalimantan), Papua New Guinea and the Philippines. At present Borneo accounts for an important proportion of world supplies. However, no figures are available because bark and tannin from *Bruguiera gymnorhiza* are sold together with bark and tannin from other mangrove trees such as *Rhizophora* and *Ceriops* species, collectively called 'mangrove cutch'. In Malaysia the production of tanbark is only a secondary consideration; charcoal and fuel are more important.

Properties As in other mangrove species, the percentage of tannin in the bark varies largely from 20% to 43% on dry weight basis, depending on age, season, and habitat. The bark of the trunk of large, aged trees is richest in tannin. The tannin belongs to the proanthocyanidins. Ellagic acid and di- and tri-o-methylellagic acid have been demonstrated in the bark. The tannin imparts a reddish colour to leather, and is often mixed with other tannins in the tanning industry. It is suitable for tanning heavy hides into sole leather.
The bark contains about 11% mucilaginous sap, which is mainly composed of arabinose, rhamnose and galactose, and also 0.05% of a mixture (5:1) of bruguierol and isobruguierol.
The wood is red-brown, heavy (about 980 kg/m^3), fine-grained, and hard, but it is a refractory timber. Sapwood and heartwood are distinct. The vessels are moderately small, rays up to 10 cells wide, often more than 3 mm high, almost homogeneous.

Description A moderate-sized, evergreen tree up to 36 m tall; bole 40–65 cm in diameter, buttressed and with kneed pneumatophores. Bark grey to almost black, roughly fissured, usually with large corky lenticels on buttresses and base of stem. Branching mostly sympodial. Leaves decussately opposite, simple and entire, coriaceous, elliptic to oblong, 8.5–22 cm × 5–7(–9) cm; base cuneate, rarely obtuse, apex acute; nerves 9–10 pairs; petiole 2–4.5 cm long, often reddish; stipules about 4 cm long, often reddish. Flowers solitary, 3–3.5 cm long, generally nodding, with 1–2.5 cm long pedicels, which are bright red on the outside curve; calyx red to pink-red, lobes (10–)12–14(–16), tube usually ribbed at the upper



Bruguiera gymnorhiza (L.) Savigny – 1, flowering branch; 2, petal with enclosed stamen-pair; 3, fruit and hypocotyl, with persistent calyx.

part; petals 13–15 mm long, 2-lobed with acute lobes, each with 3–4 long bristles, outer margins fringed with white silky hairs especially at the base; stamens 8–11 mm long, with linear anthers, embraced by the petals, and twice the number of the petals; ovary inferior, style about 15 mm long with filiform stigma. Fruit a campanulate berry enclosed by the calyx tube, 2–2.5 cm long, 1-celled and 1(–2)-seeded. Hypocotyl cigar-shaped, slightly angular, with a blunt narrowed apex, perforating the apex of the fruit and falling with it, 15–25 cm × 1.5–2 cm.

This species belongs to Aubréville's model of architecture.

Growth and development Like red mangrove (*Rhizophora mucronata* Poiret), black mangrove is viviparous, i.e. the seeds germinate while still attached to the tree. After the seedlings are released they fall vertically into the mud and immediately become established. It is one of the largest trees of the mangrove, and probably the longest living. In Cambodia and Vietnam it flowers abundantly in the rainy season from May to November.

Other botanical information Other species of the genus *Bruguiera* Lamk, which has 6 species altogether, are used in the same way as *B. gymnorhiza*. Three species are also common in mangroves in South-East Asia.

B. cylindrica (L.) Blume is extremely slow-growing. The tannin content of the thin bark is comparatively low.

The bark of *B. sexangula* (Lour.) Poiret is reported to contain somewhat less tannin than that of *B. gymnorhiza*.

B. parviflora (Roxb.) Wight & Arn. ex Griffith is not of much use for timber because of its small dimensions, and its bark is deficient in tannin.

Ecology Black mangrove is characteristic of the landward side of mangroves, usually growing on somewhat dry, well-aerated soil. It often ascends tidal parts of rivers. Sometimes it forms pure stands, but often it is associated with *Rhizophora* species, especially *R. apiculata* Blume, but also *Ceriops tagal* (Perr.) C.B. Robinson and *Xylocarpus moluccensis* (Lamk) M. Roemer. It marks the climax vegetation of littoral forests (mangroves), before the transition to land forest. It is a shade tolerant species, and able to establish itself even in pure stands of *Rhizophora* L. The regeneration after felling is usually scant or even absent.

Black mangrove has proved to be able to grow, flower, fruit and even regenerate in artificial fresh water swamps, as in the botanical garden in Bogor (Indonesia). In fact, it is sensitive to high salt concentrations, dying soon at concentrations above 3% NaCl.

Propagation and planting Seedlings can be collected either from the trees or from the ground. They are equally viable. They can be planted in a nursery, and transferred to the field 3–4 months later, spacing 3 m × 1 m. This is how the tree is propagated in Cilacap (Indonesia). Seedlings develop best where the tidal range is only about 0.35 m and the salinity is 1–2.5%. Seedlings can remain alive, floating in the water, for 5–6 months, which possibly explains the large area of distribution.

Husbandry The natural and artificial regeneration has never been extensively investigated. Some authors have proposed a 10-year rotation but in Malaysia a 20-year rotation has long been practised. The liana *Derris trifoliata* Lour. is a common weed associated with this species. Usually this weed is controlled manually, because herbicides may affect the fauna living around the trees.

Diseases and pests Seedlings may be attacked by mangrove crabs like *Scylla serrata*, *Sesarma meinerti*, and *S. smithii*. In Cilacap (Indonesia), plantations have suffered from caterpillars of the genus *Acanthopsyche*, but these pests have been controlled successfully by using Dimercon 100 at concentrations of 0.1%.

Harvesting There is no particular season for harvesting. After the trees have been felled, the bark is separated from the wood and air-dried.

Handling after harvest Chopped bark may be used directly in the tannery. The tannin can be extracted by boiling the bark in large vessels and evaporating down to a solid.

Prospects Experiments in Indonesia have shown that black mangrove can easily be planted and grown. This species might be successfully used for reafforestation in areas where mangroves have been destroyed.

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Rudjiman

Butea monosperma (Lamk) Taubert

Engler & Prantl, Nat. Pflanzenfam. 3(3): 366 (1894).

LEGUMINOSAE

$2n = 18 (+ B)$, but also recorded as 22 and 32

Synonyms *Butea frondosa* Roxb. ex Willd. (1802).

Vernacular names Flame-of-the-forest (En). Indonesia: palasa (general), plasa (Javanese, Sundanese). Burma: pouk-pen. Cambodia: chaa. Laos: chaan. Thailand: thong kwaao, tong thammachaat.

Origin and geographic distribution Flame-of-the-forest is found in the southern Himalayas of Nepal, throughout India, Sri Lanka, extending to Burma, Thailand, Indo-China and Java. It has been spread eastward as far as China and Papua New Guinea. Locally, it has been successfully established in tropical Africa, and in subtropical regions.

Uses Flame-of-the-forest can be considered as a multipurpose tree. It has dyeing as well as tanning properties. A bright yellow to deep orange-red dye can be prepared from the flowers, especially used for dyeing silk, sometimes cotton. This dye is used by Hindus to mark the forehead. A red exudate is obtained from the bark, hardening into a gum, known as 'Butea gum' or 'Bengal kino'. It can be used as a dye and as a tannin, and has medicinal properties as a powerful astringent and is applied in cases of diarrhoea. The seeds show anthelmintic activity, and also bactericidal and fungicidal effect. The flowers are useful in the treatment of liver disorders.

The coarse, fibrous material obtained from the inner bark is used for rough cordage, for caulking the seams of boats and for making paper.

In India the tree is an important host for the lac insect (*Laccifer lacca*), producing shellac. Of all lac trees, it yields the most stick lac per ha. The wood is not considered of great value, but it is sometimes used for utensils and for constructions, more commonly for fuel. It is used by Hindus in religious ceremonies.

Flame-of-the-forest is also planted as an ornamental because it flowers with a profusion of bright orange, rarely sulphureous flowers.

It is a valuable species for reclaiming saline soils.

Properties The orange dyeing substance from the flowers is butein. By extracting the flowers with boiling water and hydrolizing the extracted glycoside butrin, a yield of 2% butin ($C_{15}H_{12}O_5$) is obtained. The colourless butin can easily be transformed into butein by boiling with potassium hydroxide. Butein is very fugitive. Butrin and isobutrin are the antihepatotoxic principles in the flowers.

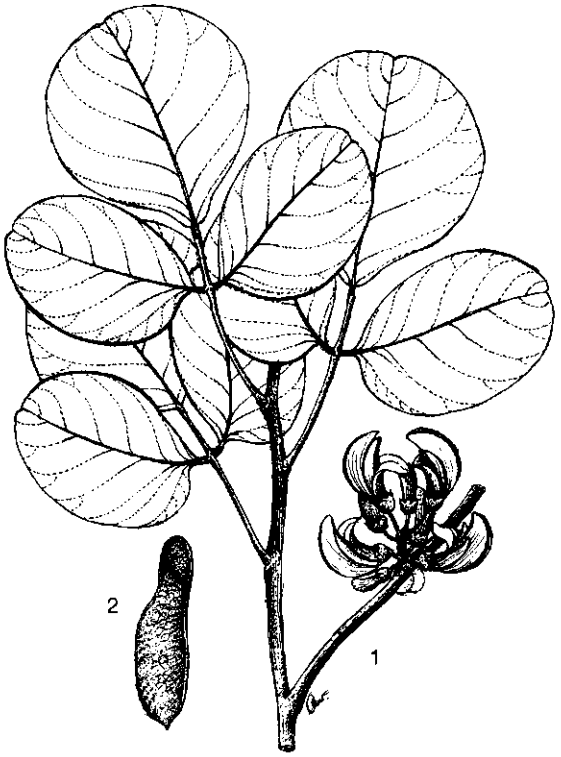
Butea gum is ruby-red. It contains about 50% tannins, and pyrocatechin, arabine and ulnine.

The seeds contain butin and ca. 20% of a yellow oil. Anticonceptive activity has been demonstrated in rats fed with seeds. Seed-coat extracts have bactericidal and fungicidal effect.

A potential anti-asthmatic agent has recently been reported from the bark.

The soft and not durable wood is light, ca. 570 kg/m^3 air dry, white or yellowish-brown when fresh, but often turning greyish because of susceptibility to sapstain.

Description A small to medium-sized leaf-shedding tree, 5–12(–20) m tall; trunk usually crooked and tortuous, with rough greyish-brown, fibrous bark, showing a reddish exudate; branchlets densely pubescent. Leaves trifoliolate; petiole 7.5–20 cm long with small stipules; leaflets more or less leathery, lateral ones obliquely ovate, terminal one rhomboid-obovate, 12–27 cm × 10–26 cm, obtuse, rounded or emarginate at apex, rounded to cuneate at base, with 7–8 pairs of lateral veins, sti-



Butea monosperma (Lamk) Taubert – 1, flowering branch; 2, fruit.

pellate. Flowers in 5–40 cm long racemes near the top of usually leafless branchlets; calyx with campanulate tube and 4 short lobes; corolla 5–7 cm long, standard, wings and keel recurved, all about of the same length, bright orange-red, more rarely yellow, very densely pubescent; stamens enclosed within the keel, 9 connate and 1 free; ovary superior, with curved style. Fruit an indehiscent pod, (9–)17–24 cm × (3–)4–6 cm, stalked, covered with short brown hairs, pale yellowish-brown or grey when ripe, in the lower part flat, with a single seed near the apex. Seed ellipsoid, flattened, about 3 cm long.

Growth and development While germinating the seed remains in the pod which opens at the tip and allows the young shoot and root to emerge. The cotyledons remain attached to the seedling for a considerable time. The tree is slow growing. Leaves are shed during dry weather. At the beginning of the rainy season the leafless tree flowers abundantly and it is very conspicuous in the forest then. At the end of the flowering period, new leaves develop which are initially pale bronze-tinged green. Birds are the chief pollinators.

Other botanical information From a few places in India a yellow-flowered form has been reported which has been named var. *lutea* (Witt) Maheshwari.

Ecology Naturally, flame-of-the-forest grows commonly in open grasslands and scattered in mixed forest. In the Himalayas it is found up to 1200 m altitude, in Java it is confined to relatively dry regions in the east, up to 1500 m altitude. Plantations can be established on irrigated as well as rainfed lands. This tree survives in saline and badly drained soils on which few trees will grow. It is not only drought-resistant but also frost-hardy.

Propagation and planting Trees are propagated by seeds. Before the beginning of the rainy season, complete pods are sown in rows 3–6 m apart. Seedlings thrive best on a rich loamy soil with pH 6–7 under high temperature and relative humidity. Root suckers are freely produced and enable vegetative propagation and easy tree recovery after damage.

Handling after harvest Flowers collected for dyeing purposes are dried. Silk can be dyed yellow with a decoction or infusion from dried flowers. The colour is not fast except when a mordant like alum or lime is used, which also deepens the colour to orange. For dyeing cotton and wool the glycoside in the flowers must first be hydrolyzed, for instance by boiling with a solution of hydrochloric acid.

Prospects As a multipurpose tree, flame-of-the-forest deserves more attention. It combines interesting dyeing and tanning properties with medicinal and ornamental qualities. The tree is especially promising as an ornamental, but it is difficult to propagate and to grow because it does not produce many seeds and is slow-growing. Research on faster ways of vegetative propagation should have priority.

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K. Chayamarit

Caesalpinia L.

Sp. Pl. 1: 380 (1753).

LEGUMINOSAE

x = 11, 12; $2n$ = 22: *C. decapetala*; $2n$ = 24: *C. coriaria*

Major species and synonyms

- *Caesalpinia coriaria* (Jacq.) Willd., Sp. Pl. 4th ed., Vol. 2(1): 532 (1799).
- *Caesalpinia decapetala* (Roth) Alston, Trimen, Handb. Fl. Ceylon 6 (suppl.): 89 (1931), synonyms: *Caesalpinia sepiaria* Roxb. (1832), *Caesalpinia japonica* Siebold & Zucc. (1845).
- *Caesalpinia digyna* Rottler, Ges. Naturf. Freunde Berlin Neue Schrift. 4: 200, tab. 3 (1803), synonym: *Caesalpinia oleosperma* Roxb. (1832).
- *Caesalpinia sappan* L., see separate treatment.

Vernacular names

- *C. coriaria*: divi-divi (general). Thailand: tan yong.
- *C. decapetala*: Mysore thorn (En). Indonesia: areuy matahiyang gunung, secang lembut (Sundanese). Thailand: kamchai. Vietnam: vu'ôt hùm.
- *C. digyna*: teri-pod plant (En). Burma: tari. Cambodia: khvaw bânla. Laos: kachaay. Thailand: kamchaai, khee raet. Vietnam: móc mèo xanh (Dông Nai).

Origin and geographic distribution The large genus *Caesalpinia* (about 200 species) is pantropical, the greater part of the species occurring in

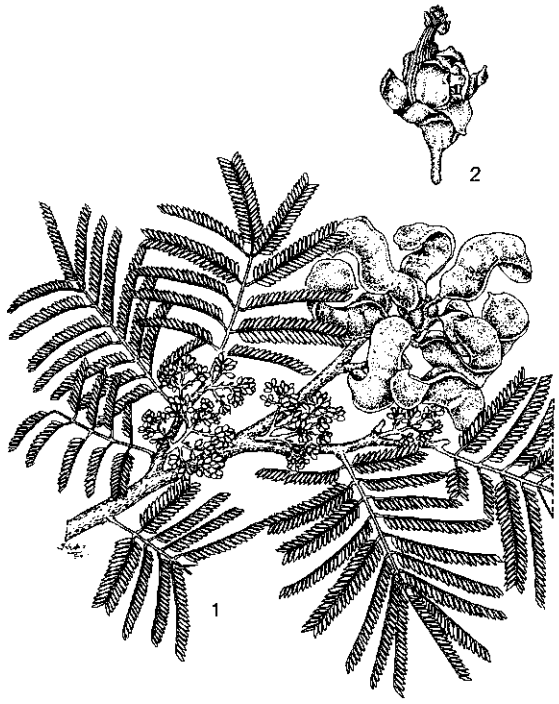
South and Central America, and about 30 species in Asia, indigenous, naturalized, or cultivated.
C. coriaria is native to tropical America and the West Indies. It has been introduced and is cultivated in Pakistan, India, Sri Lanka, Burma, Thailand, and rarely in Malaysia and Indonesia (Java); it is also cultivated in Australia and in tropical East Africa.
C. decapetala is found naturally in tropical to temperate regions in Asia, from the Himalayas south to Sri Lanka and Malesia, and north and east to China, Korea and Japan.
C. digyna has a distribution comparable with the preceding species, but is not found further north than Hainan in China.

Uses The pods of *C. coriaria* and *C. digyna* are very rich in tannin, and are used in the tanning industry. For tanning leather, the tan-stuff from the pods is generally used as a blend, mixed with other tanning materials. Divi-divi is often used in the rapid drum tannage of light leathers and in leather dressing. The pods can also serve to prepare a blackish or blueish dye and a black ink, and are sometimes employed as a mordanting agent. The wood is reported to contain a red dye. The bark of *C. decapetala* has tanning properties.
All species are reported to be used medicinally: pods of *C. coriaria* as antiperiodic and for dressing sores, the astringent root of *C. digyna* to treat tuberculosis and diabetes, and the seeds of *C. decapetala* as anthelmintic, antipyretic, analgesic and to treat dysentery and malaria.
The seeds of *C. digyna* can serve as cattle feed, and moreover contain an oil which can be used in lamps. They are sometimes eaten after being roasted. *C. decapetala* is sometimes cultivated as a hedge plant, *C. coriaria* as a shade plant. The wood is rarely used.

Production and international trade Divi-divi has been used in Central America for many centuries as a tanning material. Commercial supplies of divi-divi pods were obtained almost entirely from tropical America with Venezuela and Colombia as the major suppliers. Recent figures are not available, but in the 1950s exports of dry fruits varied from 3000–10000 t/year in Venezuela and from 1000–7500 t/year in Colombia. India was much less important as a producing country, exporting 150–400 t/year in the 1910s and 1920s. The largest consumers were the United States and Germany. The use of divi-divi as a tanning material has strongly declined since 1950 in favour of other vegetable materials and synthetic tan-stuffs. *C. decapetala* and *C. digyna* were always of local importance only.

Properties The pods of *C. coriaria* and *C. digyna* contain very high percentages of tannin, 40–45% and 40–60% (de-seeded pods), respectively. The constitution of tannin from divi-divi pods and teri pods differs. Divi-divi contains gallotannin and the ellagitannin corilagin, whereas teri pods lack ellagitannin and are reported to contain mainly monodigalloyl glucose. The tanning properties are very similar. Divi-divi and teri extracts are liable to deteriorate rapidly, especially in hot climates. They produce a light-coloured leather, which is, however, easily affected by atmospheric conditions, being soft and spongy under damp conditions and lacking pliability under dry conditions. Fermentation takes place readily because of the large amount of sugars present; it often results in reddish stains in the leather. Because of these disadvantages when used alone, divi-divi is usually used in mixtures of tan-stuffs. The extracts closely resemble myrobalans from *Terminalia* spp. The character of the tannin in the bark of *C. decapetala* is unknown.
When tested in ponds, the tannin from divi-divi pods showed algicidal activity.
The seeds of *C. digyna* contain ca. 15% protein, 40% starch and 25% fat and are suitable for use as cattle feed in admixtures with other pulses. Seeds of *C. coriaria* contain 5–9% oil.
In *C. coriaria* aucubin compounds have been demonstrated; leucoanthocyanins have been demonstrated in *C. decapetala*.
The wood of *C. coriaria* is very hard, reddish-brown and provides a red dye.

Description Climbers, shrubs or small to medium-sized trees, usually prickly. Leaves alternate, bipinnate, the rachis often prickly; leaflets opposite or alternate, sessile or petiolate. Flowers in axillary or terminal panicles or racemes, usually bisexual, 5-merous; sepals free, imbricate, usually unequal, the lowest one hood-shaped; petals free, unequal, the upper one different in shape and size; stamens 10, free, equal or alternately unequal, filaments hairy at base; pistil sessile or shortly stalked; ovary pubescent or glabrous, 1–10-ovulate; style slender; stigma funnel-shaped or bilobed. Pods dehiscent or indehiscent, thin or thick, winged or wingless, sometimes spiny or twisted or furrowed. Seeds orbicular, ellipsoid or reniform.
C. coriaria is an unarmed, crooked and spreading tree, usually up to 10 m tall, but sometimes much larger. Pinnae in 3–9 pairs, leaflets in 12–28 pairs, oblong-linear, 4–9 mm × 1–2.5 mm, sessile, with



Caesalpinia coriaria (Jacq.) Willd. – 1, flowering and fruiting branch; 2, flower.

black dots beneath. Flowers in short panicles, small, with petals 3–4 mm long, pale yellow. Pods flexuous and twisted, (2–)5–8 cm × 1–3 cm, pale to blackish-brown, 1–10 seeded.

C. decapetala is a prickly, climbing or scandent shrub, up to 10 m tall. Pinnae in 4–15 pairs, leaflets in 5–12 pairs, oval-oblong, 8–25 mm × 3–10 mm, shortly petiolate. Flowers in long racemes, large, with petals 12–15 mm long, bright yellow. Pods oblong-elliptic, 6–10 cm × 2.5–3 cm, keeled or winged, and beaked, 4–8-seeded.

C. digyna is a prickly climber or scandent shrub, 2–5 m tall. Pinnae in 8–13 pairs, leaflets in 6–12 pairs, oblong-elliptic, 5–13 mm × 2.5–5 mm, subsessile. Flowers in long racemes, fairly large, with petals 8–10 mm long, yellow. Pods oblong-elliptic, 3–6 cm × 1.5–2 cm, constricted between the seeds, (1–)2–3(–4)-seeded.

Growth and development Divi-divi trees are relatively slow growing and generally commence flowering 5–7 years after sowing. Full crops of pods are produced after about 20 years. Because of their prickly and climbing characteristics, the other species are not cultivated except in hedges.

Other botanical information Three other *Caesalpinia* species from South America, not cultivated in Asia, are used for tanning or dyeing. The pods of *C. spinosa* (Molina) Kuntze (tara), and *C. brevifolia* (Clos) Baillon (algarobilla) are used for tanning, the wood of *C. echinata* Lamk (brazilwood) for dyeing paper, calico and other materials.

Ecology Divi-divi tolerates a wide range of soil types and climates. It grows on rich clay soils and poor sandy soils with pH 4.5–8.7, and thrives in dry (warm) temperate climates to wet tropical climates, tolerating an annual precipitation of 600 mm up to over 4000 mm, and a mean annual temperature of 14.7–27.5 °C. In natural conditions in Central and South America, it is found in semi-arid, open country. Under very moist tropical conditions trees are reported to yield less than under drier conditions. At higher altitudes they do not yield well either. *C. decapetala* and *C. digyna* are found in thickets, light forests and forest borders, in Indo-China up to 1200 m. In Indonesia *C. decapetala* occurs in mountainous areas at altitudes of 1200–1700 m, *C. digyna* in drier areas, up to 200 m.

Propagation and planting Plants are propagated by seed. The seeds of teri-pod plant are very hard and must be scarified before sowing. In India, the seedlings of divi-divi are kept in the nursery for 9–15 months, and then transplanted into the field, usually at the beginning of the rainy season, at distances of 7–9 m. During the first two years, watering is necessary in the dry season. Mature trees require no care, and forage crops can be planted between the trees.

Diseases and pests Some fungi are known to attack divi-divi: *Fomes lucidus*, *Micropeltis domingensis* and *Zignoella caesalpiniae*. Stored seeds of *C. decapetala* are reported to be attacked by beetles.

Harvesting The pods of divi-divi are collected before or after they drop from the tree. Trees yield about 45–135 kg pods per year.

The prickles on the branches and twigs of teri-pod plant are a deterrent to the collection of the pods. Because of its prickly nature this plant has never been extensively cultivated, and pods are collected from wild plants.

Handling after harvest Because divi-divi pods are curved, much space is needed for packing, which makes transport expensive. The pods are usually packed in fine mesh bags. The tannins can easily be extracted. They are mainly present in the white powdery tissue just below the epidermis of the pod, and this tissue is easily collected when the dry pods are ruptured. The powder has the drawback of being slightly hygroscopic and should be

packed in sealed containers. It is susceptible to rapid deterioration. Fermentation can be minimized by the use of antiseptics.
In teri pods the seeds constitute a considerable proportion of the weight, and they should be removed because they contain little or no tannin.

Prospects Teri-pod plant might be an interesting source of vegetable tannin on a larger scale. The species is indigenous in South-East Asia, the tannin is easily extracted and it has excellent tanning properties. The seeds are nutritious with a high protein and oil content. Research priorities should concentrate on the development of cultivation methods that make the collection of pods from the prickly plants less troublesome, and methods of mechanical removal of the seeds.

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T. Boonkerd, B. Na Songkhla & W. Thephuttee

Caesalpinia sappan L.

Sp. Pl. 1: 381 (1753).
LEGUMINOSAE
$2n = 24$

Synonyms *Biancaea sappan* (L.) Todaro (1876).

Vernacular names Sappanwood, Indian redwood (En). Sappan (Fr). Indonesia: kayu secang, soga jawa (Javanese), secang (Sundanese). Malaysia: sepang (general). Philippines: sibukao (Tagalog, Bisaya), sapang (Tagalog, Bisaya, Ilokano). Burma: teing-nyet. Cambodia: sbaèng. Laos: faang dèèng. Thailand: faang (general), faang som (Kanchanaburi), ngaai (Karen, Kanchanaburi). Vietnam: vang nhuộm, tô mộc.

Origin and geographic distribution The origin of sappanwood is not certain, but it is thought to be in the region from central and southern India through Burma, Thailand, Indo-China and southern China to Peninsular Malaysia. It is cultivated and naturalized in many parts of Malesia (Indonesia, the Philippines, Papua New Guinea) and also in India, Sri Lanka, Taiwan, Solomon Islands, and Hawaii.

Uses The wood of sappanwood was a major source of a red dye up to the end of the 19th Century. It is still used for dyeing but only on a small scale. Cotton, silk, wool and matting can be dyed with it. In Indonesia, the wood is also used for colouring drinks pink. The fruits contain tannin and were used in the past to prepare a black dye together with iron. Sappanwood is also used as medicine in India, Indonesia and the Philippines. A decoction of the bark and wood is used as a cure for tuberculosis, diarrhoea, and dysentery, as an astringent and as a vulnerary. The seeds serve as a sedative. In the Philippines, the wood is a primary source of firewood. It is also made into small handicrafts, violin bows, and wooden nails. The species is often planted as living fences. Owing to the ease with which it grows and its dense growth habit, it is used for defining the boundaries of land and for protecting timber plantations against grazing animals. The leaves are used to hasten ripening of fruits such as bananas and mangoes.

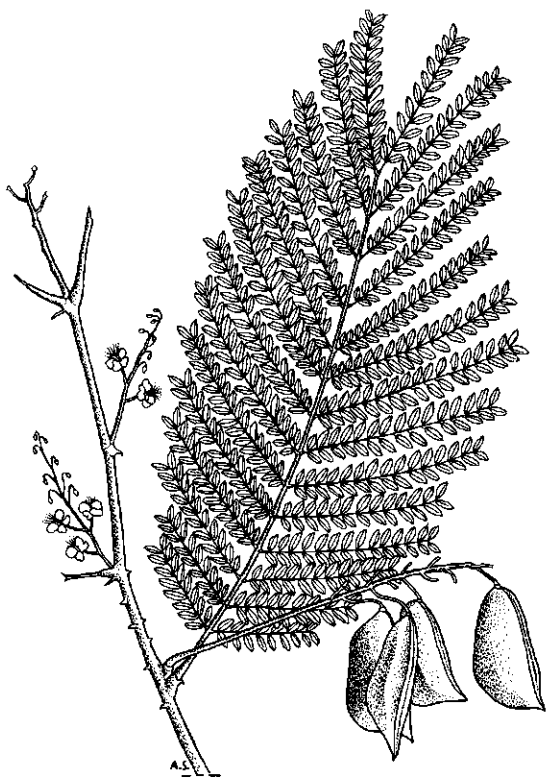
Production and international trade Not much attention has been given to sappanwood since its use as a dyewood declined at the end of the 19th Century. In Indonesia 3.06 t of wood were used for medicinal purposes in 1983 and 3.37 t in 1984, and a very small amount (ca. 60 kg) was exported in 1983. In the Philippines, it is planted by smallholders for use as firewood but statistics are not available. This species is no longer traded internationally.

Properties A red dye, called sappanin, is extracted from the heartwood. The wood also contains brazilin, an important compound of the red dye from brazilwood (*Caesalpinia echinata* Lamk). The name brazilwood, referring to the bright red colour like glowing coals, was originally used for sappanwood until the discovery of *C. echinata* in about 1500 in the region now called Brazil. The dye from brazilwood is considered superior. The wood is rasped to a coarse powder, moistened with water and allowed to ferment for a few weeks to increase the colouring power of the dye. The fermented wood is boiled in water. The dye is also extractable with alcohol and other organic solvents. The extractable dye amounts to 20% of the oven-dry weight of the heartwood.
A group of phenolic compounds called homoisoflavonoids appear to be responsible for the medicinal activity of bark and wood. The stem and leaves contain alkaloids and tannins, abundant saponin and phytosterol. The fruits contain ca. 40% tannin, which is suitable for the production of light leather goods.

Freshly cut sappanwood is light orange in colour. The colour deepens to dark red upon prolonged exposure to sunlight and/or air. Prolonged boiling intensifies the colour of the dye.

The sapwood ring is very narrow and light coloured, the heartwood makes up to 90% of the total volume. The pith is distinct and yellowish. The growth rings are distinct. The wood is straight grained with a fine to moderately fine texture, fairly heavy (600–780 kg/m^3), hard and lustrous. It is difficult to dry and susceptible to warping and collapse, but moderately easy to work; it takes a high finish, and is tough and resistant to termite attack. The energy value is about 25000 kJ/kg.

Description A small shrubby tree, 4–8(–10) m tall; roots fibrous and wiry, lacking nodules, dark coloured; trunk up to 14 cm in diameter; bark with distinct ridges and many prickles, greyish-brown; young twigs and buds hairy, brownish. Leaves stipulate, bipinnate, up to 50 cm long, with 8–16 pairs of up to 20 cm long pinnae; pinnae with prickles at the base and with 10–20 pairs of oblong, 10–20 mm × 6–10 mm long, subsessile leaflets, very oblique at base, rounded to emarginate at apex. Flowers in terminal panicles, 2–2.5 cm wide, yellow, 5-merous; sepals glabrous, petals pubescent, the superior one smaller; stamens 10, filaments woolly-hairy in the lower half; ovary superior, pubescent. Fruit a dehiscent pod, oblong-obovate, 7–9 cm × 3–4 cm, strongly flattened, shiny and glabrous with curved beak at apex, yellowish-green when young maturing to reddish-brown, 2–5-seeded. Seeds ellipsoid, flattened, 18–20 mm × 10–12 mm, brown.



Caesalpinia sappan L. – flowering and fruiting branch.

Growth and development Usually mature pods burst open in the dry season and scatter the seeds, which remain dormant until the start of the rainy season. Seeds germinate immediately if enough moisture is available. Flowering can occur after one year of growth, and in Indonesia pods are produced 13 months after planting. Initially sappanwood grows straight but after having attained about 2.5 m height, the branches start to droop and entwine with the branches of nearby trees to form thickets, generally free from undergrowth. After the tree is felled the stump sprouts profusely within two weeks. Flowering is usually in the rainy season, fruiting about 6 months later.

Ecology Under natural conditions sappanwood grows mostly in hilly areas with clayey soil and calcareous rocks at low and medium altitudes. In Peninsular Malaysia it grows best on sandy riverbanks. It does not tolerate too wet soil conditions. Sappanwood is reported to tolerate an annual precipitation of 700–4300 mm, an annual mean temperature of 24–27.5°C, and a soil pH of 5–7.5.

Propagation and planting Sappanwood can be propagated by seeds and renewed by coppicing. Germination occurs readily, but is enhanced by dipping the seeds wrapped in cotton cloth into boiling water for 5 seconds. Germination rate is then about 90%. Usually the plants are cultivated in the shade of trees in the forest or in the forest border.

Diseases and pests No serious diseases and pests have been reported, although fungi such as *Auricularia auricula-judae* and *Meliola caesalpiniae* can attack the trees.

Harvesting For use as a dyewood the tree must be harvested every 6–8 years, to allow the heartwood to become fully developed, for firewood it may be harvested every 3–4 years when the trunk has attained a diameter of 5–6 cm. The tree is cut about one metre above the ground to allow sprouts to grow from the stump. Harvesting is done manually with a machete; prickles are easily removed by brushing with the blunt edge of the machete.

Handling after harvest The dye liquor may be used immediately after the wood has fermented or is evaporated to powder, which can be stored for future use. The mordants used (aluminium acetate, stannic salts, oxalic acid, etc.) determine the final colour of the cloth, which can vary from shades of red to pink, violet and brown. Sometimes the dye is used in mixtures, for instance with indigo for purple colours and with turmeric and iron sulphate to produce a rich maroon.

Prospects A revival of the use of sappanwood as a dye source will not happen in the immediate future since synthetic dyes are cheaper to produce, brighter, more lustrous and more permanent. However, people may once again turn to natural dyes in the far future, for instance because of environmental problems with synthetic dyes, and sappanwood would then provide a renewable resource. Sappanwood may have better prospects as a medicinal plant, and as a producer of fuelwood with high energy value. The prospects for the beautiful wood are good.

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J.V. Zerrudo

Cassia auriculata L.

Sp. Pl. 1: 379 (1753).
LEGUMINOSAE
$2n = 14, 16, 28$

Synonyms *Cassia densistipulata* Taubert (1895).

Vernacular names Avaram, tanner's Cassia (En). Malaysia: gelam tangedu. Burma: peikthingat.

Origin and geographic distribution Avaram is a native of India, Burma, and Sri Lanka. It is cultivated in India, and, on a small scale, in Sri Lanka. The species has been successfully introduced in West Africa and East Africa. It has been suggested to be indigenous in Tanzania, but an early introduction and naturalization seems more likely. It was also tried in Java, where it failed.

Uses Avaram is a multipurpose plant. The bark can be used for tanning heavy hides and also goat and sheep skins, giving a buff-coloured leather of good quality, which tends to darken on exposure to light. To prevent this the leather is often finished by a tannage using myrobalans from *Terminalia chebula* Retz. The bark fibre can be made into rope, and a fermented mixture of pounded bark and dissolved molasses serves as an alcoholic beverage in some parts of India. In Sri Lanka the leaves are sometimes used to make tea. Avaram does not reach a volume adequate for timber, but sometimes handles of small tools are made from the wood. It is used for revegetating erodible soils and as a green manure, and also proved very effective in reclaiming sodic soils which have been dressed with gypsum. In times of food scarcity the pods, leaves and flowers are used as a vegetable. Avaram is suited as fodder for goats and cattle and for feeding silkworm, but poisonous substances have been reported. Medicinal uses are numerous. The roots and bark are astringent and are used for gargles, as an alterative, and to cure skin diseases. A decoction of the flowers and the seeds is recommended for diabetes, seeds are used to cure eye diseases. Leaves and fruits serve as anthelmintic. Sometimes avaram is cultivated as an ornamental.

Production and international trade Avaram was a major source of tannin in India, the most important areas of production being Madras, Hyderabad, and Mysore. In the past production was as high as 50000 t of dried bark per year. But syntans and imported barks, especially of black wattle (*Acacia mearnsii* De Wild.) from southern Africa, have largely taken avaram's place. Outside India, avaram has never been cultivated on a large scale.

Properties The bark contains 15–22% of tannin on a dry weight basis in plants over three years old. Saponin and sennapikrin are reported from the roots. The bark, flowers, and seeds contain pyrrolizidine alkaloids, suspected of hepatotoxic properties. Beta-sitosterin is found in the seed.

Botany Shrub, 2–5(–7.5) m tall, trunk up to 20 cm in diameter. Bark thin, brown, lenticellate. Leaves pinnate, with 10–14 cm long petiole and rachis provided with a gland between each pair of leaflets; stipules persistent, large and leafy; leaflets 6–13 pairs, oblong-elliptic to obovate-elliptic, 10–25(–35) mm × 5–12 mm, rounded and mucronate at apex. Flowers in corymbose, terminal pani-

Cassia auriculata L. – 1, flowering branch; 2, fruit.

cles, which consist of aggregated, 2–8-flowered racemes; sepals 5, rounded at apex; petals 1.5–3 cm long, yellow; stamens 10, the 3 lower ones largest and fertile, others usually sterile. Fruit an oblong-linear pod, 5–12(–18) cm × 1–2 cm, indehiscent, usually 10–20-seeded. Seeds with a distinct areole on each face.

In India avaram usually shows two bursts of flowers, one in the early monsoon and another in the late monsoon.

Ecology In the natural or naturalized state, avaram is found in woodland and wooded grassland. It usually grows wild in dry regions with a minimum annual precipitation of 400 mm, but it can also tolerate wet climates with an annual precipitation up to 4300 mm. The mean annual temperature can vary from 16 to 27.5°C. Avaram tolerates many types of soil, but prefers fairly rich, well-drained soils. It needs full sun.

Agronomy Avaram is easy and cheap to raise and is propagated by seed and by stem cuttings. For quick germination seeds are scarified and held in running water. The seedlings are fairly resistant to desiccation. Stem cuttings are planted 5–12.5 cm apart in rows. Thinning is necessary after the first year. Limed soil is reported to increase the amount of tannin. No serious pests or diseases are reported, although aphids and mites have been found feeding on the plant. In the third year the twig bark can be stripped. The bark is sun dried in small pieces which are directly used by the tanners. Coppiced bushes can be harvested annually. The yield averages 1500 kg of sun-dried bark per ha in a plantation of ca. 9000 plants/ha.

Prospects Avaram is easy to grow and has numerous uses. It could be an interesting plant in the drier parts of South-East Asia, especially because of its good tanning properties, and for revegetating barren tracts.

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Maman Rahmansyah

Ceriops decandra (Griffith) Ding Hou

Fl. Males., Ser.1, Vol. 5(4): 471 (1958).

RHIZOPHORACEAE

$2n = 36$

Synonyms *Ceriops roxburghiana* Arn. (1838).

Vernacular names: Brunei: tengar. Indonesia: tengar (Javanese), palun (Ambon), bido-bido (Halmahera). Malaysia: tengar (Peninsular), landing-landing (Sarawak). Philippines: malatangal (Tagalog), tungung (Bisaya), tungug (Ibanag). Singapore: tengar. Burma: ka-pyaing. Cambodia: smaè. Thailand: kapuulong (Phetchaburi), prong khaao (Samut Sakhon), samae manoh (Satun). Vietnam: dzà.

Origin and geographic distribution The genus *Ceriops* Arn. was once more widely distributed than it is today. For example, it was probably present in Europe in the Eocene; both *Ceriops* and some other Rhizophoraceous genera appear in the European fossil record before they appear in that of South-East Asia. Clearly the ranges of the species have changed. Thus although *C. decandra* is now centred in South-East Asia it is not certain that it originated in this region. Its current range extends from the Indus delta in Pakistan around

the coast of India and across the Bay of Bengal to Burma, and thence through Indo-China, Thailand and South-East Asia to Papua New Guinea. It also occurs locally in north-eastern Australia. In South-East Asia it is found in Peninsular Malaysia, the Philippines, Borneo, Java, Sulawesi, the Lesser Sunda Islands, the Moluccas, and New Guinea. It has not yet been collected from Sumatra, but recently it has been reported from there.

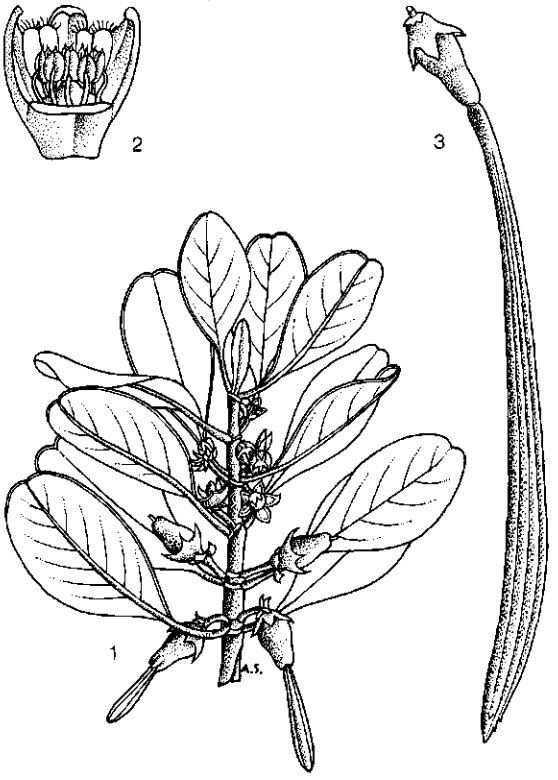
Uses In the past the bark of this species was an important source of high quality tannin, and although its use for this purpose has waned in recent years, it is still used locally. Both bark and leaves are used for tanning in South-East Asia and India. The sap of the bark yields a black dye used in the 'batik' industry, and a decoction of the bark is used to treat haemorrhages. The large scale exploitation of this species for posts, poles, firewood and charcoal has been widespread, and still occurs in places. The branches are used for tool handles, and bent ones for boat ribs. Some wood of this species has been chipped for pulp.

Production and international trade There are no reliable figures for the volumes of this species felled each year, nor for the proportions of the annual volume cut which are used for different purposes. Figures given in literature often refer to several mangrove species.

Properties The bark contains 25–37% tannin. A tannin extract imparts a reddish colour to leather and makes it somewhat harsh and thick. It is often mixed with other tanning materials, such as myrobalans from fruits of *Terminalia chebula* Retz. and bark of *Acacia nilotica* (L.) Willd. ex Del., which modify the colour of the leather. The extract is used for heavy leather. A mixture of bark and leaves gives a better leather of lighter colour than the bark alone. The development of acidity in the tanning liquors, resulting in stiffness of the leather, can be eliminated by quick tanning of the hides, or by adding alkaline phenate. Mangrove tannin is generally very soluble and develops a minimum of insoluble matter, with the result that it produces very little sludge in the tanning liquor. The basic components of the tannin are 3',4',-5,7-tetrahydroxyflavan-3,4-dioles, which ranks the tannin in the proanthocyanidins. Extracts from the bark contain about 19% of mucous substances, composed of arabinose, rhamnose and galactose.

The wood is moderately resistant to decay and has a life in contact with the ground of about 2 years. It is pale whitish-yellow when freshly cut but turns orange-brown on exposure to air, and is usually somewhat less heavy than the wood of *C. tagal* (Perr.) C.B. Robinson. When dry the wood burns with a hotter flame than that of most other mangrove species. Anatomically the wood is similar to that of *C. tagal*, but with rather larger and fewer vessels per mm^2.

Description A straight columnar tree, usually of small to medium size, but under favourable conditions attaining a height of 35 m and a diameter of the trunk of 35 cm, with a relatively narrow crown and short basal buttresses which appear to develop from the fusion of clusters of stilt roots; roots superficial, spreading radially, with small knobby and/or looping pneumatophores in wet sites; bark whitish or pale grey, smooth but slightly fissured towards the base, peeling around the buttresses; branches conspicuously jointed with swollen nodes. Leaves opposite, clustered at the end of the twigs, coriaceous, obovate to elliptic–oblong, 4.5–10 cm × 2.5–6 cm, cuneate at base, rounded or subemarginate at apex, glabrous and glossy; petiole 1–2.5 cm long, with lanceolate,



Ceriops decandra (Griffith) Ding Hou – 1, flowering and fruiting branch; 2, flower with front sepals and petals removed; 3, fruit with protruding hypocotyl.

1.5–2.5 cm long deciduous stipules at base. Flowers in head-like, condensed up to 5-flowered cymes in leaf-axils at the upper part of a branch, 5–6-merous, 5–6 mm long, with deeply lobed calyx and white ca. 2.5 mm long petals, fringe-like divided at the apex; stamens twice the number of calyx lobes, anthers longer than filaments; ovary semi-inferior, 3-celled. Fruit an ovoid-conical berry, 1–1.8 cm long, with persistent erect or ascending calyx lobes, blunt basally, warty at the apex. Seeds viviparous. Hypocotyl club-shaped, protruding below the fruit while this is still attached to the tree, 9–15 cm long, occasionally longer (e.g. in New Guinea), slightly fluted.

Growth and development Trees tend to flower periodically and synchronously over wide areas, but seasonally under seasonal climates. Fruiting is often prolific and single trees may subtend several thousands of seedlings at the same time. Seedlings take up to 12 months to develop, with shorter times in wet equatorial regions. Seedlings fall from the trees when the hypocotyls become detached from the cotyledonary tubes. Subsequent development involves a seedling being stranded and lodged in the mud, followed by the rapid production of adventitious roots which serve to anchor it. Most seedlings are slender and small and cannot survive long periods while floating in the water, and consequently are not as successfully dispersed over long distances as those of other mangrove Rhizophoraceae. However, once 'planted' in the shade of other trees their rate of establishment is very high.

Ecology *C. decandra* is most common in tidal forest in high rainfall regions, where characteristically, it grows in the middle to landward parts of the mangrove swamp. Here it is commonest in sites flooded by virtually all high tides, i.e. where the soil surface is below mean high water level. It develops best immediately behind the forest strip lining rivers, and on the slightly higher muddy tidal flats behind, between rivers and creeks. In these sites fresh water is in regular supply and salinity never exceeds that of normal sea water. Locally this species is gregarious, forming a slender pole forest, but it is most often associated with species of *Avicennia* L., *Bruguiera* Lamk and *Rhizophora* L. However, its station is not constant, and it occurs on the landward fringes of some mangrove swamps.

Handling after harvest For tanning purposes the bark of older *Ceriops* trees is peeled off, because the tannin content increases with age. The bark may be used directly in the tannery, or tanning extracts may be prepared from it, marketed as blocks or powder. Often a mixture of bark from several mangrove species (*Ceriops, Rhizophora, Bruguiera* species etc.) is used for preparing a tanning extract which is called 'mangrove cutch'.

Prospects The outlook for the uses of this species depend largely on the exploitation and reafforestation of mangroves, as is the case with other mangrove species.

Literature [1] Crevost, Ch. & Pételot, A., 1941. Catalogue des produits de l'Indochine. Tome 6. Tannins et tinctoriaux. Gouvernement général de l'Indochine, Hanoi. pp. 32–33 + fig. [2] Hou, D., 1958. Rhizophoraceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana, Series 1. Vol. 5. pp. 471–472, fig. 24 f–h. [3] Howes, F.N., 1962. Tanning materials. In: von Wiesner, J. (Editor): Die Rohstoffe des Pflanzenreichs. 5th ed. J. Cramer, Weinheim, Germany. pp. 178–184. [4] Rollet, B., 1981. Bibliography on mangrove research, 1600–1975. Unesco Paris. xxviii + 479 pp.

R.H. Hughes & S. Sukardjo

Ceriops tagal (Perr.) C.B. Robinson

Philip. J. Sci. Bot. 3: 306 (1908).
RHIZOPHORACEAE
$2n = 36$

Synonyms *Ceriops candolleana* Arn. (1838; as *C. candolliana*).

Vernacular names Brunei: tengar. Indonesia: tengar (Sumba), tanggala tutu (Gorontalo), tingi (East Kutei, Java). Malaysia: tengar. Philippines: tangal (Tagalog, Bisaya), tongog (Bisaya), sambali-rongon (Ilokano). Singapore: tengar. Cambodia: smaè. Thailand: prong (Samut Sakhon, Chanthaburi), prong daeng (Samut Sakhon), samae (peninsular). Vietnam: dzà vôi, dzà dò.

Origin and geographic distribution It is not known where this widespread and common species originated, but it is now found on coasts from East Africa to the Indian subcontinent, and thence through tropical Asia to Australia and the Pacific. It extends as far as Hong Kong, Taiwan, Yap and Palau in the north-western Pacific, and the Bismarck Archipelago, the Solomon Islands and northern New Caledonia in the south-western Pacific, with an eastern limit on Malakulu Island in the New Hebrides. However, fossils indicate that the species once had a greater range.
C. tagal is commonly found along the coasts throughout South-East Asia.

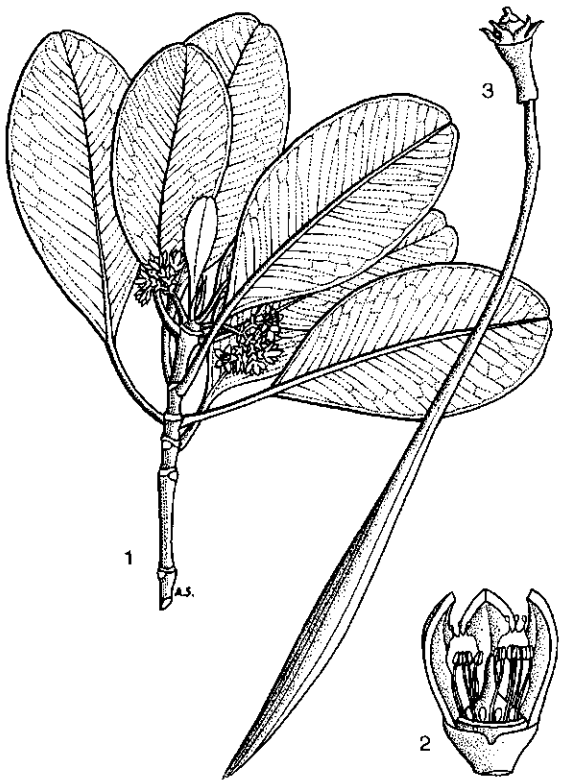
Uses Its uses are similar to those for *C. decandra* (Griffith) Ding Hou. The tannin is of high quality and frequently commands a good price, and the bark is therefore still important locally. Both bark and sap yield dyes (red and black respectively) which continue to be of importance to the 'batik' industry from Africa to the Pacific. In central Java the bark is still used in the traditional 'soga-batik'. The bark also serves to preserve and dye fishing nets and matting. The wood is used for tool handles and makes good firewood, but has been said to burn with too hot a flame for domestic use, damaging cooking pots. It makes excellent charcoal. An alcoholic beverage is obtained, illegally, from the bark, e.g. in Sabah. The tannin extract can be used as binder for particle board. The bark was locally used in traditional medicine in Peninsular Malaysia and Indonesia.

Properties The tannin content of the bark can vary considerably, from 20% to over 40%, a common and notable feature of mangrove barks. The leaves contain less tannin, about 15%. In India, solid block extracts containing 68% tannin and 15% moisture, and powder extracts containing 75% tannin and 5% moisture, have been prepared for use in the tanning industry.

Dyeing with the bark gives brown colours; if combined with indigo, shades of black and purple are obtained.

The sapwood is usually poorly defined, the heartwood is orange when freshly cut, but turns yellowish-brown or sometimes even red on exposure. The wood is heavy with an average air-dried weight of 960 kg/m^3. It is moderately durable but in contact with the ground it decays in about 2 years. The timber is not resistant to marine borers. Seasoned wood is comparatively resistant to splitting on shock and it is thus suitable for tool handles. Anatomically the wood tends to be diffuse porous, with more and smaller vessels than in other mangrove Rhizophoraceae. The conductive elements are set in expanses of mechanical tissue with scanty parenchyma. The vessels have scalariform perforation plates in common with other representatives of the family.

Description A tree of variable form, attaining exceptionally a height of 40 m and a diameter of the trunk of 40 cm with a slender stem and a compact crown in favourable sites, but in poorer conditions a tree of small dimensions or even shrub-like; stem base usually surrounded by a tightly appressed conical cluster of short stilt roots; roots superficial, spreading, with looping or knobby pneumatophores in wet situations, but some deeply descending roots may develop from the stem base; bark varying from white and pale grey to reddish-brown, deeply fissured in older specimens; branches conspicuously jointed. Leaves opposite, clustered at the end of the twigs, coriaceous, obovate to obovate-oblong, rarely elliptic-oblong, 5–12 cm × 2–7.5 cm, cuneate at base, obtuse or slightly emarginate at apex, glabrous and glossy; petiole 1.5–3.5 cm long, with 1–2.5 cm long deciduous stipules at base. Flowers in condensed up to 10-flowered cymes on the terminal nodes of new shoots, 5–6-merous, 3–5 mm long, with deeply lobed calyx and white, ca. 3.5 mm long petals, coherent at base and with 3 clavate, apical appendages; stamens twice the number of calyx lobes, anthers much shorter than filaments, explosively dehiscent; ovary semi-inferior, 3-celled. Fruit an ovoid berry 1.5–2.5 cm long, with persistent reflexed calyx lobes, pointed basally, warty over its whole length. Seeds viviparous. Hypocotyl club-shaped, protruding below the fruit while this is still attached to the tree, 15–25(–35) cm long,



Ceriops tagal (Perr.) C.B. Robinson – 1, flowering branch; 2, flower with front sepals and petals removed; 3, fruit with protruding hypocotyl.

often deeply fluted.

Growth and development Similar to that of *C. decandra*, except that the seedlings are more robust.

Ecology Although *C.tagal* reaches its greatest stature in forests in aseasonal high rainfall regions, it is more important ecologically, where seasonal climates prevail. Typically it occupies sites from the middle to the landward zones of mangrove forests, and may be flooded either by all normal high tides, or only by occasional high tides. It may become dominant in well drained zones, and forms dense low-canopied pure stands along the landward boundaries of some mangrove swamps, where the soil surface may become dry and cracked. However, these belts of *C. tagal* become open and stunted where salinity is high and in extreme situations the trees give way to open herbaceous areas or to bare saline mudflats.
In most areas, *C. tagal* is much more common than *C. decandra*.

Propagation and planting In reforestation projects establishment rates approaching 100% have been achieved. Unlike other Rhizophoraceae, the propagules (seedlings) are small and delicate, and must therefore be collected and transported to the replanting sites with care. They will not tolerate excessive desiccation. However, they are easily heeled in and become established very quickly.

Diseases and pests *Ceriops* trees are attacked by some mistletoes. The high tannin content discourages many herbivores, but crabs eat the seedlings, and whereas the magnitude of crab depredations is not immediately apparent in undisturbed forests, it becomes clear if seedlings are planted to reforest clear-felled areas. Then, in some cases, the intensity of crab browsing is, or becomes, so great that entire plantings are destroyed and the forest cannot regenerate. In older plantations monkeys cause minor damage by uprooting seedlings.

Handling after harvest In central Java the fine 'soga-batik' is still made using vegetable dyes, although on a small scale. The bark of *C. tagal*, usually called 'tingi', is one of the ingredients of the dye, together with the wood of *Maclura cochinchinensis* (Lour.) Corner and the bark of *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne. Depending on various proportions of the ingredients, cotton cloth is dyed yellowish to brownish shades in traditional patterns, in a process which often takes several weeks. After the dyeing process, a fixing-bath containing lime, sugar, and traditionally also alum and flower buds of *Sophora japonica* L., is necessary to make the colours more fast and bright.
Using this dyeing process, warm yellowish-brown colours, gradually shading off into one another, are given to the cotton cloth. These effects cannot be achieved when using synthetic dyes.

Prospects In many parts of South-East Asia, the area of mangrove forest has decreased, largely because of large-scale exploitation for firewood, charcoal, timber, and dyeing and tanning materials. Little reafforestation has been done in most of the areas where naturally occurring mangroves have been exploited. However, *Ceriops* and many other mangrove trees can be propagated easily, and the seedlings usually grow well without much care. Cutting and management of mangrove should be well-planned.

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R.H. Hughes & S. Sukardjo

Crocus sativus L.

Sp. Pl. 1: 36 (1753).
IRIDACEAE
$2n = 24$; also recorded as 14, 16, 40

Vernacular names Saffron (En). Safran (Fr). Azafran (Sp). Indonesia: kuma-kuma, sapran. Malaysia: kuma-kuma. Cambodia: romiet.

Origin and geographic distribution Saffron is known only as a cultivated plant. It probably originated in Greece, Asia Minor and Persia, where some probably related wild species occur. In very ancient times it was spread eastward to Kashmir. It was introduced in Spain by the Arabs in the 10th Century. Later its cultivation spread to neighbouring countries in southern Europe, Asia Minor, Iran, northern India, and China.
Saffron has never been cultivated in South-East Asia where the climate is not suited for this species. The product from this plant, the dried stigmas, are however imported on a small scale in

South-East Asian countries.

Uses Saffron is used mainly to colour and flavour foods. It was also used for textile dyeing, but this use declined with the advent of synthetic dyes. The many therapeutic properties of saffron are disputed, but it continues to be an important ingredient of the Ayurvedic and other systems of medicine in India. Saffron is sometimes sold in druggist's shops in Indonesia and Malaysia for medicinal uses or for flavouring food.

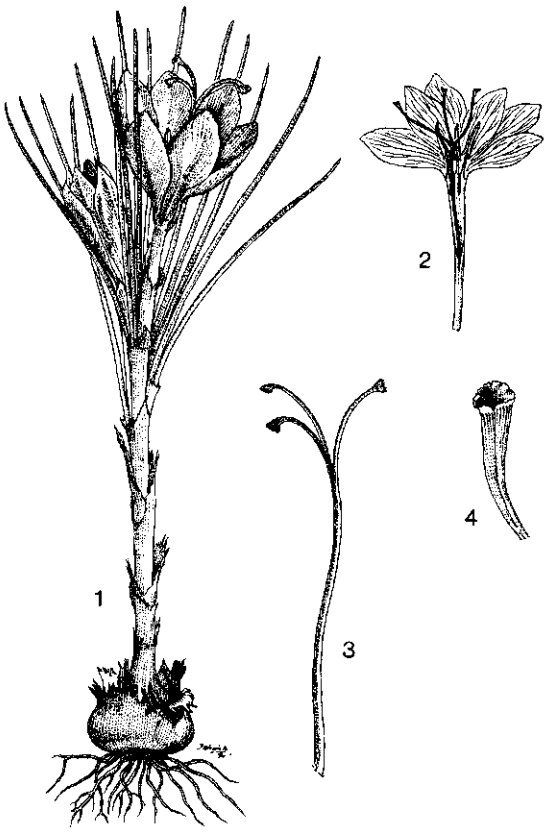
The very expensive saffron is often subject to adulteration. Not only is very impure saffron consisting of floral parts other than stigmas sold, but parts of other plant species with dyeing properties are also offered in markets in South-East Asia under the name 'saffron', such as powdered rhizomes of turmeric (*Curcuma longa* L.), and flowers of safflower (*Carthamus tinctorius* L.). The dyeing substances from these plants can be used in the same way as true saffron, and are much cheaper.

Production and international trade Saffron is by far the world's most expensive food-dye and spice. Spain is the major producer, accounting for 90% of the world's production. Other exporting countries are India (Kashmir), France, Algeria and Italy. The annual production in India in the beginning of the 1980s was estimated at 9–10 t. The international market price in that period was about US$ 1000 per kg.

Properties The chief pigments of saffron are the yellowish-red glycoside crocin and the bitter glycoside picrocrocin. On hydrolysis crocin yields the sugar gentiobiose and crocetin, a carotenoid pigment. Saffron also contains a pleasantly odoriferous compound safranal which develops during the drying process by enzymatic or thermal dissociation of picrocrocin.

Botany A small bulbous perennial plant, 10–30 cm tall, having a more or less globular subterranean corm which is 3–5 cm in diameter and surrounded by a finely reticulate–fibrous tunic. Leaves grass-like, 1.5–2(–3) mm broad, appearing before the flowers or together with the flowers. Flowers 1–3, each on a short subterranean pedicel subtended by a sheathing prophyll (spathe); perianth with a long cylindrical tube and 6 segments of 2.5–5 cm × 1–2 cm, deep lilac-purple or mauve coloured with darker veins, white or lilac in the throat; stamens 3; ovary inferior, style divided into 3 brilliant orange-red stigmas, 2.5–3.5 cm long.

C. sativus is a sterile triploid which reproduces only vegetatively. The corms reproduce annually, giving rise to new young cormlets. Saffron flowers in autumn.



Crocus sativus L. – 1, flowering plant; 2, opened flower; 3, style and stigmas; 4, stigma.

Ecology Saffron thrives best in temperate and fairly dry climates. In the areas of Spain where saffron is cultivated, annual rainfall only rarely exceeds 400 mm. Two periods of heavy rainfall are adequate for good yields, one in spring for the production of new corms and a second at the end of summer to develop blossoms. Frosts or rains during flowering are harmful and can damage the crop.

Agronomy Propagation is by means of corms. Cultural practices vary for the different producing countries. Once planted, corms may remain in the field for 3–12 years; sometimes saffron is even grown as an annual crop.

The flowering and harvesting season lasts for about 4 weeks. The flowers must be picked in the early morning, and the stigmas should be removed on the same day. The 3 stigmas are dried, along with about 5 cm of the style attached, and constitute the pure saffron of commerce. An average yield is about 1000000 flowers per ha, which in turn produces 10 kg dried saffron. Fire-dried saf-

fron is more valuable than sun-dried. Saffron is marketed both as a powder and as the much less dense 'hay saffron', i.e. loose stigmas. Quality is maintained by storage in low humidity.

Prospects As it is not suited to tropical and high-rainfall climates, saffron does not have good prospects in South-East Asia. However, as products from other plant resources are often confused with true saffron, it seems useful to give some attention to this species.

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P.C. Wessel-Riemens

Dioscorea cirrhosa Lour.

Fl. Cochinch. 2: 625 (1790).
DIOSCOREACEAE
$2n$ = unknown

Synonyms *Dioscorea rhipogonoides* Oliv. (1889), *Dioscorea matsudai* Hayata (1921).

Vernacular names Dye-yam, dyeing yam, dye-root (En). Faux gambier (Fr). Laos: thoom lüad, kabau, houa. Vietnam: cu'nâu (general), khoai leng (central).

Origin and geographic distribution Dye-yam is a native of north-eastern Thailand, Laos, Vietnam, south-eastern China (Provinces Guangxi and Guangdong), Hong Kong, Taiwan, and the southern Ryukyu Islands. Throughout this area it is sometimes also cultivated.

Uses The tubers are widely used as a source of a reddish-brown dye for colouring cloth, and as a source of a tanning material for toughening fishing nets or to prepare leather from hides.
In southern China cotton cloth and grass cloth made of ramie (*Boehmeria nivea* (L.) Gaudich.), as well as silk, are dyed with a solution of the tubers. In Indo-China cottons are dyed with dye-yam.

Production and international trade At the beginning of the 20th Century, dye-yam was an important product for export from northern Vietnam, with a maximum shipping to Hong Kong of 8000 t/year. Since 1930 exports have rapidly diminished. The main reason for this decline is undoubtedly the increasing use of synthetic dyes, but excessive exploitation of the wild populations of this species may also have caused the market to decline, as happened at the end of the 19th Century in Hong Kong. At present, dye-yam is only of local importance.

Properties Tubers contain 6.5–14% tannin. Dye-yam imparts a dark red colour to leather, and a brown colour to fishing nets. Dimeric, trimeric and tetrameric procyanidins have been isolated from the tubers, together with (+)catechin and (–)epicatechin.
The dye is extracted from the reddish flesh of tubers. It is soluble in hot water, less soluble in cold water, and almost insoluble in alcohol. A viscous extract has been prepared in Vietnam, yielding 4% of the tuber weight. This extract contained about 35% of tanning and dyeing material, soluble in hot water.

Botany A perennial dioecious herb up to 10 m long, glabrous and scandent, with tuberous rhizome (of 1 or more tubers) of variable shape and size, usually globose or pear-shaped and up to 10

Dioscorea cirrhosa Lour. – 1, part of stem with male inflorescences; 2, part of fruiting stem; 3, tuber.

cm in diameter; stems twining to the right, terete and slender, glabrous but near base often with curved prickles, yellow to brown. Upper leaves opposite, papery to thinly leathery, elliptic-ovate or elliptic-lanceolate, 8–14 cm × 2–5 cm, rounded to obtuse at base, acute or acuminate at apex, 3–5-nerved; lower leaves often alternate and larger, subcordate at base, up to 9-nerved; petioles 1.5–4 cm long, slender. Male flowers in axillary panicles composed of spikes, or in simple spikes up to 8 cm long, 6-merous, small; female flowers in axillary pendant spikes up to 10 cm long, each flower with an inferior 3-loculed ovary and 3 bifid stigmas. Fruit a 3-valved winged capsule, 1.5–2.5 cm × 2.5–4 cm, shortly stipitate, retuse at apex. Seeds winged.

In the literature, dye-yam is sometimes erroneously reported for the Philippines. This mistake probably arose because Knuth (1924) mistakenly cited *D. cirrhosa* specimens for the Philippines instead of *D. merrillii* Prain & Burkill.

Ecology Dye-yam occurs naturally in thickets and secondary forests, usually in the lowland, in southern China up to 1500 m altitude. It is sometimes not clear whether plants are truly wild or have escaped from cultivation and naturalized, as is often the case with other *Dioscorea* species.

Propagation and planting Plants can easily be propagated by tubers, which are planted near trees in the forest or in waste land, using sticks as staking material. Tubers are usually collected from plants in the wild.

Handling after harvest When about 3 years old, the tubers are harvested in the dry season when the red flesh has a high tannin content. The tubers should be harvested with care to ensure that they are not broken or bruised. They should be protected against desiccation because they lose much of their colouring properties when desiccated. For dyeing and tanning purposes, the tubers are peeled and the flesh is rasped. About 3 l of water is added to 1 kg of rasped flesh, and clothes or nets are dipped in the hot or cold solution remaining after filtering, and afterwards dried in the sun. This handling is repeated several times, until the desired reddish-brown colour is attained. The dye rapidly loses its activity, and best results are obtained with fresh solutions. Mordants such as alum, aluminium acetate and bichromate are often added to the solution, but sometimes leaves of *Psidium guajava* L. and *Piper betle* L., or mud (in China) replace the mordant. Occasionally, clothes are dyed first with other vegetable dyes, such as the bark of *Bruguiera gymnorhiza* (L.) Savigny.

Prospects In the future, when the use of natural dyes might increase again, dye-yam could be a potential substitute for synthetic dyes. The dyeing and tanning solutions are fairly easy to prepare and use. Besides, dye-yam is a herbaceous plant which is much faster and easier to grow than numerous arborescent dye and tannin-producing species. More research is desirable on its dyeing and tanning properties, on the prospects for this species in South-East Asia, and on methods of cultivation.

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Nguyen Tien Hiep & R.H.M.J. Lemmens

Diospyros L.

Sp. Pl. 2: 1057 (1753); Gen. Pl. (ed. 5): 478 (1754).
EBENACEAE
$x = 15$; $2n = 30$: *D. malabarica* var. *malabarica*

Major species and synonyms

- *Diospyros malabarica* (Desr.) Kostel. var. *malabarica*, Allg. med.-pharm. Fl. 3: 1099 (1834), synonyms: *Diospyros embryopteris* Pers. (1807), *Diospyros peregrina* Guerke (1891).
- *Diospyros malabarica* (Desr.) Kostel. var. *siamensis* (Hochr.) Phengklai, Thai. For. Bull. 11: 46 (1978), synonyms: *Diospyros siamensis* Hochr. (1904), *Diospyros embryopteris* Pers. var. *siamensis* (Hochr.) Lecomte (1930).
- *Diospyros mollis* Griffith, J. Agr. Hort. Soc. Ind. 3: 145 (1844).

Vernacular names

- *D. malabarica* var. *malabarica*: Malabar ebony (En). Indonesia: culiket (Sundanese), kledung (Javanese). Malaysia: komoi, kumun. Burma: plab, tako suam. Cambodia: dângkaô khmaôch. Laos: küa namz, hnang hèèwx, lang dam. Thailand: tako thai (general), tako suan (northern), phlap (peninsular). Vietnam: thị dâù heo, cu'ò'm thị.
- *D. malabarica* var. *siamensis*: Siamese persimmon (En). Burma: maplup. Cambodia: tang kor. Laos: m'kup tawng. Thailand: maphlap (general), makap tong (northern), makhuea thuean (north-eastern).

– *D. mollis*: Cambodia: mak' klüë. Laos: küa. Thailand: ma kluea (general), mak-kluea (Trat). Vietnam: mac nu'a.

Origin and geographic distribution *D. malabarica* var. *malabarica* has a fairly large area of distribution, extending from eastern India and Sri Lanka, Burma, Cambodia, Laos and Vietnam, to Thailand (mostly cultivated) and Indonesia (Java, Sulawesi). The geographic distribution of var. *siamensis* and *D. mollis* is limited to Burma, Cambodia, Laos and Thailand.

Uses Unripe fruits are used to dye cloth black, and for tanning nets and sometimes hides. Occasionally, the leaves are used for dyeing. In India, the gum from the fruits of Malabar ebony is used to preserve the bottoms of boats, to caulk seams, and as a glue in book binding.

The fully ripe fruit of both varieties of *D. malabarica* is edible, but usually not very palatable. It tastes of raspberry and persimmon.

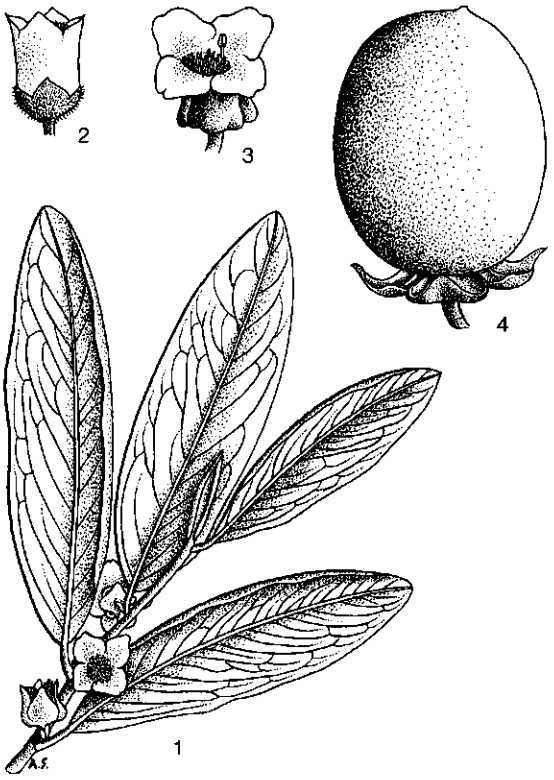
The tannin in the young fruits has many medicinal uses. The juice is applied to wounds and ulcers and is drunk in cases of dysentery and fevers; it possesses anti-bacterial and anthelmintic activity. In Thailand the bark of *D. mollis* is used to preserve alcoholic beverages.

The timber is used for cabinet work, furniture, and handicrafts. *D. malabarica* is sometimes cultivated as an ornamental.

Properties The fruits of *D. malabarica* var. *malabarica* contain about 15% tannin, the bark 12%. The tannins are probably derived from leucoanthocyanidins. The colouring matters in the fruits are derivates of naphthoquinones; in fruits of *D. mollis* 0.7–0.9% diospyrol ($C_{22}H_{18}O_4$) is found. Fruits of *D. mollis* also contain betulinic acid, oleanoic acid, methyl esters of palmitic acid, margarinic acid, stearic acid and oleic acid, lupeol, amyrine, and ß-sitosterol. Probably *Diospyros* fruits also contain saponins, which might contribute to the anthelmintic action and which might explain their use as fish poison. In Thailand, the anthelmintic medicine prepared from *D. mollis* is reported to have a toxic effect on human eyes. The fruits of *D. malabarica* var. *malabarica* contain about 50% pectin.

The wood of Malabar ebony is moderately heavy (ca. 780 kg/m^3) and moderately hard, greyish and close-grained. The heartwood of the tree is often rotten; when it is sound, it is variegated black and brown. The wood of *D. mollis* is very heavy, ca. 1300 kg/m^3 (the heaviest wood in Thailand), hard and durable.

Description Trees or shrubs, all parts often turning blackish when dry. Leaves alternate and distichous, simple and entire. Inflorescences axillary or cauliflorous. Flowers usually unisexual, 3–7-merous, with superior ovary. Fruit a leathery or fleshy berry, few-seeded.



Diospyros malabarica (Desr.) Kostel. var. malabarica – 1, branch with female flowers; 2, male flower; 3, female flower; 4, fruit.

D. malabarica var. *malabarica* is a dioecious or polygamous, small to medium-sized tree, up to 15 m (rarely up to 35 m) tall, with trunk up to 70 cm in diameter; trunk often fluted, crown conical with spreading branches; bark dark grey, more or less rough and scaly. Leaves leathery, elliptic-oblong, 7–32 cm × 2–10 cm, obtuse to acute, glabrous, yellowish when dry, shortly petiolate. Male flowers in 3–9-flowered cymes in the leaf axils, with numerous stamens, female flowers in 1–5-flowered cymes, with a globose, 4-styled ovary; corolla with short lobes. Fruit globose, 5–7.5 cm in diameter, turning yellow or orange when ripe; persistent calyx with patent-reflexed lobes. Seeds 4–8, albuminous, with ruminate endosperm.

D. malabarica var. *siamensis* differs in the persistent calyx which is broadly campanulate or flat

with ascending lobes.
D. mollis is characterized by ovate and smaller leaves, 4–8 cm × 1.5–4 cm, blackish when dry, smaller flowers with deeply lobed corolla, smaller fruits, black when ripe, and seeds with smooth endosperm.

Growth and development The woody seeds germinate in 30–60 days. Seedlings grow very slowly in the first 3–4 years. The mean annual girth increment of the Malabar ebony tree is reported to be 1.5–2.3 cm in India.
D. mollis does not flower until about the age of 30 years, but Siamese persimmon flowers earlier, at about 15 years of age. The flowers are insect-pollinated. Because male and female flowers do not bloom simultaneously breeding is hampered.
D. malabarica var. *malabarica* flowers in Java in September and October. *D. malabarica* var. *siamensis* flowers in Thailand from February to May, it fruits from May to December. *D. mollis* flowers from January to September and fruits from August to December.

Other botanical information *Diospyros* is a very large genus. Only a few species are primarily dye and tannin-producing plants; most are important as timber. Therefore the description of the genus is kept concise here. Other *Diospyros* species, which are known to be used in dyeing and tanning include *D. rhodocalyx* Kurz, *D. gracilis* Fletcher, *D. martabanica* C.B. Clarke, *D. dictyoneura* Hiern and *D. apiculata* Hiern from Thailand, *D. pyrrhocarpa* Miq. from Thailand and India, and *D. samoensis* A. Grey from Polynesia and New Guinea.

Ecology The varieties of *D. malabarica* are often found in shady and wet sites near streams in the forest, up to 500 m altitude. They occur naturally in places with up to 3000 mm annual precipation. In cultivation, Malabar ebony thrives on many types of soil, provided it is not too dry. *D. mollis* grows in dry, mixed, deciduous forest, up to 500 m altitude, in places with an annual rainfall of up to 2000 mm.

Propagation and planting Plants are propagated by seed, because propagation experiments by stem cuttings have never been successful. After collecting, the seeds should be cleaned from the pulp, dried in the shade and sown within 2 weeks. Experiments have shown that viability decreases rapidly during storage. Usually seeds are sown in a nursery at the beginning of the rainy season, after being soaked for 24 hours. Spacing is 10 cm within rows and 25 cm between rows, and the seedbeds are covered with a 9:1 mixture of coarse sand and black ash. The beds must be shaded and watered when conditions are dry. Seedlings are often transplanted into containers with soil containing 20% coarse sand, 10% black ash and 5% green manure. They are carefully transplanted to the field when ca. 15 cm tall, without damaging the long taproot. In a plantation of trees, a spacing of at least 8 m × 8 m is necessary because of the wide spreading crown. Trees are cultivated as a sole crop.

Husbandry Weeding is necessary at least 2–3 times a year during early stages of development. Generally, fertilizer is applied 1–2 times per year.

Diseases and pests The insects *Myllocerus setulifer* and *Stromatium barbatum* are reported to feed on the leaves of Malabar ebony. Some fungi may damage trees: *Diplodia embryopteridis* is found on the fruits, *Ceuthospora diospyri* and *Phyllosticta diospyri* on the leaves, *Hexagonia polygramma* in the wood.

Handling after harvest Unripe, still green fruits are used to dye cloth and tan nets. The average annual yield is 200 kg per tree for Siamese persimmon and 300 kg for *D. mollis*. The fruits cannot be kept longer than 5 days without losing much of their dyeing and tanning capacity, unless kept in water to which some lime has been added. Clothes are immersed in a solution of finely crushed fruits in water to which sometimes a mordant is added, and are then dried in the sun. When this handling is repeated about 20 times, the clothes take on a black, fairly fast colour. Sometimes the textiles are first dyed dark blue with indigo.

Prospects The *Diospyros* species treated here have several interesting uses and might be promising trees for South-East Asia. Research on silviculture and uses is desirable, especially for *D. mollis*. Malabar ebony is recommended as a road-side tree, as it is relatively resistant to air pollution.

Literature [1] Crevost, Ch. & Pételot, A., 1941. Catalogue des produits de l'Indochine. Tome 6. Tannins et tinctoriaux. Gouvernement général de l'Indochine, Hanoi. pp. 61–63. [2] Phengklai, C., 1981. Ebenaceae. In: Smitinand, T. & Larsen, K. (Editors): Flora of Thailand. Vol. 2. TISTR Press, Bangkok, Thailand. pp. 310, 329–331. [3] Sastri, B.N. (Editor), 1952. The wealth of India. Raw materials. Vol. 3. Council of Scientific and Industrial Research, New Delhi. pp. 85–86. [4] Sturm, G. & Zilliken, F., 1972. On the chemical constituents of Diospyros mollis fruits. Planta Medica 21(1): 61–66.

W. Subansenee & C. Phengklai

Excoecaria indica (Willd.) Muell. Arg.

Linnaea 32: 123 (1863).
EUPHORBIACEAE
$2n$ = unknown
Synonyms *Sapium indicum* Willd. (1805), *Stillingia indica* (Willd.) Baillon (1858), *Stillingia diversifolia* Miq. (1861).
Vernacular names Mock-willow (En). Indonesia: gurah (Sumatra). Malaysia: buta-buta, bebuta, kayu mati buta. Thailand: krahut, samo thale (central), ku-ra (peninsular). Vietnam: xói ân.
Origin and geographic distribution Mock-willow is very widely distributed. It is found in southern and eastern India, Burma, and further south and west through Malesia, except the Philippines, to New Guinea and the Solomon Islands.
Uses The leaves can be used to prepare a dye, which gives yarn a greenish-yellow colour or rattan a dark colour. The dyed yarn will gain a black colour when buried in the mud. A black colour can also be obtained by mixing the dye with charcoal and coconut oil. This mixture was formerly used in Indonesia to dye artificial hair tassels or wigs made of pineapple fibre black. The dye is also mixed with other dyes.
The young fruits are used as a fish poison; the stupefied fish can be eaten safely. The hard, globose fruits are used by children as marbles. The ripe seeds are used as vegetable or as condiment, but the fruit-wall should be removed carefully, because the latex it contains blisters the skin.
Medicinal uses are recorded as well; in Malaysia the leaves are applied to the abdomen to cure fevers, and an infusion of the leaves is used for gonorrhoea. A decoction of the root bark has purgative and emetic properties. The timber is of poor quality and is not used. The wood is used as fuel; it burns well.
Properties The latex, copious in unripe fruits and less abundant in other parts of the plant, is reported poisonous. Aesculetin, a substance poisonous to fish, has been isolated from the fruit. In the seeds 50–60% of a greenish-yellow oil is present.
Botany A small tree up to 18 m tall, usually less than 10 m, glabrous and containing latex; trunk short, not buttressed, with greyish, shallowly fissured bark; crown bushy, usually with upright branches and more or less drooping twigs. Leaves (narrowly) elliptic or lanceolate, 5–12 cm × 2–4 cm, finely crenate or serrate, apex tapered, with 2 small glands at the base of the blade; blades glossy green above, yellowish-green beneath, old leaves yellow; petiole 7–20 mm long, reddish. Flowers in (apparently) terminal, ca. 5 cm long spikes; male flowers many, with 3 stamens; female flowers solitary (or sometimes 2) at the base of the spike, with 3 long styles. Fruit a globose, woody capsule, 2.5–3 cm diameter, dark grey-brown to almost black, 3-seeded. In habit and in the leaves, this species resembles a willow.
In most literature mock-willow is found under the name *Sapium indicum*. In fact, the distinction between the genera *Sapium* P. Browne and *Excoecaria* L. is not clear, and botanists hold different views. However, in 1981 Airy Shaw placed the species in *Excoecaria*.
Ecology Mock-willow is usually found in wet places along rivers and near tidal marshes, but also in evergreen lowland forest, up to 250 m. Locally it is common.
Prospects The qualities of this species as dye, vegetable, condiment and medicine need better investigation. It might be an interesting species for lands too wet for other crops.

Excoecaria indica (Willd.) Muell. Arg. – 1, flowering branch; 2, detail of male part of inflorescence.

Literature 1 Airy Shaw, H.K., 1981. The

Euphorbiaceae of Sumatra. Kew Bulletin 36(2): 297. [2] Chadha, Y.R. (Editor), 1972. The wealth of India. Raw materials. Vol. 9. Publications & Information Directorate, Council of Scientific and Industrial Research, New Delhi. p. 229. [3] Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd ed. Vol. 1. The Malayan Nature Society. United Selangor Press, Kuala Lumpur. pp. 312–313. [4] Whitmore, T.C., 1973. Tree flora of Malaysia, a manual for foresters. Vol. 2. Longman, London. pp. 128–129.

Purwaningsih

Fibraurea tinctoria Lour.

Fl. Cochinch. 2: 626 (1790).
MENISPERMACEAE
$2n$ = unknown

Synonyms *Fibraurea chloroleuca* Miers (1871), *Fibraurea trotteri* Watt ex Diels (1910).

Vernacular names Indonesia: areuy gember (Sundanese), peron (Javanese), akar mangkedun (Bangka). Malaysia: sekunyit (Johore), akar kunyit (Iban, Sarawak), war birar (Murut, Sarawak). Thailand: kam-phaeng chetchan (central), kamin krua, kumin kua (peninsular). Vietnam: hoàng dằng, nam hoàng nhuộm.

Origin and geographic distribution *F. tinctoria* is widespread from north-eastern India and the Nicobar Islands, through Burma (Tenasserim), Thailand and Indo-China (Vietnam), east to southern China, and south to western and central Malesia. In Malesia it is found in Malaysia (Peninsular Malaysia, Sarawak, Sabah), Brunei, Indonesia (Sumatra, Java, Kalimantan, north-eastern Sulawesi) and the Philippines (Dinagat Island, north of Mindanao).

Uses The stem provides a yellow dye, which is locally used. In Kalimantan, it is used to dye mattings made from rattan and *Curculigo* species. The dye is also used for colouring cloth in India and Indo-China, and formerly in Malaysia. The yellow dye is sometimes mixed with indigo to prepare a green dye.

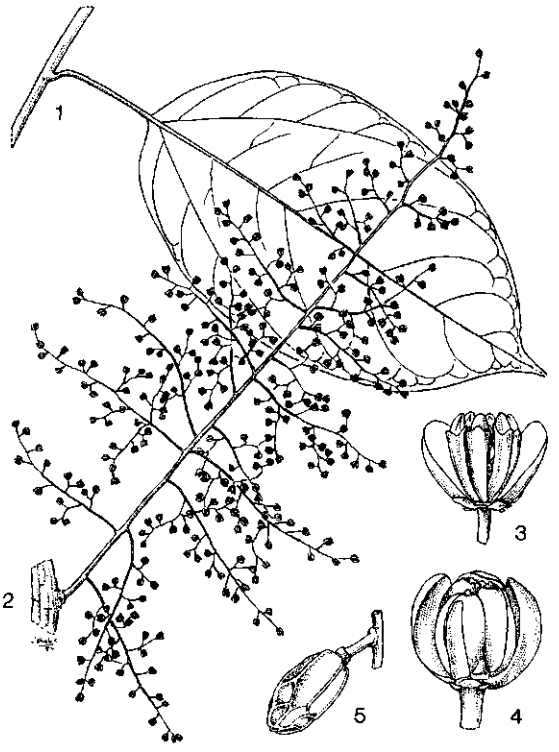
F. tinctoria has several medicinal properties. A decoction of roots and stems is employed to treat dysentery, diabetes and eye diseases in Java, and as a stomach medicine in Sarawak.

Properties The dye has been reported as being fairly permanent. The major alkaloid present in roots and stems is palmatine, a quaternary protoberbine derivate. Other alkaloids found include jatrorrhizine, colombamine and magnoflorine. The bitter substances of the columbin type fibraurin, chasmanthin and fibleucin have been isolated from bark and wood.

The plant has diuretic, analgesic and sedative activity.

The stems contain much water in the vessels as is common with climbers. The stem contains latex, the root a yellowish juice. The wood is bright yellow.

Botany A large woody, dioecious, entirely glabrous climber, up to 40 m long and with stem diameter up to 5 cm; root spongy and flexile; young shoot-tips tendrilliform; bark of older stems greyish-buff, coarsely and irregularly striate. Leaves spirally arranged, thinly coriaceous, simple and entire, exstipulate, elliptic to ovate, 10–20(–28) cm × (3.5–)5–14 cm, rounded, sometimes subpeltate at base, acuminate at apex, 3(–5)-nerved; petiole (2–)4–13 cm long, often drying blackish at least at the swollen base. Flowers in axillary or ramiflorous lax panicles, with 6 whitish or yellowish inner sepals 2.5–4 mm long, and 2–3 minute outer ones, petals lacking; male



Fibraurea tinctoria Lour. – 1, part of young stem with leaf; 2, part of old stem with male inflorescence; 3, male flower; 4, female flower; 5, dry fruit.

flowers sweetly scented, with 6 stamens having very thick columnar filaments; female flowers with 3 ellipsoidal carpels and 6 rudimentary stamens. Fruit composed of up to 3 yellow or orange drupes borne on a small knob-like carpophore.
The genus *Fibraurea* Lour. consists of 2 species: *F. tinctoria* and *F. recisa* Pierre. *F. recisa* differs from *F. tinctoria* in having only 3 stamens and a thinner endocarp. It is confined to Cambodia, Vietnam and southern China. The species have sometimes been confused in the literature. However, they are used for the same purposes. Possible confusion of *F. tinctoria* with *Arcangelisia flava* (L.) Merr. has also been reported.

Ecology *F. tinctoria* is usually found in lowland forest, primary as well as secondary or disturbed, up to 1200 m altitude. It is locally common, for instance in dry evergreen forest in Thailand, and in peat swamp forest in Sarawak. This species also occurs in bamboo forest and scrubby vegetations, along river banks and in logged forest. It grows on various soils: sandy loam, clayey soil, ultrabasic soil, sandstone and stony blackish soil.

Harvesting For the preparation of a dye-bath, stems are collected, and the wood is cut into small pieces. Slices of the stems are also sold in pharmacies for medicinal purposes.

Prospects This species is another example of a dye-producing plant which has completely lost its importance. Although *F. tinctoria* was formerly used for dyeing in many places in its large area of distribution, it is now probably almost exclusively used in traditional medicine.

Literature [1] Bisset, N.G., 1985. Phytochemistry. Kew Bulletin 40(3): 540–541. [2] Forman, L.L., 1985. A revision of tribe Fibraureae (Menispermaceae) in Asia. The Menispermaceae of Malesia and adjacent areas 13. Kew Bulletin 40(3): 539–551. [3] Forman, L.L., 1986. Menispermaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana, Series 1. Vol. 10(2). pp. 207–209, fig. 9(a–h). [4] Siwon, J., Thijs, C., Verpoorte, R. & Baerheim Svendsen, A., 1978. Studies on Indonesian medicinal plants. The alkaloids of Fibraurea chloroleuca Miers. Pharmaceutisch Weekblad voor Nederland 113: 1153–1156.

R.H.M.J. Lemmens

Garcinia hanburyi Hook.f.

Journ. Linn. Soc. Lond. 14: 485 (1875).
GUTTIFERAE
$2n = 44$

Synonyms *Garcinia morella* Desr. var. *pedicellata* Hanbury (1864).

Vernacular names Gamboge tree (En). Cambodia: rung. Thailand: rong. Vietnam: vàng nghệ, dang hoàng.

Origin and geographic distribution Gamboge tree is a native of Cambodia, southern Vietnam and Thailand. It has been introduced in Singapore.

Uses This tree is valued because of the resinous sap, called gamboge, which exudes from incisions in the bark. This sap is used as a golden-yellow colouring matter for varnishes, lacquer, paints, and ink.
Gamboge is a drastic purgative, an emetic, and a vermifuge for treating tapeworm, but it is no longer used in human medicine. Sometimes it is given to cows as purgative.
The wood is sometimes used for interior work.

Properties The reddish-yellow to brownish-orange sap contains 70–80% resin and 15–25% gum. The main acidic component of the resin is cambogic acid ($C_{38}H_{44}O_8$). The main components of the gum are arabinose (ca. 50%), and galactose (ca. 40%); the gum is soluble in water and forms a yellow emulsion in water. Gamboge is odourless and tasteless or slightly acid. Large doses of gamboge, administered as a medicine, can be fatal.
The wood is pale or brownish-yellow, straight grained, with fine texture, and fairly heavy, weighing about 900 kg/m^3. It is moderately hard and works easily; it takes a fine polish.

Botany An evergreen, small to medium-sized tree, up to 15 m tall, with short and straight trunk, up to 20 cm in diameter; bark grey, smooth, 4–6 mm thick, exuding a yellow gum-resin. Leaves opposite, leathery, elliptic or ovate-lanceolate, 10–25 cm × 3–10 cm, cuneate at base, acuminate at apex, shortly stalked. Flowers in clusters or solitary in the axils of fallen leaves, 4-merous, pale yellow and fragrant, unisexual or bisexual; male flowers somewhat smaller than female and bisexual; sepals leathery, orbicular, 4–6 mm long, persistent; petals ovate, 6–7 mm long; stamens numerous and arranged on an elevated receptacle in male flowers, less numerous and reduced in female flowers; ovary superior, 4-loculed, with sessile stigma. Fruit a globose berry, 2–3 cm in diameter, smooth, with recurved sepals at the base and crowned by the persistent stigma, 1–4-seeded.

Garcinia hanburyi Hook.f. – 1, flowering branch; 2, male flower with front sepal and petals removed; 3, fruit.

Seeds 15–20 mm long, surrounded by a pulpy aril. The gum-resin from *G. hanburyi* is often called Siamese gamboge to distinguish it from the similar product from the bark of *G. morella* Desr., called Indian gamboge. The species are closely related, and *G. hanburyi* has been considered in the past as a variety of *G. morella*.

Ecology Gamboge tree occurs naturally in rain forest on altitudes up to 800 m, with annual rainfall up to 2500 mm. Normally it flowers in November and December and fruits from February to April.

Harvesting Gamboge tree is not in cultivation; only wild trees are tapped. Usually trees are not tapped before they are 20 years old, when the trunk has attained a diameter of about 15 cm. A spiral incision is made in the trunk just below the lowest branches, and the exudate is collected in a bamboo container. About every 3 days the content is poured into smaller bamboo stem parts (about 75 cm long), in which the gum-resin coagulates in about a month or longer. The bamboo containers are then cracked and the gamboge is removed in cylindrical sticks (pipe gamboge), which is the usual form in trade. Sometimes gamboge is moulded and pressed into cakes.

Prospects In Singapore, gamboge tree has been planted successfully. It has never been tried elsewhere in Malesia. As it is apparently well-suited to a moist climate, it is a promising tree for the production of dyeing material and lacquer.

Literature 1 Anonymous, 1895. Siam gamboge. Kew Bulletin (1895): 139–140. 2 Crevost, Ch., 1927. Catalogue des produits de l'Indochine. Tome 4. Exsudats végétaux–stick-lac. Gouvernement général de l'Indochine, Hanoi. pp. 80–85 + fig. 3 Perry, L.M., 1980. Medicinal plants of East and Southeast Asia. Massachusetts Institute of Technology Press, Cambridge, Massachusetts, USA. p. 174. 4 Sastri, B.N. (Editor), 1956. The wealth of India. Raw materials. Vol. 4. Council of Scientific and Industrial Research, New Delhi, India. p. 106.

K. Chayamarit

Gardenia jasminoides Ellis

Philos. Trans. 51(2): 935, t. 23 (1761).
RUBIACEAE
$2n = 22$

Synonyms *Gardenia florida* L. (1762), *Gardenia grandiflora* Lour. (1790), *Gardenia augusta* (L.) Merr. (1917).

Vernacular names Cape jasmine, garden gardenia (En). Indonesia: kaca piring (Sundanese), ceplok piring (Javanese), jempiring (Bali). Malaysia: bunga cina, bunga susu, sangklapa. Philippines: rosal (Tagalog). Laos: inthavaa, ph'ud. Thailand: khet-thawaa (northern), phut cheen (central), phut-tharaksaa (Ratchaburi). Vietnam: dành dành.

Origin and geographic distribution Cape jasmine is indigenous in southern China, Japan, the Ryukyu Islands, and Taiwan, possibly also locally in Sri Lanka. It is widely cultivated in the tropics and subtropics, and sometimes naturalized. In South-East Asia it is commonly planted in gardens.

Uses The pulp of the fruit is used in China and Japan for colouring food yellow. Some extracts are commercially available in Japan; they are used to colour boiled beans, fish eggs, hot cakes, liquor, sweets, ices, noodles, candies and imitation crab. Occasionally textiles are also dyed yellow or scarlet, although the colour is rather impermanent. Cape jasmine is often planted as an ornamental, and sometimes for hedges. The fragrant flowers are

used in perfumery, and in China they are used for flavouring tea. Several parts of the plant are used medicinally. The roots are used against headache, dyspepsia, nervous disorders, and fever; the leaves are applied in febrifugous poultices; the fruits are used against jaundice and diseases of kidneys and lungs.

Properties The colouring matter in the fruits contains a glycoside, which is identical with crocetin from saffron (*Crocus sativus* L.). This carotenoid pigment can be extracted from cape jasmine in larger quantities than from saffron, and without the accompanying flavours; this has led to the development of 'gardenia extracts' as a pigment source. Several patents have been developed during the 1980s, many of them in Japan. Many of these patents involve extraction of the fruit followed by treatment with proteases or ß-glucosidase which react with primary amines from proteins or amino-acids. Through altering the conditions a variety of colours including yellow, red, violet, green and blue can be obtained. The oil extracted from the flowers is fragrant, especially because of the presence of styrene acetate. The bark contains ß-sitosterol and nonakosane, the leaves and flowers contain mannit. The seeds contain starch and an oil which is principally composed of palmatic, oleic and linoleic acid.

Gardenia jasminoides Ellis – 1, flowering branch; 2, fruiting branch.

Botany Usually an evergreen, erect shrub up to 2 m tall, but small trees up to 12 m tall have been recorded. Roots strong. Stem up to 10 cm in diameter, usually much branched. Leaves opposite, elliptic to oblong-ovate, 5–10(–15) cm × 2–4.5(–7) cm, cuneate at base, acute or acuminate at apex, shortly petiolate and with stipules connate in pairs. Flowers large, solitary in the axils of the upper leaves, (sub)sessile, very fragrant; calyx 5–8-lobed, persistent corolla white, later yellowish, tube ca. 3 cm long, lobes 5–8, spreading; anthers as many as corolla lobes, linear and sessile; ovary inferior, style long, stigmas capitate. Fruit a leathery, ovoid or ellipsoid berry, 1.5–3(–4.5) cm long, 5-ribbed, crowned with the persistent calyx, yellow to red at maturity, containing many seeds.

Plants cultivated as ornamental in South-East Asia are often double-flowered, with petaloid or poorly developed stamens and sterile ovary. Several cultivars are sold as garden plants, for instance the large-flowered cultivars 'August Beauty', 'Florida' and 'Fortuniani', or dwarf plants such as 'Radicans'. 'Mystery' is a tall cultivar, used as shade tree.

Ecology Cape jasmine is originally a species from temperate climates. In tropical areas it grows well, at altitudes of 400–1200 m. In the tropical lowland it flowers poorly or not at all. It thrives best on properly drained, but not too dry soils, with pH 6–7, and it prefers sunny places.

Agronomy The plant is usually propagated by cuttings or by marcotting; the best time is soon after flowering, and younger branches should be used. Cattle manure or compost should be applied regularly. Plants may start flowering as soon as one year after planting. Regular pruning after flowering is advisable.

The most common pest is mealy bug, often followed by sooty mould, covering the leaves with a greyish-black layer. This pest can be controlled by spraying with a kerosine emulsion containing derris or nicotine.

Prospects Cape jasmine has potential as a substitute for chemical substances in colouring food. However, more research is needed to prove the harmless character of the dye. It is an interesting ornamental plant, and also has potential as a source of natural perfume.

Literature [1] Freund, P.R., Washam, C.J. & Maggion, M., 1988. Natural color for use in foods. Cereal Foods World 33(7): 553–559. [2] Holttum, R.E., 1971. Gardening in the lowlands of Malaya. The Straits Times Press Ltd., Singapore. pp. 106,

136. 3 Sastri, B.N. (Editor), 1956. The wealth of India. Raw materials. Vol. 4. Council of Scientific and Industrial Research, New Delhi. p. 110. 4 Smith, A.C., 1974. The genus Gardenia. American Journal of Botany 61: 113–114.

H. Sangat-Roemantyo & Wirdateti

Haematoxylum campechianum L.

Sp. Pl. 1: 384 (1753).
LEGUMINOSAE
$2n = 24$

Vernacular names Logwood, campeachy wood, blackwood (En). Bois de campèche, bois bleu, bois de sang (Fr).

Origin and geographic distribution Logwood is indigenous to Central America and the adjoining parts of South America. The plant was discovered by the Spanish on the shores of Campeche Bay in the Gulf of Mexico before 1525. It was introduced into the Caribbean where it widely naturalized, and into most parts of the Old World tropics, e.g. South-East Asia. It was introduced in Singapore in 1876. Logwood is cultivated on a very limited scale in Malaysia (Penang), Indonesia (Java), and the Philippines.

Uses The main product of the tree is the heartwood; it is the logwood of commerce. This wood yields a series of dyes in darker tints of grey, brown, violet, blue and black. The dyes give a fairly permanent colour to several natural fabrics such as silk, wool, and sometimes cotton, but also to synthetics such as nylon and rayon. They may be used to dye leather as well as fur, feathers, paper and bone, and also in the manufacture of inks. Haematoxylin, the colouring agent of logwood, is a histological stain used for staining cell nuclei; alcoholic solutions serve as indicator for alkaloid titration.

Logwood may be grown in gardens as a hedge, or for its delicate foliage and fragrant flowers. These flowers are the source of a very good honey.

As timber, its use is largely limited by the irregularity of the trunk. The wood is strong but brittle; it is durable for use outdoors and in contact with the ground. It is sometimes used for furniture and fancy articles because it may be finished to a very smooth surface and takes a high polish. The wood burns readily. Medicinally it is a mild astringent; its value is attributed to the presence of tannin and haematoxylin. As an astringent and tonic it is prescribed in the form of a decoction and liquid extract. It is also useful against diarrhoea, dysentery, atonic dyspepsia and leucorrhoea. An ointment prepared from the wood is said to be useful against cancer and hospital gangrene. Haematoxylin has been shown to possess anti-inflammatory properties.

In South-East Asia, and also in India, logwood is only occasionally cultivated as hedge plant or ornamental, not for production of dyewood.

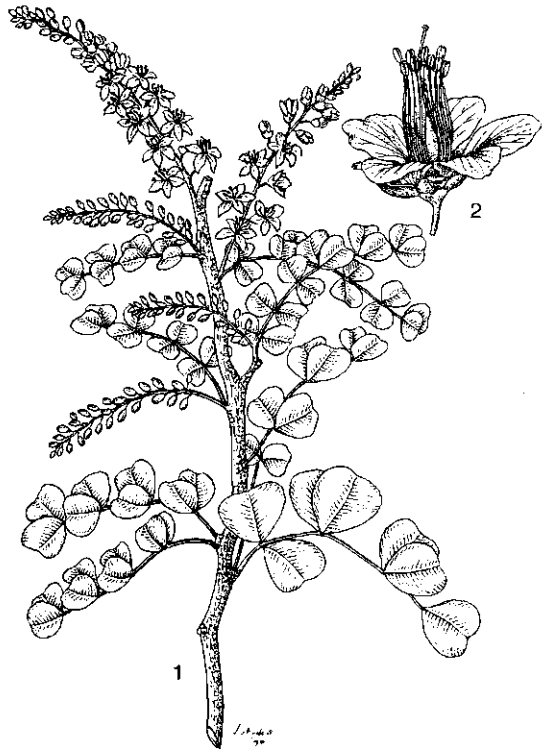
Production and international trade With annual exports of 100000 t of wood, the logwood industry reached its peak during the latter half of the 19th Century. Logwood cutting is now a minor industry. To cheapen the cost of transport, logwood is mainly traded in the form of powdered extracts today.

The total logwood trade in 1990 is unlikely to be more than 500 t/year and might be much less. The main commercially producing countries are in the Caribbean area. France and Switzerland are the major importers. They are the main suppliers to the consuming countries in Europe, North America and Japan. In recent decades the price has fluctuated considerably.

Properties Immediately after the tree has been felled, its heartwood is yellowish. On exposure to air it gradually acquires a bright reddish colour. Later it becomes dark purple with darker stripes, frequently tinged orange. Old wood may be coloured red. These different colours of the wood are caused by different substances. Fresh young wood contains about 10% colourless haematoxylin. This oxidizes to haematoxein, in pure form a dark violet crystalline substance with a green metallic lustre. In dyeing, the dyer produces haematoxein from haematoxylin. Haematoxylin is soluble in water, and is extracted from chips of the wood. Haematoxein is far less soluble in water and during the dyeing process it may be converted into isohaematin, which is even less soluble.

Besides haematoxylin, heartwood contains tannin, resin, quercetin, traces of volatile oil, oxalic acid, and acetic acid. The wood is very hard and heavy, with an air-dry weight of 950–1085 kg/m^3. The wood is compact, the grain interlocked, the texture is coarse but fairly even. It has an agreeable odour resembling violets, and a sweet astringent taste. The sapwood ring is thin, white or yellowish, and does not contain haematoxylin.

Description A small, bushy tree up to 15 m tall, but usually smaller, often thorny and gnarled; trunk irregularly fluted and contorted, attaining a length of 2–3 m and a diameter of 60 cm, although usually much less, prolonged into large, rather long and straight branches; bark grey to brown,



Haematoxylum campechianum L. – 1, flowering branch; 2, flower.

rather smooth, peeling in flakes. Leaves alternate, paripinnate, distichous or fascicled on very short branches; stipules partly small and caducous, partly spine-like; leaflets in 2–4 pairs, obcordate or obovate, 10–35 mm × 5–25 mm, acute at base, emarginate at apex, closely veined and glabrous. Flowers in 5–20 cm long racemes in the axils of present or fallen leaves, 5-merous, sweet-scented; calyx 4–5 mm long, deeply lobed; petals 5–7 mm long, bright yellow; stamens 10, free; ovary superior, shortly stalked, glabrous; style filiform. Fruit a lanceolate, extremely flattened pod, 3–5 cm long, pointed at both ends, dehiscent not along the sutures but along the median of the sides, usually 2-seeded.

Growth and development Logwood grows slowly, but cultivation is easy. With favourable growing conditions, the trees attain harvestable size in about 12 years. However, trees planted in the botanical garden at Bogor (Indonesia) in 1886 were only 2 m tall in 1918.

Other botanical information *Haematoxylum* L. ('bloodwood') is a small genus with about 4 species. It is indigenous to Central America and southern Africa. In Central America 2 species are usually distinguished, both producing a dye in the wood. Only *H. campechianum* has spread over most of the tropics.

In Central America logwood trees which do not produce haematoxylin have been found. They are referred to as 'bastard logwood'.

Ecology Logwood is a lowland species which may grow under very different conditions. In Central America it grows best in flat marshy areas often inundated by rivers. In the West Indies, the best wood is produced in interior valleys and moist coves in the lower slopes of hills. In Jamaica, logwood is common on exposed limestone hillsides in dry secondary thickets. Logwood prefers light soils with some humus.

Propagation and planting Logwood is propagated by seed or cuttings.

Harvesting In Central America logwood is mostly collected from the wild where it occasionally forms almost pure stands.

The older the tree, the richer the colour of the wood because of oxidation of haematoxylin. In trade, however, wood with non-oxidized haematoxylin, thus young wood, is preferred. At harvest, the wood is cut into pieces 1–2.5 m long, and the sapwood is removed.

Handling after harvest The pieces of wood are transported to the factory where they are mechanically reduced to small chips. The dye is extracted in boiling water, the resulting orange-red solution turns yellow and later black when cooled. After evaporation a powder remains.

Genetic resources No specific data are available on the genetic variability, but the wide variation in habitats and the existence of plants lacking haematoxylin suggest considerable variation within the species.

Prospects A more or less constant group of consumers appreciate logwood for its specific properties. The inadequacy of the alternatives has helped to maintain a reasonably good market outlook for the product. In fact, logwood is one of the few vegetable dyes with current importance on the world market. Although world demand is not expected to increase substantially, experiments on the cultivation of logwood in South-East Asia might be worthwhile.

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Palo de campeche (Haematoxylon campechianum L.). Inireb Informa. Communicado 17. Mexico. 3 pp. 3 Kochhar, S.L., 1981. Economic botany in the tropics. MacMillan India Ltd, Delhi, Bombay, Calcutta, Madras. pp. 380–381. 4 Sastri, B.N. (Editor), 1959. The wealth of India. Raw materials. Vol. 5. Council of Scientific and Industrial Research, New Delhi. pp. 2–3.

C.J.P. Seegeler

Impatiens balsamina L.

Sp. Pl. 2: 938 (1753).

BALSAMINACEAE

$2n = 14 (+ 2B)$, but also recorded as 12, 18, 20, 24

Synonyms *Impatiens cornuta* L. (1753).

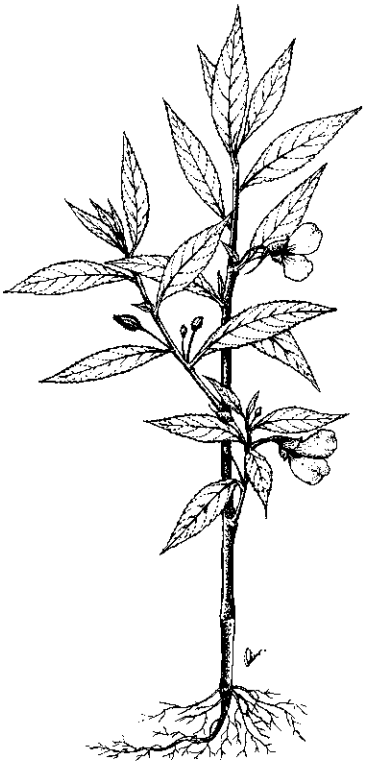
Vernacular names Garden balsam, garden balsamine (En). Balsamine des jardins (Fr). Indonesia: pacar air (general), pacar banyu (Javanese), paru inai (Minangkabau). Malaysia: bungatabo, inai ayer, laka kecil. Philippines: kamantigi (Tagalog, Ilokano), solonga (Bisaya). Burma: dau dalet. Thailand: thian dok, thian baan, thian suan (central). Vietnam: moc tai, bông mong tay (southern), nac ne'.

Origin and geographic distribution Garden balsam is a native of India and parts of mainland South-East Asia. It is widely cultivated and often naturalized in tropical and subtropical regions; it is also cultivated in temperate regions. Throughout South-East Asia it is commonly grown in gardens.

Uses The flowers are used to prepare a red dye for finger nails, as a substitute for henna (*Lawsonia inermis* L.). Because of its large and usually red flowers, garden balsam is commonly cultivated as an ornamental in gardens. It has several medicinal uses. Leaves and sometimes roots are used in poultices for wounds, skin diseases, pustules, torn nails, and felons. Flowers have fungicidal and possibly also bactericidal properties, and are said to be effective in cases of lumbago, intercostal neuralgia and as haemostatic. The seeds are edible, and contain oil which can be used for burning lamps and in the surface-coating industry. In Bali (Indonesia) the leaves are eaten. In China, the flowers are used as a cosmetic just like henna flowers.

Properties The flowers of garden balsam contain the same dyeing agent as henna, lawsone or 2-hydroxy-1,4-naphthaquinone, which explains the matching uses. Also present is 2-methoxy-1,4-naphthaquinone (lawsone-methylether) which possesses fungicidal properties. The pigments in the flowers have been investigated extensively, and include leucoanthocyanins, anthocyanins and flavonols. The seeds contain 18–27% of a greenish, viscous oil, largely consisting of parinaric acid (29%) and linolenic acid (30%). The seeds contain about 16% protein and no starch.

Botany An annual herb, 15–60(–80) cm tall. Stems erect, simple or sparsely branched, with swollen joints, glabrous, or pubescent when young. Leaves arranged spirally, but lower leaves occasionally opposite, (narrowly) lanceolate to narrowly elliptic, 3–10(–15) cm × 1.5–3 cm, cuneate at base, acute at apex, serrate, glabrous, and sessile or shortly petiolate. Flowers 1–3 together in leaf-axils, red, purple, white or variegated, variable in size, up to 3.5 cm long, with slender pedicels; sepals 3, the lowest one larger, petaloid, funnel-shaped and spurred; petals 5, seemingly 3, the upper one free and long-mucronate at apex, the other 4 pairwise connate; stamens 5, fused in the upper half; ovary superior, densely



Impatiens balsamina L. – flowering and fruiting plant.

pubescent. Fruit a fleshy 4–5-valved capsule, explosively dehiscent, broadly fusiform, 12–20 mm × 6–8 mm, densely pubescent.

Garden balsam is a very variable species, particularly in the size of leaves and flowers. Many varieties and cultivars have been recognized. Double-flowered plants and dwarf forms have been selected for ornamental purposes.

Ecology Garden balsam is found naturally from sea-level to 1250 m altitude on wet, rather open places or as forest undergrowth. In cultivation it thrives best in rich, loose soil with water freely available. In the tropics it usually flowers all the year round.

Agronomy Plants are easily propagated from seed. Seedlings are raised in the nursery. A mixture of coconut dust, coarse sand, and clayey soil in the ratio of 3:1:1 is recommended as potting material, applied with 50 g of castor meal and 20 g of fertilizer per pot. Garden balsam is susceptible to powdery mildew, often caused by *Sphaerotheca fuliginea*.

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L. Phuphathanaphong

Indigofera L.

Sp. Pl. 2: 751 (1753); Gen. Pl. (ed. 5): 333 (1754).

LEGUMINOSAE

$x = 8$; $2n = 16$: *I. arrecta*, *I. suffruticosa*, *I. tinctoria*

Major species and synonyms

- *Indigofera arrecta* Hochst. ex A. Rich., Tent. Fl. Abys. 1: 184 (1847);
- *Indigofera suffruticosa* Miller ssp. *suffruticosa*, Gard. Dict. ed. 8, No 2 (1768), synonym: *I. anil* L. (1771);
- *Indigofera suffruticosa* Miller ssp. *guatemalensis* (Mocino, Sessé & Cerv. ex Backer) de Kort & Thijsse, Blumea 30: 135 (1984), synonym: *I. guatemalensis* Mocino, Sessé & Cerv. ex Backer (1908);
- *Indigofera tinctoria* L., Sp. Pl. 2: 751 (1753), synonym: *I. sumatrana* Gaertner (1791).

Vernacular names General: indigo (En). Indonesia: tom, tarum. Malaysia: tarom. Philippines: anil. Thailand: khram. Vietnam: châm.

- *I. arrecta*: Natal-indigo, Bengal-indigo, Java-indigo (En). Indonesia: tom atal, tom katemas (Javanese).
- *I. suffruticosa* ssp. *suffruticosa*: Indonesia: taem-taem, tagom-tagom, tom cantik. Philippines: tina-tinaan (Tagalog), tayum (Bisaya, Ilokano). Thailand: khraam-thuean (Shan-Chiang Mai), khraam yai (Ubon Ratchathani).
- *I. suffruticosa* ssp. *guatemalensis*: Guatemala-indigo (En). Indonesia: tom presi.
- *I. tinctoria*: Common indigo, Indian indigo (En). Indonesia: tom jawa, tarum alus, tarum kaju. Malaysia: nila, tarum. Philippines: tagung-tagung (Bisaya), taiom (Ilokano), taiung (Pampango). Cambodia: trôm. Laos: khaam. Thailand: khraam (general), na-kho (Karen, Mae Hong Son). Vietnam: chàm, chàm nhuôm.

Origin and geographic distribution The large genus *Indigofera* (ca. 700 spp.) is distributed throughout the tropics and subtropics of Asia, Africa and the Americas; most of the species occur in Africa and the southern Himalayas. About 40 species are native to South-East Asia, and many others have been introduced. Many species are cultivated in all tropical regions. *I. arrecta* is a native of East and southern Africa and has been introduced in Laos, Vietnam, the Philippines (Luzon) and Indonesia (Sumatra, Java, Sumba, Flores). Both the subspecies of *I. suffruticosa* originate from tropical America, and are locally cultivated in Java. *I. tinctoria* probably originates from Asia, but its distribution is now pantropical.

Uses *Indigofera* species are widely used as a source of the blue dye indigo throughout the tropics. They are also recommended as a cover crop and for green manure, especially in tea, coffee and rubber plantations. The leaves of *I. arrecta* and *I. tinctoria* are used in traditional medicines for epilepsy and nervous disorders and to heal sores and ulcers.

Production and international trade The cultivation of *Indigofera* on a large scale started in the 16th Century in India and South-East Asia. Later large plantations were also established in Central America and the southern United States. The export of indigo to Europe was of great importance and had to compete with the dye from woad, *Isatis tinctoria* L., which was cultivated mainly in France, Germany and Great Britain. The commercial production of synthetic indigo, which came

into use in 1897, proved catastrophic to the production of natural indigo, and by 1914 only 4% of the total world production was of vegetable origin. At present, the crop is still cultivated for dye on a small scale in India (in the northern part of Karnataka) and in some parts of Africa and Central America. In Indonesia, *Indigofera* is still grown in some villages on the north coast of Java and in the whole of east Indonesia where natural indigo is used for traditional and ritual fabrics.

Properties *Indigofera* plants contain the glucoside indican. After soaking the plants in water, enzymic hydrolysis transforms indican into indoxyl (indigo-white) and glucose. Indoxyl can be oxidized to indigo-blue.

Many species contain toxic organic nitro compounds. However, *I. tinctoria* is said to be palatable to cattle.

The leaves of *I. arrecta* and *I. tinctoria* contain respectively (% dry matter basis): N 4.46, 5.11; P_2O_5 0.02, 0.78; K_2O 1.95, 1.67; CaO 4.48, 5.35.

Description The genus *Indigofera* comprises shrubs, shrublets and herbs (but then woody at the base), with spreading or ascending branches and with indumentum of biramous hairs. Leaves alternate, usually imparipinnate, sometimes trifoliolate or unifoliolate. Flowers in axillary racemes, pedicelled, calyx campanulate with 5 teeth, corolla papilionaceous. Fruit generally a linear pod (in some species almost globose), straight or upcurved, with 1–20 mostly globose to ellipsoid seeds. Seedlings with epigeal germination, cotyledons thick, short-lasting.

I. arrecta is a large shrub up to 3 m tall, often cultivated as an annual, with ca. 5 mm long flowers and 2–2.5 cm long straight pods, containing 6–8 seeds.

I. suffruticosa ssp. *suffruticosa* is a shrub up to 2.5 m tall with 5 mm long flowers and curved pods, containing 4–6 seeds.

I. suffruticosa ssp. *guatemalensis* has smaller flowers (3 mm) and straight pods with 1–3 seeds.

I. tinctoria is a small shrub (up to 1 m tall) with 5 mm long flowers, straight or slightly curved pods, containing 7–12 seeds.

Other botanical information *I. arrecta*, *I. suffruticosa* and *I. tinctoria* are closely related and intermediate specimens (possibly of hybrid origin) have been found.

In India, *Indigofera articulata* Gouan has also been cultivated as a dye-producing plant. However, it has never been introduced for dyeing in South-East Asia.

Ecology *Indigofera* species can be grown from sea-level up to 1650 m and do best on permeable soils, rich in organic matter. As a dye plant *Indigofera* is grown on upland soils and as a secondary crop on paddy soils. Land should be properly drained.

When used as a cover crop, *I. arrecta* can only be grown in gardens with little or no shade. Plants prefer a hot, moist climate with a rainfall of no less than 1750 mm/year. The crop withstands waterlogging for up to 2 months.

I. tinctoria does not tolerate heavy rainfall and waterlogging.

In the natural or naturalized state, species are found on open, sunny places such as wasteland, road-sides, riverbanks and grassland, sometimes up to 2000 m above sea-level.

Propagation and planting Propagation is by seed, except for *I. suffruticosa*, which is propagated by cuttings. To prevent insect damage seeds can be treated with wood ash before sowing. Seeds of *I. arrecta* possess a hard seed-coat and must be scarified. Land is prepared by ploughing or by hoeing. Sowing is done either on seed-beds or directly into the field, 3–4 seeds per hole, 60 cm apart within

Indigofera tinctoria L. – 1, flowering branch.
Indigofera suffruticosa Miller – 2, fruit.

rows and 45–60 cm between rows. Germination takes about 4 days. When seed-beds are used, seedlings are transplanted at 4–6 weeks.
Cuttings are made by dividing well-developed branches into pieces 30 cm long, which are kept for 2–3 days in a cool place before planting.
Cuttings, 2–3 per hole, start rooting by the second week.

Husbandry Weeding and earthing up is done about 1 month after planting and again 1 month later. Cover crops are slashed at regular intervals.

Diseases and pests *I. arrecta* can be attacked by *Bacillus solanacearum*. On Java *I. tinctoria* is not susceptible to pests and diseases; after lignification, however, in humid regions, it is attacked by *Corticium salmonicolor* (jamur upas). In other production areas *I. tinctoria* is reported to be attacked by various fungi and insects and by the nematode *Heterodera glycines*.

Harvesting Branches are harvested, usually early in the morning, when the plants are 4–5 months old and the crop has made a closed stand. This is usually the flowering stage. About 3–4 months later the plants can be cut again; a crop can be harvested three times a year. The total life span for dye crops is 2–3 years, and 1.5–2 years for cover crops. Indigo is harvested only once on paddy soils because the plants must give way for the next rice crop.

Yield *I. arrecta* is the chief source of blue dye; it is also used as a cover crop and a green manure crop. The yield from this species is higher than from any other species of *Indigofera*. Annual yields of 22–100 t green matter per ha have been reported in India; the recorded output of indigo cake is 137–325 kg/ha per year.
Yields of *I. tinctoria* as a dye crop are in the order of 10–13 t/ha of green matter per year, but may vary widely according to area, season and cultivation method.

Handling after harvest The harvested branches are placed in a tank containing water to which some lime has been added and weighted down with planks. After some hours of fermentation, during which enzymic hydrolysis leads to the formation of indoxyl, the liquid is drained off and stirred continuously for several hours to stimulate oxidation of the indoxyl. Afterwards the solution is left to rest and the insoluble indigo settles to the bottom as a blueish sludge. The water is drained and after the indigo has dried, it is cut into cubes or made into balls. To dye textiles, indigo is reduced to a soluble form by a fermentation process under alkaline conditions. In traditional preparations of the dye, various reducing agents such as molasses are used, together with coconut-milk, bananas and the leaves of *Psidium guajava* L. The alkalinity is maintained by adding lime. After the textile has been dipped into the solution it turns blue when exposed to the air.

Prospects Indigo has been called 'the king of dyes'. No dye plant was as closely combined with culture as the indigo plant. The deep blue colour of the dye was highly appreciated, and its history is remarkable and covers thousands of years. However, the use of indigo of vegetable origin has nearly died out and it has been almost completely replaced by synthetic indigo. In recent years, interest in natural dyes has been increasing in many countries, not only because of concern about the environmental pollution caused by dye-producing chemical industries and the suspected injurious effects of synthetic dyes to health, but also because there has been a revival of interest in the relation between dyes and culture. Hopefully this new interest will gain ground rapidly enough to prevent indigo from disappearing completely as a crop in South-East Asia.

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R.H.M.J. Lemmens & P.C. Wessel-Riemens

Lawsonia inermis L.

Sp. Pl. 1: 349 (1753).
LYTHRACEAE
$2n = 30$

Synonyms *Lawsonia spinosa* L. (1753), *Lawsonia alba* Lamk (1789).

Vernacular names Henna, Egyptian privet, camphire (En). Henné (Fr). Indonesia: inai (general), pacar kuku (Javanese). Malaysia: pacar kuku, inai, hinna. Philippines: cinamomo (Tagalog). Burma: dan. Cambodia: krâpéén. Laos: kaaw.

Thailand: thian khaao, thian daeng, thian king. Vietnam: lá mòn, nhuộm móng tay.

Origin and geographic distribution Henna occurs wild from Iran to western India. From there it has been spread eastward to the rest of India and Indonesia, and westward to the Middle East where it became one of the important plants of Islam. It later followed Islamic armies and traders from Arabia reaching as far as Spain, Madagascar, the Moluccas, Indo-China and Japan. It is now distributed throughout the tropics and subtropics. Henna is mostly grown in home gardens and commercial production is limited to a few places in India, Pakistan, Egypt, Libya, and the Sudan.

Uses Henna is one of the oldest cosmetics in the world and its leaves are used to colour the fingernails, to paint or decorate the palms of the hands and the soles of the feet, and to dye the hair. Written records of its use date back more than 2500 years. It is of great importance in Islam, where it is used in many ceremonies, especially marriage. This latter use has been adopted also in Hinduism. Henna is also used as a perfume.

Throughout South-East Asia and Indo-China up to Japan it is mainly used by women as a dye for the fingernails. In other areas this is only a secondary use. The use of henna to dye the palms of the hands and the soles of the feet has spread through most of the Muslim world and India. As part of the preparations for the marriage ceremony, the hands and feet of the bride are often very elaborately decorated. Henna is used universally as a basis for hair dyes. A wide range of shades from shining, reddish-blond to chestnut brown and intense, deep black can be obtained by the use of admixtures or by combining the treatment with other ones. Indigo is commonly added to obtain a black colour. This use of henna is not restricted to women. In Iran and Afghanistan men often use it to dye their hair and beards. It is even used to dye the manes and tails of horses of dignitaries for grand parades.

To prepare the dye for skin, nails or hair, fresh or dried leaves or henna powder are rubbed with water to which some lemon juice and lime are added to obtain a paste. Depending on the use, the colour required, and the locality, substances like gambier, powder of areca nut, indigo or alum may be added. The paste is carefully applied to the skin or nails, or rubbed into the hair and left for 6–12 hours, covered with a damp cloth or sometimes a betel leaf. The colour is fast and cannot be removed by washing; it has to wear off.

In the past, henna was widely used to dye silk and wool, and less commonly cotton. It may still be used in the dyeing of Morocco leather.

The use of a perfume made from the flowers of henna is largely restricted to Egypt, northern India and Java. The perfume is greenish in colour and is prepared by macerating the flowers in oil.

Henna is widely grown in gardens as an ornamental or as a hedge plant, appreciated for the strong, pleasant fragrance of its flowers, which is reminiscent of tea rose (*Rosa chinensis* Jacq.).

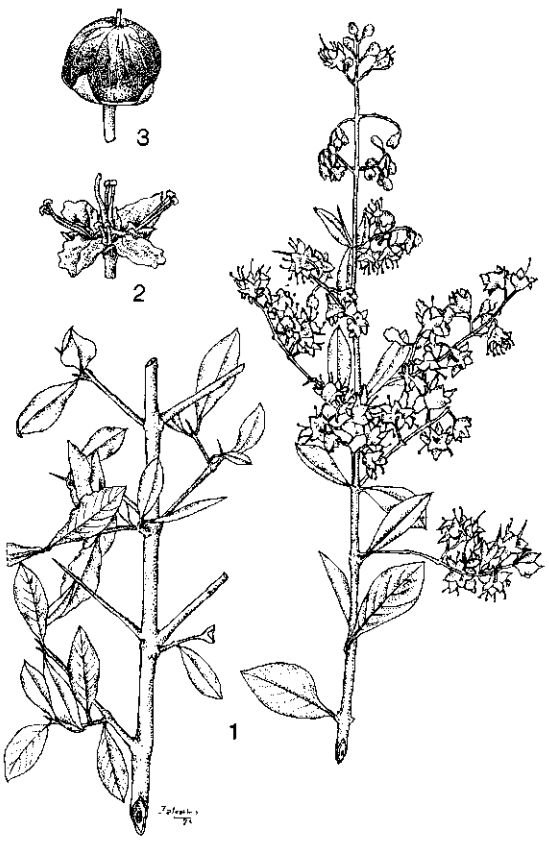
The wood of henna is fine grained and hard and has been used to make tent pegs and tool handles in India. Small twigs are used as toothbrushes in Indonesia.

In traditional medicine henna is used as a panacea against almost any disease. Only the medicinal uses that have been confirmed in clinical tests are mentioned here. Extracts of the leaves have an astringent effect on the skin, making it somewhat hydrophobic. This effect, combined with a slight bactericidal and fungicidal action, makes it a useful medicine against many skin and nail complaints. In Arabic and Ayurvedic medicine, preparations from the leaves and possibly other parts of the plant are used in childbirth and as an abortifacient. Leaves and roots are effective against certain forms of diarrhoea.

Production and international trade Because large quantities of henna are produced at home or for the local market, and because henna is mostly classified under categories including several other products, it is impossible to obtain accurate estimates of production. Exports of powdered and dried leaves from India, Egypt and the Sudan amounted to 6000–8000 t/year in the period 1975–1980. Total exports must be over 10000 t/year. Demand for henna rose rapidly between 1960 and 1980, but has since levelled off. The main importers are the Arab countries, France, Britain and the United States.

Properties The dyeing agent in henna is lawsone or 2-hydroxy-1,4-naphthaquinone (naphthalenedione) ($C_{10}H_4O_3$), which is present in the leaves at a concentration of 1–1.5(–2)%. It attaches itself strongly to proteins, and as a result the dye is very fast. The stems contain variable amounts of tannins. On steam distillation, the flowers yield 0.01–0.02% essential oils, which can be used as a basis for perfumes. These oils mainly consist of α- and β-ionones. The seeds contain about 10% of a non-drying, viscous oil, composed mainly of oleic, linoleic and stearic acids.

Description A much-branched, glabrous shrub or small tree, 2–6 m tall, with greyish-brown bark, unarmed when young, older plants with spine-



Lawsonia inermis L. – 1, lower and upper part of flowering branch; 2, flower; 3, fruit.

tipped branchlets. Young branches quadrangular. Leaves opposite, entire and subsessile, elliptic to broadly lanceolate, 1.5–5 cm × 0.5–2 cm, acuminate. Flowers numerous in large, pyramidal, terminal cymes, fragrant, 1 cm across and 4-merous, calyx with 2 mm long tube, and 3 mm long spreading lobes; petals orbicular or obovate, white or red; stamens 8, inserted in pairs on the rim of the calyx tube; ovary 4-celled, style up to 5 mm long, erect. Fruit a globose capsule, 4–8 mm in diameter, many-seeded, opening irregularly. Seeds 3 mm across, angular, with thick seed-coat.

Growth and development Henna can grow to the size of a large shrub or even small tree, but is normally grown like lucerne (*Medicago sativa* L.), i.e. as a short-lived perennial crop, up to 60–70 cm tall.

Other botanical information Red and white-flowered types are sometimes distinguished as different botanical varieties. Plants with red flowers are much less common than plants with white ones.

Ecology Henna requires high temperatures for germination, growth and development. It is adapted to a wide range of conditions. It tolerates poor, stony and sandy soils, but is also well adapted to heavy, fertile clay soils. Low air humidity and drought are tolerated.

Propagation and planting When grown commercially, henna is either grown from seed and transplanted, or propagated by cuttings. In northern Africa land is prepared carefully by ploughing up to 40 cm deep, and heavily manuring. Fields are then levelled and prepared for basin irrigation. In India, where production is less intensive, land is only ploughed a few times. Because of its hard seed-coat, henna seeds have to be pre-germinated before sowing. They are first steeped in water for 3–7 days, during which time the water is changed daily. They are then placed in small heaps and kept moist and warm for a few days. Care is taken to drain excess water. When the seed-coat has softened and the seed has started to swell, it is ready to be sown in a nursery. During the first days after sowing, the soil should be kept moist and daily irrigations are often required. When the plants are about 40 cm tall they are lifted, cut back to about 15 cm and transplanted. Planting densities range widely from 20000 to 200000 plants/ha, depending on water availability. An amount of 3–5 kg of seed per ha is needed. For propagation by cuttings, branches with 6–8 buds are used.

Husbandry Under intensive commercial production, as in northern Africa, the crop is irrigated during the dry season and heavily fertilized. In India it is grown on a larger scale, less intensively, often without irrigation and rarely fertilized. Fields are hoed once or twice per year and weeded when required. Plants produce their maximum yields during the first 4–8 years after planting, but are often left in the field for 12–25(–40) years. Henna removes large quantities of nutrients from the soil. A yield of 1000 kg dry leaves removes 180–190 kg N, 100–150 kg K_2O and 10–30 kg P_2O_5.

Diseases and pests Very few pests and diseases attack henna. A black root rot caused by *Corticium koleroga* and a bacterial leaf-spot caused by *Xanthomonas lawsoniae*, have been reported from western India.

Harvesting Plants are generally harvested twice a year from the second year onwards under intensive cultivation. Harvesting starts 1 or 2 years later under extensive management. During the first year plants are cut at about 5 cm above the ground, later they are cut at ground level. Harvesting is done when the flower buds

start to form.

Yield Few reliable statistics on yields are available. Under irrigation, henna may yield 2500–3000 kg/ha per year of leaves on dry weight basis, reaching 4000 kg/ha under optimal conditions. Under rainfed conditions in northern India yields of 700–1500 kg/ha are obtained.

Handling after harvest In South-East Asia fresh leaves are picked from the home garden when needed and used fresh. In the Arab world and India, leafy branches are harvested, left to dry, and the leaves are separated from the branches by beating; the dry sticks may be left around the field as fencing. Drying should be rapid to retain the green colour of the leaves, which is an indication of good quality. Because of the better drying conditions, leaves harvested during the hot dry season are of better quality than those from the second harvest. For export, dried leaves are packed into bales of 170 kg. Alternatively, the dried leaves are milled to powder. Dried leaves are preferred by most traders, as they are less easily adulterated.

Genetic resources A large number of traditional cultivars exists, often associated with the location of production, differing in size of the leaves or in colour of the flowers. No inventory of the variation has been made.

Prospects The very low toxicity of henna and its strong roots in tradition make it one of the few natural dyes for which demand is still growing. The ongoing research for innocuous natural dyes may add to its present uses. If more attention were given to the selection of cultivars with a high lawsone content and to the development of better drying and processing techniques, it should be possible to expand its commercial production to more humid areas.

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L.P.A. Oyen

Lithocarpus sundaicus (Blume) Rehder

Journ. Arn. Arb. 1: 131 (1919).
FAGACEAE
$2n$ = unknown

Synonyms *Quercus sundaica* Blume (1823), *Quercus pruinosa* Blume (1823), *Quercus lamponga* Miq. (1861).

Vernacular names Sunda oak (En). Indonesia: pasang batu, pasang parengpeng (Sundanese), pasang balung (Javanese). Malaysia: mempening bagan, mempening merah (Peninsular). Thailand: ko lap taopuun (Trang).

Origin and geographic distribution Sunda oak is native to Thailand (peninsular), Malaysia (Peninsular, Sabah, Sarawak), Singapore, the Philippines (Luzon, Mindoro), and Indonesia (Sumatra, Kalimantan, Java). It is not cultivated.

Uses The bark has been used occasionally in Indonesia (Java) for tanning hides into leather. Although Sunda oak was already being recommended some 70 years ago as a good source of tanning material, it has never been used extensively.
The timber is sometimes used in house-building for beams, columns and planks, and occasionally also for furniture and tool handles.

Properties Air-dried bark contains 15–22% tannin, rarely less. Nothing is known about the constitution of the tannin, but it probably belongs to the group of ellagitannins, just like the tannins from bark and wood of *Quercus* and *Castanea* spp. The tannin has excellent tanning properties, giving a flexible, light yellow leather. It can be used for the production of sole leather, but also of upper leather. The bark has acid forming properties in the tan liquor, which is advantageous in early stages of the tanning process.
The wood is brownish- or reddish-white, moderately heavy (500–700 kg/m^3 at 15% moisture content) and moderately hard. It is very liable to shrinkage and splitting, and even after accurate seasoning it is susceptible to considerable warping. The timber is not durable when exposed or in contact with the ground. Resistance to termites is poor. The seed weight is about 4 g.

Botany A small to medium-sized tree, 10–36 m tall, with trunk 20–90 cm in diameter; stilt roots

Lithocarpus sundaicus (Blume) Rehder – 1, flowering branch; 2, fruits.

or buttresses occasionally present; bark greyish-brown, fissured or scaly; young branches initially densely yellowish-brown hairy, later glabrescent, lenticellate. Leaves spirally arranged, coriaceous, simple and entire, ovate or elliptic, 10–24 cm × 4–10 cm, rounded or acute at base, acute or acuminate at apex, glabrescent and brownish above, densely yellowish-brown hairy beneath, shortly petiolate and stipulate. Flowers in male or hermaphrodite 10–15 cm long inflorescences arranged in subterminal paniculate clusters, unisexual; male flowers in clusters of 3, each flower usually with a 6-lobed perianth, 10–12 stamens, and a rudimentary pistil; female flowers usually solitary along basal part of inflorescence, with a 6-lobed perianth, an inferior ovary crowned by 3–4 styles, and rudimentary stamens. Fruit an indehiscent nut, surrounded in the basal part by a saucer-shaped, scaly cupule, depressed-ovoid, 1.3–2 cm × 2–3 cm, brown, with rounded or acute apex. Germination hypogeal.

L. sundaicus is a rather variable species. The habit of the tree, the size, texture and indumentum of the leaves, and to a lesser extent the size of the cupules and fruits more or less depend on the altitude. Plants from higher localities (1500 m and above) often have a short and crooked trunk, comparatively small and thick leaves with a thick indumentum and large fruits, whereas specimens from lower situated localities are usually characterized by a long, straight and columnar trunk, large and thin leaves with less indumentum and small fruits. The tree coppices readily, and offshoots grow about 1–1.5 m in the first year after coppicing.

In Europe and North America, the bark of several species belonging to another genus of Fagaceae, i.e. *Quercus* L., is highly valued as source of tanning material. The barks of many Asiatic 'oaks' (belonging to the genera *Quercus* and *Lithocarpus* Blume) are known to be rich in tannin, but do not appear to have been used appreciably in local tanning.

Ecology Sunda oak is found in primary forests, from sea-level up to 2600 m altitude. Locally it is common, for instance in the lowland forests of Peninsular Malaysia and in forests between 500 and 1500 m in western Java. In other areas the species is rare, for instance in southern Thailand and the Philippines.

Harvesting In experimental plantations in Java it was found that the bark of trees as young as 5 years already contained large amounts of tannin (16.5–22% on a dry weight basis). A tree 8 m tall, with a trunk diameter at breast height of 12 cm, has an average yield of 3.5 kg dry bark. The bark can easily be removed from the trunk. In general, oak bark is dried in the open air, and normally it is used in tanneries as it is and not made into extract.

Prospects Sunda oak might be a promising source of tanbark. The bark contains much tannin, even more than oak bark, which was so highly valued in Europe for the production of heavy leathers before the deforestation of large areas. The tannin has excellent properties, giving a fine leather of light colour. The bark of young trees already contains a large amount of tannin. It is easily detached from the wood, and trees can be readily coppiced. Experiments in Java showed good results but should be repeated on a larger scale to give a decisive answer about the prospects for this species.

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Products Research and Development Centre, Bogor, Indonesia. pp. 111–115. [3] Soepadmo, E., 1972. Fagaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana, Series 1. Vol. 7(2). pp. 375–376. [4] Wind, R., 1924. Bijdrage tot de kennis van de plantaardige looimiddelen en het vraagstuk der looistofvoorziening van Nederlandsch-Indië [Contribution to the knowledge of vegetable tanning materials and the question of tannin supply in the Dutch East Indies]. Mededeelingen van het Proefstation voor het Boschwezen No. 9. Departement van Landbouw, Nijverheid en Handel in Nederlandsch-Indië, Batavia. pp. 214–221.

R.H.M.J. Lemmens

Macaranga tanarius (L.) Muell. Arg.

DC., Prodr. 15(2): 997 (1866).
EUPHORBIACEAE
$2n = 22$

Vernacular names Indonesia: tutup ancur (Javanese), mapu (Batak), mara (Sundanese). Malaysia: kundoh, mahang puteh, tampu. Philippines: binunga (Tagalog), kuyonon (Bisaya), himindang (Bikol). Thailand: ka-lo (Malay, Yala), paang (Chantaburi), mek (peninsular). Vietnam: bach dâu nam.

Origin and geographic distribution *M. tanarius* has a very large area of distribution, from the Andaman and Nicobar Islands, Indo-China, southern China, Taiwan and the Ryukyu Islands, throughout Malesia, to northern and eastern Australia and Melanesia. It is commonly found in mainland South-East Asia (southern Thailand, Peninsular Malaysia), and on many Malesian islands (e.g. Sumatra, Borneo, the Lesser Sunda Islands, Sulawesi, New Guinea, throughout the Philippine Archipelago).

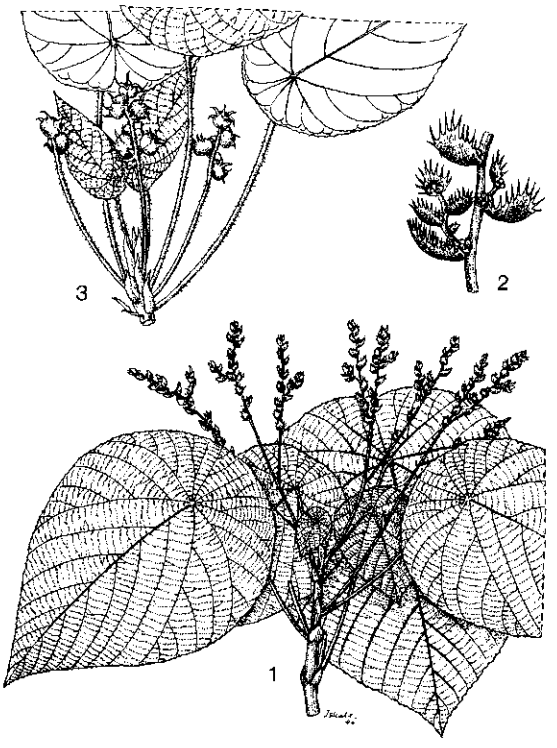
Uses The bark contains tannin which is used for toughening fishing nets. Nets dipped in a decoction of the bark will stand the influence of seawater for a considerable time. In Indonesia, the leaves have been reported to dye matting black, like other species of Euphorbiaceae do.

Bark and leaves are widely utilized in the Philippines in the preparation of a fermented drink called 'basi' made from sugar cane. In Sumatra, fruits are added to palm juice when it is boiled down, improving the quality of the sugar produced.

In Indonesia and the Philippines, the kino tapped from the bark is used as a glue, particularly for fastening together parts of musical instruments. The timber is not used on a large scale, but in Sumatra it is used to make ladders for picking pepper and in the Philippines wooden shoes are made from it, whereas in Malaysia it serves to build temporary houses. The bark is used for making food containers in Sumatra. The medicinal uses are numerous. A decoction of the bark is applied against dysentery and a decoction of the root against fever and haemoptysis. Powdered leaves are used in poultices for healing wounds.

Properties The tannin content of the bark is not high, only slightly exceeding 2%. This makes the bark unsuitable for tanning leather, but it is suitable for tanning fishing nets. The addition of leaves of *M. tanarius* stimulates the fermentation of sugar cane molasses, and consequently increases the alcoholic yield of the beverage prepared from it. Stem and leaves contain diterpenoids (e.g. macarangonol), triterpenoids (e.g. friedelin, ß-amyrin), and steroids (e.g. sitosterol). The bark contains ellagic acid, a tannin constituent.

The timber is soft and light, about 500 kg/m^3 air



Macaranga tanarius (L.) Muell. Arg. – 1, branch with male inflorescences; 2, part of male inflorescence; 3, fruiting branch.

dry. It is not durable and not resistant to termite attack, but it is fairly tough. The grain is straight or only shallowly interlocked, the texture is moderately fine and even.

Botany A small to medium-sized dioecious tree up to 20 m tall, usually much shorter; branches rather thick, glaucous, pubescent when young. Leaves alternate; blade peltate, suborbicular, 8–32 cm × 5–28 cm, rounded at base, acuminate at apex, entire, sometimes denticulate or slightly lobed, with distinct veins, hairy when young; petiole 6–27 cm long, with large caducous stipules at base. Flowers in axillary, paniculate inflorescences, composed of bracts enclosing clusters of flowers; male flowers minute, many in a cluster, with (3–)5–6(–10) stamens, female flowers few in a cluster, with a subovoid, glandular, 2-celled ovary and 2 large stigmas. Fruit a 2-coccous capsule, about 1 cm in diameter, with long soft prickles, yellowish glandular outside. Seeds globose, about 5 mm in diameter, rugose.
M. tanarius is an anemophilous plant.
Some other Malesian species of the genus *Macaranga* Thouars contain enough tannin for potential use for tanning nets or leather. One of these is *M. triloba* (Blume) Muell. Arg., rich in tannin but apparently not used for tanning.

Ecology *M. tanarius* is often very common in secondary forest, especially in logging areas. It is also found in thickets, brushwoods, village groves, and beach vegetation. It occurs on clayey, loamy and sandy soils, usually in the lowlands, but in Java it is found up to 1500 m altitude.

Handling after harvest After the tree has been felled, the bark is removed in large sheets, cut into strips of ca. 1.5 m × 0.2 m and dried in the sun. The pieces of bark are packed in bundles and sold for tanning or for use in the preparation of 'basi' drink in the Philippines. Leaves gathered from under the tree and dried are sometimes used for the latter purpose.

Prospects *M. tanarius* has never been used extensively, but nevertheless it can serve several purposes: as tanning material, as glue, as an addition to beverages, as timber and as medicine. It seems worthwhile to do research on the different aspects of the potential uses of this species which is locally so common in types of vegetation strongly affected by man.

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Purwaningsih & S. Sukardjo

Maclura cochinchinensis (Lour.) Corner

Gard. Bull. Singapore 19: 239 (1962).
MORACEAE
$2n$ = probably 28

Synonyms *Cudrania javanensis* Trécul (1847), *Maclura javanica* Blume (1856), *Cudrania cochinchinensis* (Lour.) Kudo & Masam. (1932).

Vernacular names Indonesia: kayu kuning (general), tegeran, soga tegeran (Javanese). Malaysia: kederang, kedrae. Philippines: kokompusa (Ilokano), talolong (Ilokano, Igorot), patdang-labuyo (Tagalog). Cambodia: khlaè, nhoër khlaay. Thailand: kae kong (Phrae), kae lae (central), klae (peninsular). Vietnam: dây mo'qua.

Origin and geograpic distribution *M. cochinchinensis* is extremely widely distributed. It is found from the Himalayas in Nepal and India to Japan, and south through Malesia to the Bismarck Archipelago, New Caledonia, and eastern Australia.

Uses The heartwood, particularly of the larger roots, but also of the stem, is used to dye textiles yellow; it is also used in mixtures of dyes. In Indonesia it is used as an ingredient of the traditional 'soga-batik', together with the bark of *Ceriops tagal* (Perr.) C.B. Robinson and *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne. Sometimes the dye is used for colouring other materials like mattings.
Some medicinal uses of the wood are also reported, notably against fever. A decoction of the roots is used to alleviate coughing. The young leaves are sometimes eaten raw. The fruit is edible.

Production and international trade As the wood is collected from plants in the wild on a fairly small scale, no figures on production and trade are available. In the major batik areas, as in central Java, it is reported to be more and more difficult to obtain. The wood is, for instance, collected in Irian Jaya and transported to Java.

Properties The colouring substance in the wood is possibly morin and/or maclurin, which are also

present in other dye plants such as the related *Chlorophora tinctoria* (L.) Gaudich. (old fustic) from South and Central America. Substances found in bark and wood include cudraniaxanthone, butyrospermol acetate, kaempferol, aromadendrin, populnin, quercetin and taxifolin. The heartwood is liver-coloured and hard.

Description A branched thorny shrub, scrambling or even becoming a liana. Stems up to 10 m long, and up to 15 cm in diameter, with long thorns on the nodes, containing latex; bark light greyish or brownish. Leaves spirally arranged, elliptic to oblong or obovate, (2–)4–9(–11) cm × 1–3.5(–5) cm, entire, base cuneate, apex obtuse to shortly acuminate and mucronate, glabrous or sparsely pubescent, shortly petiolate and with caducous stipules. Inflorescences axillary, usually in pairs but also solitary, short-pedunculate, capitate, bracteate, unisexual; male heads 7–10 mm in diameter, with 4-staminate flowers, female heads 6–8 mm in diameter, containing flowers with a filiform stigma. Fruiting heads composed of accrescent fleshy perianth and bracts forming a capitate syncarp, 15–20 mm in diameter, ripening yellow to orange and red. Seeds rounded, ca. 5 mm across, brown.

Other botanical information A densely hairy form of this variable species has been named var. *pubescens* (Trécul) Corner. This variety is found in Malesia.

Maclura cochinchinensis (Lour.) Corner – fruiting branch.

Growth and development Seedlings have small, suborbicular and obtuse leaves. On developing the long scrambling and thorny shoots, the leaves become narrowly lanceolate and large, up to 12 cm × 2 cm. Adult plants produce the usual elliptic to obovate leaves. This species is a slow grower, stems reaching 10–15 cm diameter in about 10–15 years.

Ecology *M. cochinchinensis* grows in lowland forest and up to 1800 m altitude. It can be found in thickets and brushwood. Locally it is common.

Harvesting Branches 10–15 cm in diameter in which the heartwood is already formed are harvested. In Irian Jaya the sapwood is removed immediately.

Handling after harvest In the traditional 'soga-batik' process the wood is chopped into small pieces (3–5 cm), and mixed with the chopped bark of *Ceriops tagal* and *Peltophorum pterocarpum*, usually in the ratio of 1:2:4, but other proportions are also used, depending on the desired colour. The mixture is put into a pan, covered with water, and boiled until it has thickened to the right consistency; this usually takes about 8 hours. After cooling, filtering, and about 2 hours of precipitation, the liquid is transferred to another pan and used for dyeing cotton textiles. For this purpose the textile, partly covered by wax where colouring is not wanted, is soaked in the warm to cool (but not hot) infusion until absorption is even. Then, the textile is dried in a shady place. This process of soaking and drying is repeated at least 20 times for good quality 'soga-batik'.

Also in Malaysia the heartwood of *M. cochinchinensis* is sometimes used for colouring fabrics. Some colours other than yellow can be obtained by combination with other vegetable dyes, for instance red with sappan wood (*Caesalpinia sappan* L.), green with indigo (*Indigofera arrecta* Hochst. ex A. Rich.), and orange-green with turmeric (*Curcuma longa* L.).

Prospects *M. cochinchinensis* was formerly extensively used in 'batik' processes. The easy availability of synthetic dyes has largely reduced the use of the vegetable dye, but *M. cochinchinensis* is still locally used in dyeing processes, for instance in Surakarta (Central Java). However, the traditional 'soga-batik' produced with it is very expensive and used only in ceremonies, particularly by Javanese nobility. As the demand for 'soga-batik' is decreasing and as it is becoming more and

more difficult to obtain the wood, the use of this vegetable dye so highly esteemed in Javanese culture can be expected to disappear completely in the near future. More information on the cultivation, use and chemistry of this species, and on vegetable dyeing processes in general, is most desirable.

Literature 1 Corner, E.J.H., 1981. Moraceae. In: Dassanayake, M.D. & Fosberg, F.R. (Editors): Flora of Ceylon. Vol. 3. Smithsonian Institute, Washington D.C. pp. 224–226, fig. 4. 2 Murti, V., Seshadri, T. & Sivakumaran, S., 1972. Cudrania xanthone and butyrospermol acetate from the roots of Cudrania javanensis. Phytochemistry 11(6): 2089–2093. 3 Susanto, S.S.K., 1973. Seni kerajinan batik Indonesia [Indonesian batik art and industry]. Balai Penelitian Batik dan Kerajian, Jakarta. pp. 64–81, 108–114, 164–180, 313. 4 Walker, E.H., 1976. Flora of Okinawa and the southern Ryukyu Islands. Smithsonian Institute Press, Washington D.C. p. 399.

H. Sangat-Roemantyo

Mallotus philippensis (Lamk) Muell. Arg.

Linnaea 34: 196 (1865; 'philippinensis').
EUPHORBIACEAE
$2n = 22$

Synonyms *Croton philippense* Lamk (1786).

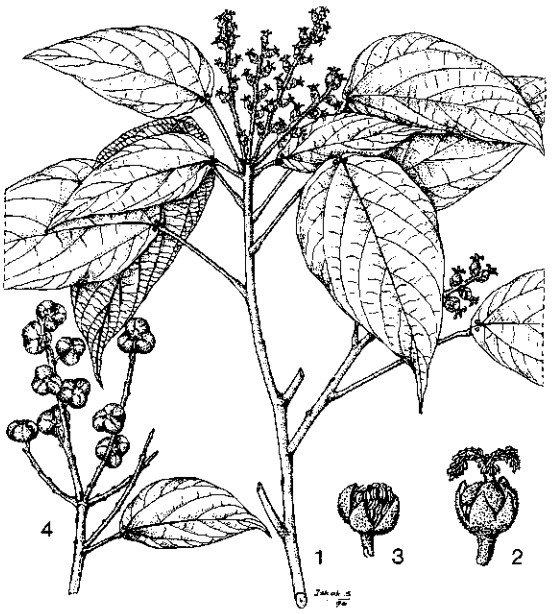
Vernacular names Kamala tree, monkey face tree (En). Rottlière des teinturiers, croton tinctorial (Fr). Indonesia: kapasan (Javanese), ki meyong (Sundanese), galuga furu (Ternate). Malaysia: rambai kuching, kasirau, balik angin. Philippines: banato (Tagalog), tagusala (Bisaya), pangaplasin (Ilokano). Burma: hpawng-awn. Cambodia: 'ânnadaa. Laos: kh'aay paax, khiiz moon, tangx thôôm. Thailand: kaai khat hin (general), khee nuea (Chiang Mai), saet (central). Vietnam: rùm nao, ba chia, canh kiên.

Origin and geographic distribution Kamala tree is widespread, from the western Himalayas, through India, Sri Lanka, to southern China, Taiwan and the Ryukyu Islands, and throughout Malesia to Australia and Melanesia.

Uses The granules which cover the ripe fruit are used in India as a dye ('kamala') for dyeing silk and wool bright orange. Kamala also serves as a preservative for vegetable oils and dairy products. Kamala is also recorded to be used as a dye for food-stuffs and beverages, which seems unlikely because it is generally known as a purgative.
In pharmacy kamala is used as anthelmintic and an extract of kamala in hexachlorethane may be useful in treating liver fluke in cattle. Kamala is also known to affect the fertility of animal and man. The seeds yield kamala seed oil which can be used as a substitute for tung oil, obtained from *Aleurites* spp., in the production of rapid-drying paints and varnishes. The seed oil is also used as a fixative in cosmetic preparations. All parts of the tree can be applied externally to treat parasitic infections of the skin.
The wood is sometimes used as timber for implements, and often as fuelwood. It is also suitable for paper pulp. The leaves are used as fodder.

Properties The dye is insoluble in cold water and slightly soluble in boiling water, but it is freely soluble and forms deep red solutions in alcohol, ether and alkalies. The principal colouring substances are rottlerin ($C_{30}H_{28}O_8$), crystallizing in salmon-coloured needles or plates, and its yellow isomer, isorottlerin, which together constitute about 11% of the weight of the kamala powder of ripe fruits. Other substances of the dye are resins (ca. 65%), wax (ca. 2%), and small amounts of the pigments 4-hydroxyrottlerin and 3,4-dihydroxyrottlerin, volatile oil, citric and oxalic acid, tannin, and gum. Rottlerin is active as an anthelmintic, it affects the fertility of female rats and guinea pigs, and is reportedly toxic to frogs, worms, and some fish species. In overdoses it causes nausea in humans. However, kamala is regarded as harmless in vegetable oils.
The seeds contain up to about 20% oil, often much less. Kamala seed oil is dark brown to pale yellow, is very viscous and has a tendency to polymerize. Its principal fatty acid is kamlolenic acid (ca. 60%). Seeds are reported to contain a toxic glycoside. Roots, stems and leaves contain hydrogen cyanide, a poisonous acid. The bark contains 6–10% tannin, the leaves contain a smaller amount.
The wood is whitish to pale reddish-grey, often with darker streaks, and fairly close and straight-grained. It is hard and moderately heavy, averaging 770 kg/m^3. It shrinks much and is susceptible to insect attack.

Description A small to medium-sized monoecious tree, up to 25 m tall and with a bole up to 50 cm in diameter, but usually much less. Slash turning deep red. Branchlets reddish-brown glandular. Leaves alternate and simple, more or less leathery, ovate to lanceolate, 5–16(–23) cm × 2–7(–9.5) cm, cuneate to rounded and with 2 glands at base, acute or acuminate at apex, entire, conspicuously 3-nerved, hairy and reddish glandular beneath; petiole 1–4(–10) cm long, puberulous



Mallotus philippensis (Lamk) Muell. Arg. – 1, branch with female inflorescences; 2, female flower; 3, male flower; 4, fruiting branch.

and reddish-brown. Male flowers in terminal and axillary, 2–10(–16) cm long, solitary or fascicled paniculate spikes, each flower with numerous stamens, small; female flowers in spikes or slender racemes, each flower with a stellate-hairy, 3-celled ovary with 3 papillose stigmas. Fruit a depressed-globose, 3-lobed capsule, 5–7 mm × 8–10(–12) mm, stellate-puberulous and with abundant orange or reddish glandular granules, 3-seeded. Seeds subglobose and black, ca. 4 mm across.

Growth and development The growth is comparatively slow, mean annual girth increment being reported in India 0.65 cm, and mean girth after 16 years less than 15 cm.

Ecology Kamala tree is common in evergreen forest, especially in secondary forest, and sometimes even dominant in the undergrowth. It also occurs in scrubby vegetations and on open rocky ground. In forests in India it is dominated by sal tree (*Shorea robusta* Gaertner f.); it is often gregarious and precedes the appearance of sal tree, for which it prepares a 'nursery' by killing off grasses. Kamala tree withstands considerable shade, it is frost-hardy and resistant to drought. It is found at altitudes between 0–1600 m.

Propagation and planting Kamala tree can fairly easily be propagated by seeds sown at the beginning of the rainy season in a nursery. As the germination rate is often poor (for example, because of drought and insect attack) it is advisable to sow close, about 5 cm apart, and to thin out later. After one year seedlings are usually transplanted into the field. Dried seeds can be stored in gunny bags or in tins in a dry place for about 6 months without losing viability. Row planting with field crops has proved successful. Trees also reproduce from root suckers. However, kamala tree is not cultivated on plantation scale at present.

Husbandry Loosening of soil and regular weeding are necessary for at least 2 years after sowing.

Diseases and pests Several fungi causing rot have been reported to attack kamala tree. The wood is susceptible to attack from insects, especially beetles, such as *Monochamus bimaculatus*, *Xylotrechus smei*, *Agrilus malloti*, *Sinoxylon* spp., *Lyctus africanus*, and *Stromatium barbatum*.

Handling after harvest The red granules are usually separated by beating and shaking the ripe fruits, or by stirring the fruits vigorously in water. The yield of kamala powder is only 1.5–4% of the weight of the fruit, which makes the product very expensive. Kamala is often adulterated with other vegetable dyes or minerals. To dye silk and wool, 4 parts of kamala, 1 part of alum and 2 parts of sodium bicarbonate are mixed in the powdered state with a small quantity of sesamum oil, and boiled in a pan. The bright orange to red colour is fairly fast to soap, acids and alkalies, but fades somewhat when much exposed to sunlight.

The seed oil can be extracted with light petroleum, benzene, ethyl ether or ethyl acetate. A high vacuum is used for stripping the solvent, as the oil polymerizes even at ambient temperature. Kamala oil can also be extracted by mixing with linseed oil or other vegetable oils and heating and filtering the mixture. Kamala oil solidifies when the extract is cooled.

Prospects Kamala is now rarely used as a dye. It is much too expensive to compete with synthetic dyes, but might have prospects in the food industry as an antioxidant. More research on the properties and nature of the dye is necessary to find its potential applications in the food industry. The oil from the seeds is another product worth attention. Kamala tree also has some interesting medicinal properties. It is surprising that the uses of this plant, which is common in many parts of its large area of distribution, are almost unknown outside India.

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hoff, Groningen, the Netherlands. p. 483. 2 Crevost, Ch. & Pételot, A., 1941. Catalogue des produits de l'Indochine. Tome 6. Tannins et tinctoriaux. Gouvernement général de l'Indochine, Hanoi. p. 70. 3 Levingston, R. & Zamorra, R., 1983. Medicine trees of the tropics. Unasylva 35(140): 7–8. 4 Sastri, B.N. (Editor), 1962. The wealth of India. Raw materials. Vol. 6. Council of Scientific and Industrial Research, New Delhi. pp. 229–233.

C.C.H. Jongkind

Marsdenia tinctoria R. Br.

On Asclepiad. 17 (1810), preprint for Mem. Wern. Nat. Hist. Soc. 1: 30 (1811).

ASCLEPIADACEAE

$2n$ = unknown

Synonyms *Asclepias tinctoria* Roxb. (1832).

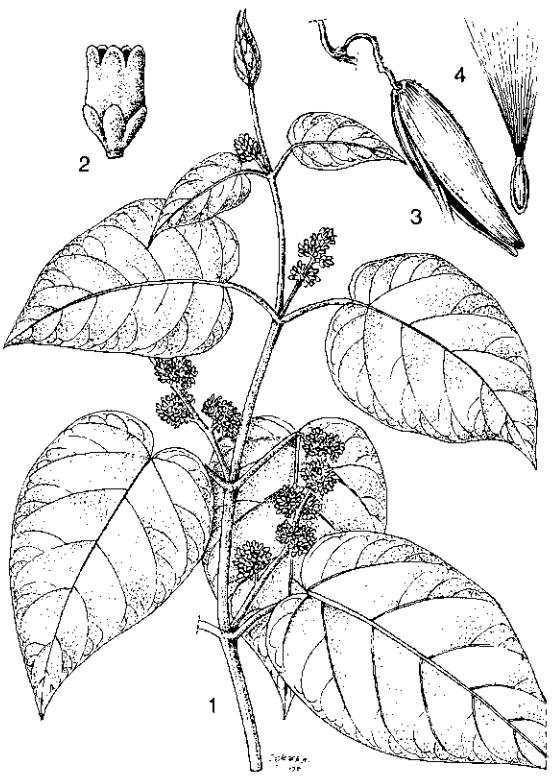
Vernacular names Indonesia: tarum akar (general), aka sanam (Minangkabau), tarum areuy (Sundanese). Malaysia: akar tarum, tarum hutan, tarum akar. Philippines: payangit (Tagalog), tayom-tayom (Ilokano), lamus (Bagobo). Cambodia: dok bonenk. Laos: büak. Thailand: khraam thao.

Origin and geograpic distribution *M. tinctoria* is widely distributed from the subtropical Himalayas of Nepal and India, through Thailand and Peninsular Malaysia, south to Indonesia (Sumatra; once found on Java), and the Philippines; east and north to southern China, Taiwan, and the Ryukyu Islands. It is rarely cultivated in India, Burma, Thailand, and Indonesia (Sumatra, Java).

Uses The leaves are used for dyeing textiles blue in the same way as indigo (*Indigofera* spp.), and for dyeing hair black. In traditional medicine the leaves are applied internally for intestinal disorders, and externally to stimulate hair growth. In Bangladesh an extract of the plant is used to induce abortion.

Properties The glucoside indican is thought to be present in the leaves, just as in indigo, but this is not certain, because no chemical analyses of the dyeing substances are available. The alcoholic extract of the plant and its alkaloidal fraction show oxytocic action on sensitized uterine horns in rats. Several triterpenes have been isolated. The bark contains fibre.

Botany A winding shrub or vine, usually up to 5 m tall; leaf-bearing stems slender and green, puberulous, older stems about 1.5 cm thick, (sub) glabrous, with longitudinal corky ridges. Leaves



Marsdenia tinctoria R. Br. – 1, flowering branch; 2, flower; 3, fruit; 4, seed.

opposite, simple, (broadly) ovate to lanceolate, 5–13 cm × 2–6(–7.5) cm, rounded to subcordate at base, acute or shortly acuminate at apex; petiole 1–4 cm long, puberulous. Flowers in axillary, umbel-like cymes or in many-flowered up to 15 cm long racemes, small, shortly stalked; calyx very small, pubescent; corolla urn-shaped, 2.5–4 mm long, yellow and somewhat fleshy, hairy inside, with distinct corona; stamens united into a tube, anthers with apical membranes, inflexed over the stigma; ovaries superior, 2 per flower, stigma 1, large. Fruit composed of 1 or 2 lanceolate follicles, 4–6(–8) cm long, pubescent, containing numerous, comose seeds.

Ecology *M. tinctoria* occurs naturally in primary and secondary forests at low and medium altitudes, climbing on trees or sometimes over rocks. It is also found in thickets and on open ground, possibly as remnants of former cultivation. It was formerly especially grown in places where heavy rainfall prevented indigo from being grown successfully.

Agronomy Plants are propagated by cuttings,

layers, and grafts. Weeding and fertilizing are necessary. In plantations in Sumatra, leaves used to be first plucked 4 months after planting. The plantations remained productive for about 5 years. The dye can be extracted from the leaves in the same way as indigo from *Indigofera* spp., i.e. in tanks containing water and lime. The quality of the dye is comparable to indigo.

Prospects *M. tinctoria* is a little-known dye plant. As far as is known, it has not been used in dyeing processes for many decades, and little has been published on its uses. However, it might be an interesting alternative for indigo if vegetable dyes regain ground from synthetic dyes again. Research priorities could be investigation of the chemical composition of the dye, and the properties and potential uses of the fibre in the bark.

Literature 1 Backer, C.A. & Bakhuizen van den Brink, R.C., 1965. Flora of Java. Vol. 2. Noordhoff, Groningen, the Netherlands. pp. 271–272. 2 Chowdhury, A.K.A. & Khaleque, R.A., 1984. Oxytocic principles from Marsdenia tinctoria (herb of Bangladesh). Dhaka University Studies (Bangladesh) 32(1): 85–88. 3 Crevost, Ch. & Pételot, A., 1941. Catalogue des produits de l'Indochine. Tome 6. Tannins et tinctoriaux. Gouvernement général de l'Indochine, Hanoi. p. 65. 4 Sastri, B.N. (Editor), 1962. The wealth of India. Raw materials. Vol. 6. Council of Scientific and Industrial Research, New Delhi. p. 306.

T. Boonkerd, B. Na Songkhla & W. Thephuttee

Morinda citrifolia L.

Sp. Pl. 1: 176 (1753).
RUBIACEAE
$2n = 44$

Synonyms *Morinda bracteata* Roxb. (1814), *Morinda litoralis* Blanco (1845).

Vernacular names Indian mulberry (En). Morinde (Fr). Indonesia: mengkudu (Javanese), bengkudu (Minahasa, Gorontalo), cangkudu (Sundanese). Malaysia: mengkudu besar, mengkudu jantan. Philippines: tumbong-aso (Tagalog), bangkuro (Bisaya), apatot-nga-basit (Ilokano). Burma: al. Cambodia: nhoër srôk, nhoër thôm'. Laos: nhoo baanz. Thailand: yo ban. Vietnam: nhàu.

Origin and geographic distribution Indian mulberry is a native of Queensland (Australia). It may have been distributed by man and carried westwards into the Indian Ocean by sea currents, reaching the Seychelles, and similarly into the Pacific between 30°N and 30°S latitude, reaching the Marquesas, Hawaii, and Easter Island. It is present throughout South-East Asia both wild and cultivated. It often occurs wild in coastal zones. It is naturalized in the Caribbean region.

Uses Before the introduction of synthetic dyes (e.g. alizarin) the red dye from the rootbark of Indian mulberry was important. In the late 19th Century, there were plantations in coastal areas of northern Java and adjoining islands. Nowadays, single trees are encouraged or cultivated in gardens mainly for medicinal purposes. Cultivation for the dye is restricted to areas where traditional textile dyeing is still important, e.g. in the production of high quality batik on Java.

Most parts of the tree have been widely used medicinally since ancient times. In Vietnam roots serve to treat stiffness and tetanus and have been proven to combat arterial tension. Elsewhere they are used as febrifuges and as a tonic. The bark is used as a tonic and as an antiseptic on skin lesions, ulcers and wounds. The leaves are used to treat dysentery, diarrhoea, colic, nausea and convulsions and as a febrifuge, tonic and antiseptic. The fruits are used as a diuretic, a laxative, an emollient and as an emmenagogue, for asthma and other respiratory problems, as a treatment for arthritic and comparable inflammations, in cases of leucorrhoea and sapraemia and for maladies of inner organs. Roots, leaves and fruits may have anthelmintic properties. In traditional medicine the parts used are administered raw or as juices and infusions or in ointments and poultices.

Despite the smell of putrid cheese when ripe, the fruits are eaten raw or prepared, as are the leaves. The fruit pulp can be used to cleanse hair, iron and steel. The wood splits excessively in drying and its uses are restricted to fuel and poles. In Malaysia and Thailand the tree is used as a support for pepper plants.

Properties The basis of the morindone dyeing matter, called Turkish red, is the hydrolysed (red) form of the glycoside morindin. This is the most abundant anthraquinone which is mainly found in the rootbark which reaches a concentration of 0.25–0.5% in fresh bark in 3–5 years. It is similar to that found in *Rubia tinctorum* L. and to synthetic alizarin. The curative properties of the plant parts are ascribed to the presence of medicinally active anthraquinone derivates. The fruit contains rancid smelling capric acid and unpleasant tasting caprylic acid. It is thought that antibiotically active compounds are present. The nutritional value of the fruit and leaves is considerable. The leaves are a rich source of vitamin A.

Morinda citrifolia L. – 1, flowering branch; 2, inflorescence- infructescence.

Description An evergreen shrub or small crooked tree with a conical crown, 3–8(–10) m tall, with a deep taproot; bark greyish or yellowish-brown, shallowly fissured, glabrous; branchlets quadrangular. Leaves opposite and simple, elliptic-lanceolate, (10–)15–50 cm × 5–17 cm, entire, acute to shortly acuminate at apex, cuneate at base, pinnately nerved, glabrous; petioles 0.5–2.5 cm long; stipules variable in size and shape, broadly triangular. Inflorescences globose heads, 1–4 cm long peduncled, in axils of stipules opposite normally developed leaves; flowers bisexual, fragrant; corolla funnel-shaped, up to 1.5 cm long, white; stamens inserted on the mouth of the corolla; stigma bilobed. Fruit an ovoid syncarp of red-brown, pyramidal, 2-seeded drupes, 3–10 cm × 2–3 cm, yellow-white. Seeds black, with hard albumen and distinct air chamber.

Growth and development The seed remains viable for at least 6 months. Germination is 3–9 weeks after sowing. Plant growth is 1.2–1.5 m in 6 months. Flowering and fruiting start in the third year and continue throughout the year. Maximum age is at least 25 years.

Other botanical information *M. citrifolia* is sometimes subdivided into two varieties: var. *citrifolia* and var. *bracteata* (Roxb.) Hook.f. The latter has calyx-limbs with 1–2 leaflike, linear-lanceolate lobes ca. 1–1.5 cm long; the stem is straighter and the leaves are smaller than var. *citrifolia*.

Ecology Indian mulberry is commonly found up to altitudes of 1500 m in humid and seasonal climates of the region, with an estimated annual rainfall of 1500–3000 mm or more. In areas where the plant is cultivated, the soil is usually well structured and of volcanic origin (Java), but it may be poor and ferralitic (Cambodia). In the wild the plant also appears on infertile, degenerated soils, sometimes badly drained or with a very low water-retention capacity and a deep water table.
The species occurs in evergreen, (semi-)deciduous to more or less xerophytic formations, often typically littoral vegetations. It also occurs in pioneer and secondary vegetation after cultivation and bush fires (Cambodia), deforestation or volcanic activity (Krakatau). It is persistent and very tolerant. The ability of the seeds to float explains its wide distribution and occurrence on many seashores. Inland distribution agents are fruit-eating bats and birds.

Propagation and planting Indian mulberry is propagated by seeds which should be sown in nursery beds. After germination, seedlings are transplanted at ca. 1.2 m × 1.2 m in well-tilled soil.

Husbandry Weeding is carried out at least twice and starts about 1 month after transplanting. No maintenance is needed after the first year. Intercropping with cereals and perennials is possible (e.g. shade in coffee).

Harvesting High-yielding bark may be expected after 3–5 years. The roots are dug out, cleaned in water, and the bark removed.

Yield Yield of bark is reported to be 500–1000 kg/ha, containing about 0.25% morindin.

Handling after harvest The bark is ready for use after drying in the sun for several days. In the complex cold-dyeing process of the Java batik, cloth is prepared with an alkalic emulsion, 4 times a day, for 10 days. The bark is pounded with jirak bark (*Symplocos fasciculata* Zoll.), mashed with water and applied to the cloth by hand. This is repeated for 5 days. The cloth acquires a clear red, wash-fast colour. Elsewhere, the same dyeing principle is used. Jirak bark serves as a mordant. It is rich in aluminium salts.

Genetic resources The species is diminishing in its natural habitat. It is not very likely to be

endangered by serious genetic erosion given its pioneering character, its natural variation and its wide, though small-scale, cultivation. There are no reported germplasm collections.

Prospects Renewed interest in natural dyes and medicine in Indonesia and elsewhere may revive bark production. Evaluation of fruits and leaves for nutritional purposes is recommended.

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J.J. Groenendijk

Myrica esculenta Buch.-Ham.

D. Don, Prod. Fl. Nep.: 56 (1825).
MYRICACEAE
$2n$ = unknown

Synonyms *Myrica farquhariana* Wallich (1826), *Myrica sapida* Wallich (1826), *Myrica nagi* auct. non Thunb.

Vernacular names Box myrtle (En). Indonesia: ki keper (Sundanese), samben, woru gesik (Javanese). Malaysia: telur chicak, gelincek, kesami (Peninsular). Thailand: metchun tua phuu (Phangnga), ruesee sek (Chai Nat), maak-mon-on (Shan-Chiang Mai).

Origin and geographic distribution Box myrtle is native to a large part of South Asia. It is found in the Himalayas of Nepal, in southern China east to Guangdong province, in northern India, Burma, Indo-China and Thailand. In Malesia it occurs in Peninsular Malaysia, the Philippines, and Indonesia (Sumatra, Kalimantan, Java, the Lesser Sunda Islands). Box myrtle is very rarely cultivated.

Uses In China the bark is a major source of tannin extract which is used to tan hides into leather. In India the bark is only occasionally used for this purpose. It contains a yellow colouring matter, which can be used to dye mordanted cotton yellowish to brownish shades. The fruits are edible, tasting sourish sweet, and are used in desserts and in the preparation of a refreshing drink. In the sub-Himalayan region of India they are reported to be one of the tastiest wild fruits and are eagerly collected. The wax-like substance which covers the fruits is sometimes separated by boiling in water, and is used for making candles and soap. A decoction of the bark is used as a traditional medicine against diarrhoea, affections of bronchial tubes and lungs, dysentery and fevers.

Production and international trade In 1987 the production of tannin extract in China was 20000 t, for which about 60000 t of bark of box myrtle is needed. The tannin extract is primarily used in the domestic leather industry, but a few thousand tonnes per year are exported to South-East Asian countries. As a result of excessive bark-peeling, the number of trees has decreased considerably in China in recent years, but no statistics are available. Outside China, the bark has been used only occasionally as a tanning material. The bark price in 1990 in China is US$ 120 per t.

Properties The bark contains 18.6–33.7% of tannin on dry weight basis. The tannin is a mixture of partially galloylated polymeric prodelphinidins. An aqueous extract from the bark contains sludges which can be made soluble by treating with bisulphite. The spray-dried tannin extract is a light brownish-yellow powder, containing less than 12% water, 66–70% tannin and 2–6% precipitate, depending on quality. The tannin extract is characterized by a relatively high penetration rate and a light colour of the leather. It is used alone or blended with other tannin extracts. Hides tanned with box myrtle bark in India are reported to crack easily and the leather to be somewhat darker than leather tanned with wattle bark.
The yellow colouring matter from the bark is myricetin, $C_{15}H_{10}O_8$, present in the bark as the glycoside myricitrin, $C_{21}H_{20}O_{12}$. The edible portion of the fruit is its juicy pulp, which constitutes 75% of the whole fruit. The juice contains about 4 mg of vitamin C per 100 ml. The timber is rather closely grained and reddish-brown in colour.

Botany A small, evergreen dioecious tree, up to 15 m tall, trunk up to 40 cm in diameter, crooked and irregularly branched; bark greyish-brown, 5–15 mm thick; buds and twigs usually clothed with long hairs, mixed with scattered sessile glands. Leaves spirally arranged, coriaceous, lanceolate-obovate or oblong-obovate, (2.5–)5–18 cm × 1–4.5 cm, usually cuneate at base, acute or obtuse at apex, entire or sometimes coarsely ser-

Myrica esculenta Buch.-Ham. – 1, branch with male inflorescences; 2, branchlet with fruits.

rate, more or less glabrous and minutely glandular beneath, exstipulate; petiole 2–10 mm long. Flowers in catkins, which are arranged on up to 8 cm long stalks in leaf-axils; each flower subtended by a bract; male flowers with (2–)4 stamens, anthers red; female flowers with an initially hairy ovary and two filiform-subulate stigmas. Fruit an ellipsoid drupe, 1–2 cm long, beset with rounded tubercles, red when ripe, 1-seeded.

Fruits mature in about 6 months after flowering. In South-East Asia box myrtle can be found flowering and fruiting throughout the year.

Myrica esculenta has often been confused with the closely allied *Myrica rubra* (Lour.) Sieb. & Zucc., which is cultivated in China, Korea and Japan for the fruits. It cannot be excluded that the latter species is conspecific.

Ecology In South-East Asia, box myrtle occurs in light forests, where it is locally numerous. It prefers dry, well-drained soils, and can be found on sandy dunes and stony laterites, from the lowland up to 1700 m altitude. In India and China, box myrtle grows in a subtropical climate on hills and mountains at 900–2100 m altitude.

Handling after harvest After the trees have been felled, the bark is peeled from the trunk, cut into short segments and air-dried. The pieces of commercial bark in China are less than 5 cm long and packed in sacks of 40–50 kg. An aqueous extract of the bark can be spray-dried to a powder with high tannin content. The fruits remain fresh for 2–3 days only. A major problem in India is that the harvesting period is too long and fruits from a single tree have to be harvested in many pickings. Trees yield 15–25 kg of fruits per year.

Prospects Box myrtle is not extensively used in South-East Asia. Occasionally it is used as fuelwood and the fruits are eaten. As the bark has shown good tanning properties in China, box myrtle is a promising source of tanning material for the local leather industry of South-East Asian countries. The species should be cultivated to counteract the rapid decline in the number of wild trees in China in recent years.

Research should concentrate on the tanning properties, methods of propagation and cultivation, and improvement of fruit quality.

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Chu Chengde & Sun Dawang

Nyctanthes arbor-tristis L.

Sp. Pl. 1: 6 (1753).

OLEACEAE

$2n = 44$

Synonyms *Nyctanthes dentata* Blume (1849).

Vernacular names Night jasmine, coral jasmine, tree of sadness (En). Indonesia: srigading (Sundanese, Javanese). Malaysia: seri gading. Laos: salikaa. Thailand: kannikaa, karanikaa. Vietnam: dza hoa, lài tàu.

Origin and geographic distribution Night jasmine is native to the subtropical Himalayas of Nepal and India, and is probably introduced in the more southern parts of India, and in South-East Asian countries such as Thailand, Malaysia and Indonesia. It is widely cultivated in tropical and subtropical regions all over the world.

Uses Night jasmine certainly came into use as a dye early. The bright orange corolla tubes of the flowers contain a saffron-yellow colouring matter,

which was formerly used for dyeing silk, sometimes in conjunction with safflower (*Carthamus tinctorius* L.), turmeric (*Curcuma longa* L.), and indigo (*Indigofera* spp.). Locally the dye is also used for dyeing cotton cloth and as a cheap substitute for saffron in colouring the robes of Buddhist priests.

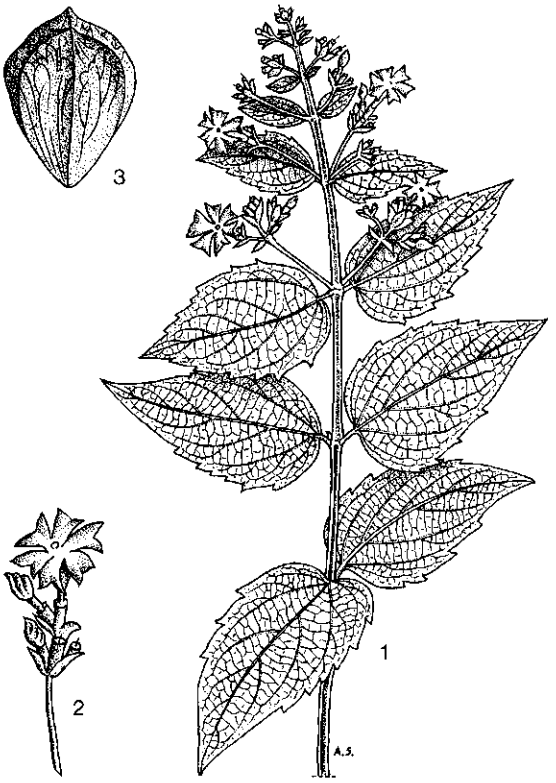
The essential oil in the fragrant flowers, which is similar to the oil in jasmine, is used as perfume. The bark may be used as a tanning material, and the leaves are sometimes used for polishing wood and ivory. In India, Indonesia (Java) and Malaysia, the flowers are used medicinally to provoke menstruation. The bitter leaves are useful against fevers, rheumatism and as an anthelmintic. In Java, an extract of the leaves is sometimes used as a tonic, and in India it is reported useful as cholagogue, laxative, diaphoretic and diuretic, and an extract is given to children for the expulsion of roundworms and threadworms. An anti-inflammatory activity of the leaves of night jasmine has been recorded recently, and an insecticidal effect of an extract from shade-dried leaves has been reported. Powdered seeds ameliorate scalp scurf.

Night jasmine is often planted near Hindu temples in India and Sri Lanka, as well as in Malaysia and Indonesia. The fallen flowers are collected, strung into garlands, and esteemed as votive offerings. It is also planted in hedges. The wood is sometimes used for boarding, and as firewood.

Properties The dye is nyctanthin, allied to crocetin from saffron (*Crocus sativus* L.). The flowers also contain an abundance of mannitol. Substances found in the leaves include mannitol, ß-amyrin, ß-sitosterol, benzoic acid and derivates of kaempferol. The seeds contain about 15% of a pale yellow-brown oil, nyctanthic acid and ß-sitosterol, and the bark contains a glycoside and alkaloids, suspected of being poisonous to animals and humans.

The wood is fairly heavy, averaging 880 kg/m^3, brown, close-grained and moderately hard.

Botany A large shrub or small tree up to 10 m tall. Bark scabrous, grey. Branches spreading, rough, twigs tetragonal, scabrous. Leaves decussately opposite, ovate, (4–)6–12 cm × 2–6.5(–9) cm, cuneate to subcordate at base, acute or acuminate at apex, margin entire or with a few teeth, very scabrous above with bulbous-based hairs, pubescent beneath, shortly petiolate. Flowers in axillary or terminal, bracteate cymes consisting of 2–7-flowered corymbs, with quadrangular, slender peduncle, fragrant and sessile; calyx campanulate, about 5 mm long; corolla with a cylindric, orange tube and 5–8 spreading, imbricate and more or less contorted, white lobes, 5–15 mm long; stamens 2, inserted near the top of the corolla tube; style about as long as the corolla tube, stigma obscurely bifid. Fruit a cordate to almost orbicular flat capsule, about 2 cm across, brown, 2-celled, opening transversely from the apex. Seeds 1 per cell, compressed.



Nyctanthes arbor-tristis L. – *1, flowering branch; 2, inflorescence; 3, fruit.*

The small genus *Nyctanthes* L. (1–2 species) is variously classified in the families Oleaceae and Verbenaceae, and sometimes together with the genus *Dimetra* Kerr. in a separate family Nyctanthaceae. Some cultivars with ornamental value have been described in India, for instance 'Karna-phool' and 'Seeya Shrinagar'.

Ecology In its native area night jasmine is found on rocky ground in dry hillsides, and as undergrowth in dry deciduous forest. It can be cultivated from sea-level up to 1500 m altitude at the equator, within a wide range of rainfall patterns, from seasonal to non-seasonal. It tolerates moderate shade. The flowers open at sunset and usually wither after sunrise the next day.

Agronomy Night jasmine is easily propagated by seeds or cuttings. It coppices readily and is not browsed by goats or cattle. A powdery mildew caused by *Oidium* spp., can do some damage to the foliage, but it can be controlled by dusting with sulphur. Plants are sometimes susceptible to leaf-spot and other diseases caused by fungi.
For dyeing, fabrics are immersed in a decoction of the corolla tubes. They impart a beautiful orange, yellow or golden colour like saffron, but the colour is easily washed out, and will fade rapidly in the sun. To make the colour more permanent, lime juice or alum is added to the dye bath. Then the colour is moderately resistant to light, soap, alkali and acid.

Prospects Apart from its religion-related function, it is worthwhile to investigate more thoroughly the many reported uses of night jasmine. The species is easy to cultivate in a very wide range of ecological circumstances.

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Tukirin Partomihardjo

Oldenlandia umbellata L.

Sp. Pl. 1: 119 (1753).
RUBIACEAE
$2n = 36$

Synonyms *Hedyotis umbellata* (L.) Lamk (1791).

Vernacular names Chay-root, Indian madder (En).

Origin and geographic distribution Chay-root occurs naturally from north-eastern to south-eastern India, in Burma and Sri Lanka. It has also been reported in Cambodia and Indonesia (near Jakarta), probably as a relic of former cultivation. It was once extensively cultivated along the Coromandel coast (eastern India).

Uses The name 'chay-root' was used in India for the bark of *O. umbellata* roots, an important source of dye before the large-scale production of synthetic dyes started at the end of the 19th Century. It was known for its ability to impart a red colour to wool, silk and calico fabrics. It was much employed for dyeing handkerchiefs in Madras, for which that town was once so famous. Small quantities of the dye have been traded to Europe, but without much success.
A decoction of the leaves and bark is considered expectorant and is prescribed in cases of bronchial catarrh, bronchitis and asthma. A decoction of the leaves is used as a wash for poisonous bites in India.

Properties The dye consists of a complex mixture of quinones. Some constituents are similar to those found in the dye from *Rubia cordifolia* L. (Indian madder), such as alizarin, rubichloric acid and ruberythric acid. Other major constituents of the true Indian madder dye, such as purpurin and purpuroxanthin, are not found in chay-root. Chay-root dye is considered to be somewhat inferior to the dye of Indian madder, possessing only about half the dyeing power of that species. The plants contain mannitol, which is common in the family Rubiaceae.

Botany An annual or biennial herb, often somewhat woody and much-branched, up to 30(–50) cm tall, with a very long, up to 90 cm, yellow-red taproot; stems angular, rough and pubescent. Leaves opposite, often seemingly fascicled, or decussate, linear-lanceolate, small, 8–30 mm × 1–5 mm, decurrent at base, acute or apiculate at apex, entire and subsessile; stipules short. Flowers in 3–12-flowered axillary and terminal umbel-like, long-stalked cymes, 4-merous, about 4 mm across, with a campanulate pinkish-white corolla much longer than the calyx, 4 stamens, and an inferior ovary. Fruit a globose dehiscent capsule, small, 1.5–2.5 mm across, crowned by the persistent calyx lobes. Seeds reticulate.
In its wild state, chay-root is a low, widely spreading, almost stemless plant, but under cultivation it grows more erect. The flowers are dimorphic (heterostylous). Plants have either flowers with long stamens exserted from the corolla tube and a short style, or flowers with short stamens included in the corolla tube and a long style.
O. umbellata is sometimes called Indian madder. However, this English vernacular name is more commonly used for *Rubia cordifolia* which is also a source of red dye.

Ecology Chay-root prefers sandy soils along coasts and river banks where the roots can pene-

Oldenlandia umbellata L. – 1, flowering and fruiting stems; 2, flower; 3, fruit; 4, part of the root.

trate the soil deeply. In India, it was cultivated along the coast, in the same places where wild plants grow. In Indonesia, the species is recorded as a weed in upland rice.

Agronomy The cultivation of chay-root is labour-intensive. Plants are propagated by seed, which are sown at the beginning of the rainy season in thoroughly ploughed land. The sandy and loose soil which chay-root needs should be watered and manured with cow-dung, and regular weeding is necessary. To obtain maximum yield per year, roots are usually harvested after about 6 months; to do this, the soil is loosened with a narrow-bladed iron spade and the roots are carefully removed. In collecting from the wild, the roots of 2-year-old plants are preferred for dyeing, because the bark of these plants yields more colouring matter. The roots are dried in the sun for 5 days and tied in large bundles. A mordant is needed to dye wool, silk and cotton red. Therefore, alum is usually added to a solution of the dye.

Prospects Chay-root has not been used for dyeing purposes for many years. The dye has been replaced by aniline dyes which are cheaper, brighter and faster. Chay-root might benefit from a reviving interest for natural dyes in the future, but it will then have to compete with other herbaceous plants producing a red dye, like Indian madder, which have better dyeing properties.

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E.H. Mandia

Omalanthus populneus (Geiseler) Pax

Engl. & Prantl, Nat. Pflanzenfam. 3, 5: 96 (1890).
EUPHORBIACEAE
$2n$ = 36, but also n = recorded as 76.

Synonyms Usually referred to as *Homalanthus populneus* (Geiseler) Pax (orthographic variant); *Omalanthus leschenaultianus* A.H.L. Jussieu (1824), *Homalanthus populifolius* (Reinw.) Hook.f. (1888), non *Omalanthus populifolius* Graham.

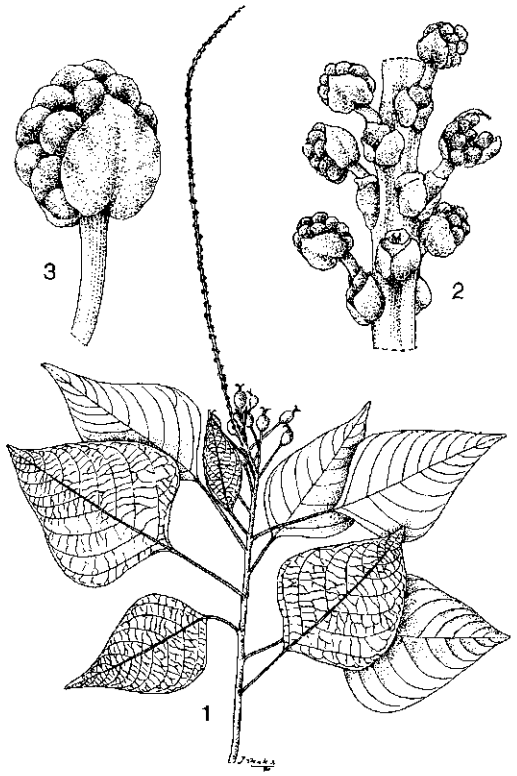
Vernacular names Mouse deer's poplar (En). Indonesia: tutup (general), tutup abang (Javanese), totop (Madura). Malaysia: ludahi, kayu mata buta darat. Philippines: malabinunga (Tagalog), balanti (Bisaya, Bikol). Thailand: mae mae.

Origin and geographic distribution *O. populneus* is distributed from southern Thailand, all over Malesia, except New Guinea, to the Bismarck Archipelago.

Uses The bark and leaves serve in dyeing rattan, matting, pandan handicrafts and cotton cloth black. The rattan, matting and pandan are often buried in the mud before or after being soaked in a boiled infusion of bark and leaves. The roots and leaves are used as a medicine, e.g. against fever; the leaves are given to cattle as a vermifuge, but are reported to be poisonous, as is also the latex from other parts of the plant. The fruit is used in Sabah for treating wounds, and the terminal buds of about 1 m high plants are reported to be eaten by women to induce abortion. The leaves serve for wrapping taro for cooking. The wood is sometimes used in houses, but it is soft and not durable.

Properties The watery latex is poisonous. The wood is white and soft. Fibres with simple pits, moderately long, ca. 1.25 mm. Vessel elements 0.5–1.3 mm long, with simple perforation plates; ray-vessel pits usually round, ovoid to elongated, and larger than the intervessel pittings.

Botany A small tree, up to 6(–10) m tall, glabrous and with watery latex; bark greyish and roughened; crown flattish with spreading branches. Leaves triangular-ovate to rhombic-ovate, 3–12 cm × 2.5–10 cm, entire, base almost truncate with two small glands at the base of the blade, apex acuminate; blades glaucous beneath, withering yellow to reddish; petiole 2–7 cm long, reddish. Flowers in terminal, 10–25 cm long racemes; male flowers many, with 6–10 stamens; female flowers 2–8 at the base of the raceme, long-stalked, with 2 long stigmas. Fruit a subglobose capsule, ca. 1 cm in diameter, two-lobed, glaucous, with 2 cavities each containing a single black seed. A.H.L. de Jussieu published the genus as *Omalanthus*. In the literature, *Homalanthus* is usually used, but since this is not a conserved genus name, it is incorrect. *Omalanthus populifolius* Graham is a very closely related species from Australia (Queensland, New South Wales), and is rarely found on Woodlark Island and the Louisiade Archipelago. This species is often confused with *O. populneus*, and sometimes cultivated in botanical gardens. Another closely related species is *Omalanthus novoguineensis* (Warb.) Lauterb. & K. Schumann, found from the Moluccas, Tanimbar Islands and Timor to the Bismarck Archipelago, Solomon Islands and Australia (Queensland). *Omalanthus beguinii* J.J. Smith is endemic in the Moluccas, and used there in the same way as *O. populneus*.



Omalanthus populneus (Geiseler) Pax – 1, flowering branch; 2, detail of male part of inflorescence; 3, male flower.

Ecology *O. populneus* is locally common, especially in mountains in secondary forest and young regrowth; it is also found in lowlands in the undergrowth of primary forest and along rivers. It is recorded as growing on various types of soils.

Prospects Research in the Philippines indicates the wood characteristics are favourable for the production of pulp and paper. This use is perhaps more promising than the use as dye.

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Purwaningsih

Peltophorum pterocarpum (DC.) Backer ex K. Heyne

Nutt. Pl. Ned. Ind., 2nd ed., Vol. 2: 755 (1927).
LEGUMINOSAE
$2n = 26, 28$

Synonyms *Peltophorum ferrugineum* (Decne.) Benth. (1864), *Peltophorum inerme* (Roxb.) Naves & Villar (1880).

Vernacular names Yellow flame, copper pod, yellow poinciana (En). Indonesia: soga (general), soga jambal (Javanese). Malaysia: batai laut, jemerelang laut. Philippines: siár (Sulu). Thailand: non see (general), krathin paa (Trat), saan ngoen (Mae Hong Son). Vietnam: lim sét, trắc vàng.

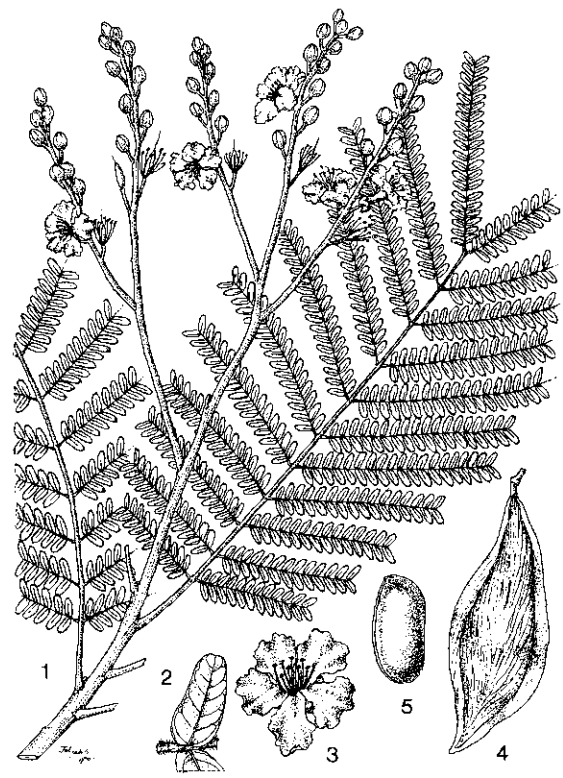
Origin and geographic distribution Yellow flame is distributed over a large area ranging from Sri Lanka, the Andaman Islands, Thailand and Indo-China (Vietnam and Cambodia), through the whole of Malesia to northern Australia. In Malesia, the species occurs throughout Malaysia, Indonesia and the Philippines, and locally in Papua New Guinea (mouth of Bensbach River). It is widely cultivated throughout its natural area of distribution, and also in the Bismarck Archipelago, India, tropical Africa, the West Indies, Central America, Florida and Hawaii.

Production and international trade Recent data on production and trade are not available. Barks are becoming more and more scarce at markets in central Java.

Uses The bark represents an important component of 'soga' dye in Java, and is often mixed with the bark of *Ceriops tagal* (Perr.) C.B. Robinson, the wood of *Maclura cochinchinensis* (Lour.) Corner, and other ingredients. The bark is also used in tanning leather, and for preserving and dyeing fishing nets. In India it is sometimes used as a substitute for wattle (*Acacia* spp.) bark blended with myrobalans from *Terminalia* spp. to get a better result. On Timor (Indonesia) the bark is used for fermenting palm wine. In traditional medicine the bark is used in various preparations as a tonic or an astringent to cure or relieve intestinal disorders, afterpain at childbirth, sprains, bruises and swellings, or as a lotion for eye troubles, muscular pains and sores.
Yellow flame is commonly used as an ornamental in gardens, parks and road-sides because of its showy fragrant yellow flowers which contrast with the reddish-brown pods, and its umbrella-shaped crown. It is also used as a shade and cover plant in cacao and coffee plantations. Since it is fast-growing and wind-firm, yellow flame is used for reforestation of wastelands covered with 'alang-alang' grass (*Imperata cylindrica* (L.) Beauv.) and as a windbreak. The tree also serves as a host for the lac insect. The leaves, which are rich in protein, are used as cattle feed, e.g. in Madura (East Java). The beautiful golden yellow flowers may be used as cut-flowers.
The timber is suitable for cabinet work, coach-building, furniture and planks, but it is little used for these purposes; it is used as fuel.

Properties The bark contains 11–21% tannin which is of the proanthocyanidin type. The tannin gives a fairly light-coloured, full and strong leather of desirable feel. Wood and leaves contain smaller amounts of tannin.
The bark yields a reddish-brown dye, the nature of which is not known but which is probably connected with the tannin. The dye, used in Indonesia in a mixture of several vegetable dyes and other ingredients, is a 'mordant dye'; this means that a mordant must be used to give the colour fastness. The leaves contain a large amount of proteins. An antifungal principle is present in leaflets and buds. An alcoholic extract from the flowers has an anti-inflammatory effect in mice and rats, and also an antibacterial activity. The flowers contain a flavanone glycoside pigment, naringenin 7-glucoside. The sapwood is whitish and distinct; the heartwood is light reddish-brown, moderately heavy, moderately hard and fine-textured. It is easy to work, and resistant to insect attack.

Description A deciduous, usually medium-sized tree, up to 30 m tall, sometimes a large tree (up to 50 m), with a straight trunk and a dense umbrella-shaped crown; trunk generally up to 70 cm in diameter, often less, sometimes buttressed; bark up to 15 mm thick, pink coloured in cross section, light brown to red inside. Leaves bipinnately compound



Peltophorum pterocarpum (DC.) Backer ex K. Heyne – 1, flowering branch; 2, pair of leaflets; 3, flower; 4, fruit; 5, seed.

with 4–15 pairs of pinnae, and a rusty pubescent petiole and rachis together 25–30 cm long; stipules small; leaflets in 8–22 pairs per pinna, oblong-elliptic, 8–30 mm × 3–10 mm, oblique at base, rounded-emarginate at apex, finely pubescent beneath. Flowers in racemes combined into a terminal up to 45 cm long panicle, 5-merous, fragrant and long-stalked; sepals 5–10 mm long, reflexed; petals (ob)ovate or orbicular, 1.5–2.5 cm long, yellow, wavy and spreading; stamens 10, filaments woolly at base; ovary superior and hairy, style filiform. Fruit an elliptic to oblong-lanceolate pod, 5–13.5 cm × 1.5–2.5 cm, shortly stalked, acute at apex, more or less winged, glabrous, longitudinally veined and copper coloured when ripe, later blackish, 1–5-seeded. Seeds oblong, 10–12 mm × 5 mm, flattened. Germination epigeal, seedling with 4–6 cm long hypocotyl and stalked, 3-nerved, glabrous cotyledons.

Growth and development The first leaf of the seedling has 4–6 pairs of opposite and almost sessile leaflets. Subsequent leaves are also evenly pinnate, but soon the leaves become bipinnately compound. Yellow flame is fast-growing. Young trees raised from seed will flower in 4 years under good conditions. The crown is at first bushy and flat-topped, then the outer branches gradually increase in length and finally droop to the ground to form an umbrella-shaped crown. In South-East Asia yellow flame sheds leaves during 1–2 weeks after a pronounced dry weather period, then develops new shoots. After flushing the tree starts flowering. At first, young upstanding clusters of brown flower buds darken the crown. The buds of each raceme open from the base of the raceme towards the apex; several flowers open at the same time. This makes the crown full of blooms of a bright golden-yellow colour which lasts for several weeks. Only a few flowers develop into purple-brown pods which protrude above the crown. The cycle of flushing and leaf fall varies, and is genetically controlled. In Peninsular Malaysia the cycle varies between 6 and 9 months, but in other places it is more regular. It seems that regularity is due to selection under strongly seasonal conditions.

Ecology Under natural conditions yellow flame is a lowland species, rarely occurring above 100 m altitude. It frequently grows along beaches and in mangrove forest, especially along the inner margin of the mangroves. In Java it is also found probably wild in Imperata fields and teak forests. The species prefers open forest. It has been suggested that yellow flame thrives best under more or less seasonal conditions. Under cultivation, yellow flame can be grown well up to 600 m altitude, sometimes even up to 1600 m, e.g. in Papua New Guinea.

Propagation and planting Yellow flame can be propagated by seeds, graftings or cuttings. Untreated seeds need several months to germinate. Germination is hastened by filing or scarifying one end of the hard seed-coat, softening the seed-coat in diluted acid, or immersing the seed in boiling water for 2 minutes followed by soaking it in cold water for one night.

Preferably, seedlings are raised in nurseries for about a year before transplanting into the field. Young trees are often planted in an intercropping system with mahogany or teak. Grafts or cuttings may be used for better uniformity for road-side trees.

Husbandry After the first year of establishment in the field, little effort is needed to maintain yellow flame plantations. The stand will survive even when the ground is covered by a thick mass of 'alang-alang' and other tall grasses.

Diseases and pests Yellow flame does not suffer much from diseases and pests. However, in Singapore the foliage is severely damaged by the night-flying beetle *Autoseria rufocuprea*. Powdery mildew caused by *Oidium* spp. is reported from India.

Handling after harvest In the traditional brown dyeing of 'batik' in Indonesia, the cotton cloth which has been given a specific pattern and which has been waxed by means of writing ('batik tulis') or stamping ('batik cap') is immersed in a solution of 'soga' dye. Usually parts of the cloth have already been dyed dark blue using indigo or synthetic dyes, but the colour will become black after soga dyeing.

The solution of soga dye is prepared as follows: bark of yellow flame is mixed with bark of *Ceriops tagal* and wood of *Maclura cochinchinensis*. These materials are chopped into chips about 5 cm long and put into a big jar of water until the chips are fully submerged. After boiling for several hours to reduce the amount of water by half, the thick solution is transferred to a pan and water is added again to the chips in the jar. The chips may be extracted in the same way 3 times, and the resulting solutions are added to the first solution.

The proportion of the barks and wood depends on the colour desired. A large proportion of yellow flame bark gives a dark brown colour; large proportions of *Ceriops* bark and *Maclura* wood give reddish-brown and yellow-brown colours, respectively. Usually the bark of yellow flame is the main ingredient. Sometimes wood of *Caesalpinia sappan*

L. or bark of *Albizia lebbekoides* (DC.) Benth. is added to give the dyeing solution a more reddish colour, and pine resin is often added to the mixture, too. However, materials used for soga dyeing vary according to the place of batik production.

The cloth is immersed in the cooled solution for about 15 minutes and is turned over and over to let the solution penetrate evenly. Then the cloth is hung on a rack over the pan; when it has stopped dripping, it is removed and dried in the shade. The process of immersion and drying is repeated until the desired colour is obtained. Usually 16–18 immersions are sufficient, but for fine batik sometimes 30 immersions are necessary to obtain an even colour. After the last dyeing bath, the cloth is immersed in a lime solution and then boiled in water to liquefy the wax. The wax is scraped off the cloth, which is then washed in fresh water and dried.

To develop and make the colour fast, the batik cloth is immersed in a mordant bath which is a mixture of water, sugar, alum, lime juice, and sometimes the flower buds of *Sophora japonica* L., lac-dye and other ingredients. The result of this long process of soga dyeing is a cloth with yellowish- to reddish-brown colours which shade off gradually into one another. The cloth has a typical smell which differs from cloths dyed with synthetic dyes. The colours may last long, but the cloth should not be washed in soap or a detergent solution. For washing, a solution of ripe fruits of *Sapindus rarak* DC. in water should be used, and drying should be done in the shade.

Prospects In recent years yellow flame has become a widely appreciated ornamental plant for gardens and road-sides. Its prospects as an ornamental are very good because this species is quick-growing, fairly resistant to insect attack, and very showy with its spreading crown and profusion of yellow flowers.

The use of the bark in dyeing is decreasing rapidly. Dyers tend to use synthetic dyes because they are easier to obtain and cheaper, the colours are fast, and the quality of the batik cloth can be standardized. The bark of yellow flame is still used in the manufacture of 'soga' batiks, especially in central Java. The germplasm of yellow flame must be collected and evaluated if this species is to have a chance to be a dye plant in the future.

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N. Wulijarni-Soetjipto & R.H.M.J. Lemmens

Peristrophe bivalvis (L.) Merr.

Interpr. Rumph. Herb. Amboin.: 476 (1917).

ACANTHACEAE

$2n$ = unknown

Synonyms *Peristrophe tinctoria* (Roxb.) Nees (1832), *Peristrophe roxburghiana* (Schultes) Bremek. (1955).

Vernacular names Indonesia: noja (Javanese). Malaysia: noja. Philippines: deora (Bisaya), kaladuda (Lanao), taoda (Manobo). Vietnam: kim long nhuôm.

Origin and geographic distribution *P. bivalvis* is distributed from eastern India and Sri Lanka to central China, Taiwan, the Philippines, Malaysia, and Java. It is (or was) cultivated in India (Bengal and Assam), the southern Philippines, and, rarely, in Java. Often the plant is semicultivated, as a relic of former cultivation.

Uses The twigs and leaves give a purplish or orange-red dye, used in Indonesia to colour cotton and mattings in a mixture with other dye plants, such as the leaves of *Hemigraphis* sp. and *Symplocos* sp. and root-bark of *Morinda citrifolia* L., or in a mixture with leaves of *Melastoma* sp. and bark of *Ceriops* sp., practised in Malaysia. In India the twigs serve to dye matting, sometimes also in mixtures. In traditional medicine, a poultice made from pounded leaves is reported to relieve skin complaints.

Properties The identity of the dyeing matter of *P. bivalvis* is still unknown.

Botany An erect, often much-branched herb up to 1 m tall, rarely up to 1.5 m. Stems subquadrangular, usually swollen above the nodes, pubescent,

Peristrophe bivalvis (L.) Merr. – 1, flowering plant; 2, fruit.

especially apically, or nearly glabrous. Leaves opposite, membranaceous, ovate to lanceolate or oblong, 7–16 cm × 2.5–7.5 cm, cuneate to rounded at base, acuminate at apex, margins entire or shallowly undulate, glabrous above, sparingly pubescent beneath; petiole 0.5–3(–4) cm long. Flowers in terminal cymes, which are composed of 1–4 involucres, each involucre with 2–6 flowers and 2 large, unequal bracts; calyx 3–7 mm long, pilose with ordinary and glandular hairs; corolla 3.5–5 cm long, with long, tortuous tube and bilabiate, resupinate limb, pubescent outside, reddish-violet, sometimes pale; stamens 2, inserted near the top of the corolla tube, long-exserted, filaments retrorsely hirsute; style filiform, 2-lobed. Fruit a clavate to ellipsoid capsule, 1.5–2 cm long, pubescent, 2-valved with 2 orbicular, flat and slightly tuberculate seeds per valve.

Peristrophe montana Nees is reported to be used in the same way as *P. bivalvis*. Certain other members of Acanthaceae that yield a dye, such as *Hypoestes rosea* Decne. and *Strobilanthes crispus* (L.) Blume, are sometimes mistaken for *P. bivalvis*.

Ecology *P. bivalvis* is often found on cultivated lands, in thickets and coconut groves, often probably a relic of cultivation. Under supposed natural conditions it grows along watercourses in forests. In the Philippines it is cultivated up to 1600 m altitude.

Agronomy Plants can be propagated by cuttings and seeds. Usually cuttings are preferred because growth is quicker. Cuttings taken at any time from tender shoots will root in 3 or 4 weeks in a suitable nursery bed. Plants grow fast, and mostly after about 4 months the twigs can be lopped. Fresh or dried twigs can be used for dyeing. They are cut into small chips, pounded, and boiled in water. The material to be dyed can then be dipped in the solution. Material for matting is boiled in the solution for some hours, or left for some days in the cooled solution, then removed and dried. Textile is dipped in the cooled solution (with or without mordant), and dried in the shade, and this treatment is repeated several times. In Java the textile or yarn is first steeped in the solution for some days and afterwards boiled and dried. The dyeing solution may also contain parts of other dye plants. Without the addition of other plants, matting material acquires a red colour and textile a dull red colour.

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L.E. Groen

Phyllanthus emblica L.

Sp. Pl. 2: 982 (1753).
EUPHORBIACEAE
$2n = 98, 104$.

Synonyms *Emblica officinalis* Gaertner (1791).

Vernacular names Emblic myrobalan, Indian gooseberry, aonla (En). Myrobalan emblic (Fr). Indonesia: kimalaka (general), malaka (Sundanese), kemloko (Javanese). Malaysia: laka, melaka. Burma: ta-sha-pen. Philippines: nelli. Cambodia: kântûët préi. Laos: khaam poomz. Thailand: ma-khaam pom (general), kan-tot (Khmer,

Chantaburi), kam thuat (Ratchaburi). Vietnam: chùm ruột, me ru'ng.

Origin and geographic distribution Emblic myrobalan is indigenous to a large area ranging from the southern Himalayas of Nepal and northern India to the south of the Indian subcontinent, Sri Lanka, Burma, Thailand and Indo-China to southern China and Malesia. In Malesia this species occurs naturally in Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, the Lesser Sunda Islands and Ambon. Emblic myrobalan is fairly commonly cultivated throughout its natural area of distribution, and also in the Mascarene Islands. Long ago the species was recorded once in Madagascar.

Uses Immature fruits are used for tanning in India and Thailand, often in combination with other tanning materials such as chebulic and beleric myrobalans (*Terminalia chebula* Retz. and *T. bellirica* (Gaertner) Roxb., respectively). The bark of the twigs is also of considerable value as tanning material. In combination with the leaves of *Carissa spinarum* L. (30%) and *Anogeissus latifolia* Wallich (20%), the twig bark gives a good leather with reddish-brown colour. Stem bark and leaves have also been used locally for tanning.

The leaves are employed for dyeing matting, bamboo wickerwork, silk, and wool brown. The colour becomes black when iron is used as mordant. Matting can be dyed dark colours with a decoction of the bark. In Indonesia, as well as in Indo-China and China, the fruits are used to prepare a black ink and a hair dye.

The astringent and sour ripe fruits are edible. They are rarely eaten raw; more commonly they are used in cooked food, or as sweetmeat and pickle. They are also made into jam, jelly and syrup.

Emblic myrobalan has numerous medicinal uses. In India the fruits are one of the important ingredients of a famous medicine of the Ayurvedic system. In fact, the fruits are applied for an enormous variety of complaints. The bark and roots also serve as a local medicine.

The leaves are used as fodder and as green manure. Trees are planted with others to conserve soil.

The timber is used for implements and sometimes for building; it can be used to build wells as it is durable under water. The wood is an excellent firewood and provides charcoal of good quality.

Production and international trade No figures are available either on the production of tanning material or on the production of fruits for consumption.

Properties Fruits, bark and leaves are rich in tannin. Dried pulp of unripe fruits contains 18–30% tannin, sometimes even more (up to 35%). The tannin content of ripe fruits is much lower. The dry stem bark contains only 8–9% tannin, but occasionally as much as 20%. The bark of twigs is usually richer, containing 12–24% tannin on dry weight basis. Leaves may yield 22–28%. The tannins of the fruits belong to the group of gallotannins and ellagitannins, giving on hydrolysis gallic acid in large amounts, ellagic acid in small amounts, and glucose. The tannin of the bark is different; it belongs to the group of proanthocyanidins, giving (+)leucodelphinidin on hydrolysis. It gives a reddish-brown leather with a soft grain which lacks somewhat in flexibility, which is why it is usually mixed with other tanning materials.

The fruit is an extremely rich source of vitamin C, 100 g of juice containing 600–1300 mg of ascorbic acid, sometimes even more. This explains many of the medicinal applications. The tannin in the fruit prevents or retards the oxidation of the vitamin, so that the fruits can be preserved in salt solution or as dry powder while still maintaining their antiscorbutic value. The fruits have diuretic, laxative and purgative activity and also show molluscicidal and antimicrobial properties. The fruit is a rich source of pectin. Fruits of wild plants weigh approximately 5.5 g, cultivated fruits average 28–50 g. Seeds yield about 16% of a brownish-yellow oil. Seed weight is about 570 g/1000 seeds.

The roots are said to be emetic.

The wood is fairly heavy, weighing 720–930 kg/m^3, and is hard and close-grained. It has a reddish colour and is liable to split.

Description A small to medium-sized deciduous tree, rarely up to 25 m tall but usually much shorter, up to 7.5 m; trunk often crooked and gnarled, up to 35 cm in diameter; bark thin, smooth, grey, peeling in patches, with numerous bosses from which the leaf-bearing branches arise; branches spreading. Leaves distichous and densely crowded along the apices of lateral twigs, reduced along the main branches, simple and entire, narrowly oblong, 5–25 mm × 1–5 mm, rounded to subcordate and more or less oblique at base, acute or obtuse and mucronate at apex, subsessile, glabrous. Flowers fascicled in axils of leaves or fallen leaves, unisexual, the male flowers numerous at base of young twigs, the female flowers solitary and further along the twig; male flowers pedicellate with 6 pale-green 1.5–2.5 mm long perianth-lobes and 3 stamens with entirely connate filaments and anthers; female flowers sessile, with 6 somewhat larger perianth-lobes, a cup-

Phyllanthus emblica L. – 1, flowering branch; 2, male flower; 3, female flower; 4, fruiting branch.

like disk, and a 3-celled superior ovary crowned by 3 styles connate for more than half of their length and deeply bifid at apex. Fruit a depressed globose drupe, in wild plants 13–25 mm × 23–30 mm, in cultivated plants often larger (up to 42 mm in diameter), pale green changing to yellow when mature; stone with 3 subdehiscent compartments, each usually containing 2 seeds. Seeds trigonous, 4–5 mm × 2–3 mm.

Growth and development The tree is rather slow-growing. Trees usually bear fruits at the earliest when 8 years old, but sometimes they begin to bear when 5–6 years old. In many areas, full-grown trees are rare as a result of slow growth and exploitation.

The tree produces two types of shoots: determinate and indeterminate. The indeterminate shoots are long and provide annual extension growth to the tree. They neither flower nor abscise. The determinate shoots are short, bear flowers, defoliate and abscise. New determinate shoots emerge a few months after abscission of old shoots, and 95% of them will produce flowers. Young shoots are light red, turning green after 2 or 3 days. After about 15 days they produce 2 rows of leaves, and at the same time flowers appear in the axils of the young leaves. Flowering peaks one month after the new shoots appear. In Java this is around August.

Leaves develop completely after fruit set. The development of the leaves probably inhibits flowering. The embryos remain dormant for a period of about 3.5 months. Fertilization is reported to take place within 36 hours following pollination, but the zygote and the endosperm nuclei remain in the uninucleate stage for periods of up to 120 days. The retardation in the development of the fruits correspond with a period of rapid shoot growth, after which shoot growth slows down or stops. It has been suggested that a supra optimal level of auxins translocated from the shoot tips to the embryo causes the dormancy. The fruits are ready for harvesting about 7 months after flowering. They can be retained on the tree for about 3 months without considerable loss in quality or yield.

In some places the tree flowers twice a year. Flowering can also be forced by defoliation by hand, which forces the production of new shoots.

Other botanical information In literature emblic myrobalan has occasionally been confused with the 'true' myrobalans from *Terminalia* species. However, they only have in common the tannin-yielding fruits. Several *Phyllanthus* species, including *P. emblica*, resemble legumes. The feathery leafy and deciduous branchlets are identical to pinnate leaves (for instance, those of *Parkia* spp.). The cultivars cultivated as fruit trees in India include 'Banarasi', 'Chakla', 'Desi', 'Francis', 'Kanchan', and 'Krishna'.

Ecology Emblic myrobalan is a light-demanding species which is often common in grassy areas, brush and village groves. In Java it is also found in teak forests, in Peninsular Malaysia it is frequent in lowland forests. The species is photosensitive, only producing flowers at a daylength between 12 and 13.5 hours.

The tree is fire-resistant, and is one of the first trees to recover after a fire. It occurs from almost sea-level to 1200 m altitude in north-western Thailand and Indonesia (Java); in the sub-Himalayan region even up to 1500 m. Emblic myrobalan is slightly tolerant of alkaline soils. In Indonesia it is found in very dry areas but not along the coasts. However, some cultivars are sensitive to drought, and also to frost.

Propagation and planting In the past, propagation was usually by seeds. For extensive production and selection, vegetative propagation is nec-

essary. A high percentage of rooting (84%) has been reported from semi-hard wood cuttings collected from the middle portions of invigorated shoots of young trees and planted in beds at a temperature of about 33°C. Budding and softwood grafting may also give good results. In the early stages of growth, copious watering in the dry season and some weeding are necessary.

Husbandry The tree coppices well and pollards moderately well. Coppiced shoots grow particularly vigorously, and coppicing is considered the system most suitable for the production and collection of tanbark on a commercial scale. Usually plantations need much weeding because the canopy is not closed by the thin crowns.

Diseases and pests In India several diseases have been reported. A dieback disease is caused by *Botryodiplodia theobromae*, and seedlings are susceptible to a root-rot disease caused by *Rhizoctonia solani*. Trees may be affected by rusts such as a leaf rust caused by *Phakopsora phyllanthi* and a ring rust caused by *Ravenelia emblica*.
Indarbela spp., bark-eating caterpillars, damage trees. The fruits are susceptible to rot diseases as a result of infection by *Penicillium* spp., *Glomerella cingulata*, *Phoma putaminum*, and *Aspergillus niger*.

Harvesting The bark of shoots of less than 5 cm diameter is used to obtain a good tannin. Usually branches can be coppiced every 2 years. For use in tanning, the fruits should be harvested unripe.
The fruiting season is exceptionally long since the ripe fruits may be retained for several months on the tree without significant loss of quality. Because of this, a long period is available for picking the fruits for consumption.

Yield The average annual yield of wild trees in India is about 15 kg of fruit per tree. Some cultivars may yield over 25 kg of fruit.

Handling after harvest Quickly-dried bark contains much more tannin than slowly-dried bark. Therefore it has been recommended to dry the bark rapidly in the sun. The stone of unripe fruits should be removed and the remaining flesh dried and ground to prepare a tanning material.
Fresh fruits are not palatable because of their astringent and sour taste. The astringency can be removed by steeping the fruits in brine for a few days. Fruits are often preserved by splitting, removing the stone, putting the segments into a solution of 42% glycerol, 42% sucrose, water and preservatives, then heating to 90°C for 3 minutes. The fruits are allowed to equilibriate in the solution for two days at 2°C, then they are drained and packed into containers. Fruits preserved in this way remain acceptable for about 2 months at room temperature, and much longer when cooled, while the ascorbic acid content drops slowly.
Marketability of fresh fruits is improved by a combined treatment with wax emulsion and 10 mg/l morphactin. This delays browning and reduces the infection rate from *Aspergillus* and *Penicillium* species. For medicinal purposes, fruits are simply dried.

Prospects Emblic myrobalan is a tree which deserves more attention. As a tannin and dye-yielding species it has interesting aspects because it could be a regular supplier of tanning and dyeing material by coppicing the tree or harvesting young fruits. Trees are not killed at harvest as is so often the case with species yielding tanbark.
Experiments in Indonesia show that this species is not easy to cultivate on a large scale. It is rather slow-growing and needs much weeding. New experiments of methods of cultivation might be worthwhile. Selection for large edible fruits is normally not compatible with selection for fruits with high tannin content. Combined selection for tanning and medicinal purposes seems to be possible. Emblic myrobalan has great therapeutic potential.

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A.J.J. van Schaik-van Banning

Phyllanthus reticulatus Poiret

Lamk, Encycl. Méth. Bot. 5: 298 (1804).
EUPHORBIACEAE
$2n = 26$

Synonyms *Phyllanthus multiflorus* Willd. (1805), *Kirganelia reticulata* (Poiret) Baillon (1858).

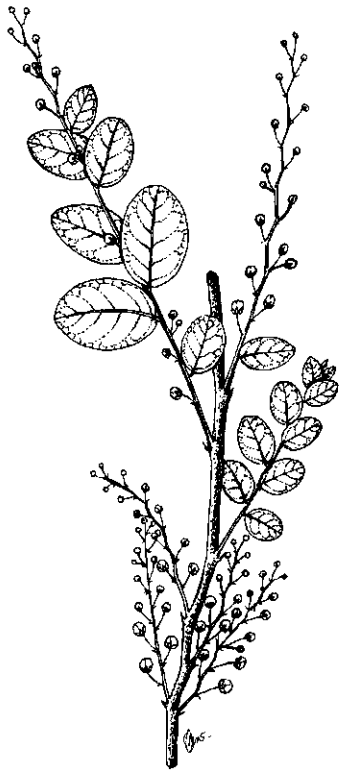
Vernacular names Indonesia: wawulutan (Sundanese), trembilu, congcong belut (Javanese). Malaysia: tampal besi, kayu darah belut. Philippines: malatinta (Tagalog), matang-buiud (Bikol), sungot-olang (Bisaya). Cambodia: prâpéénh chhmôôl. Laos: 'am 'aiz, kang paax. Thailand: kaang plaa khruea (general), mat kham (Phrae), am aai (Nakhon Ratchasima). Vietnam: phèn den.

Origin and geographic distribution *P. reticulatus* is found throughout the Old World tropics. In Asia it is widely distributed from India and Sri Lanka to southern China and eastern Malesia (Irian Jaya), including the whole of South-East Asia. This species is also widespread in tropical Africa.

Uses A black ink is prepared in the Philippines from the ripe fruits. In Indonesia a decoction of stems and leaves was used for dyeing cotton black. It is also used as a mordant. In India the root is reported to produce a red dye.
P. reticulatus has numerous medicinal uses. Roots, bark, leaves, as well as fruits are used for a large number of complaints, notably to treat asthma and coughs, and for injuries of the skin. The wood is sometimes used to make utensils.

Properties Very little is known about the phytochemistry of *P. reticulatus*. The plant contains tannic acid which is partly responsible for its medicinal and dyeing properties. A number of triterpenoids including sitosterol, friedelin, and betulinic acid have been demonstrated in the stems and leaves.
The wood is hard and tough, and greyish-white to reddish.

Botany A monoecious scandent shrub or small bushy tree, up to 5 m tall (in Africa rarely up to 18 m tall); trunk up to 15 cm in diameter, bark rough, brown to grey, branchlets slender. Leaves differently shaped; spirally arranged scale-like, ca. 1.5 mm long on the orthotropic shoots; plagiotropic shoots with normally developed, distichous, elliptic to (ob)ovate leaves, 1–3(–5) cm × 0.5–2(–2.5) cm, entire, cuneate to rounded at base, obtuse to emarginate at apex, glabrous and shortly petiolate. Flowers in few-flowered fascicles or solitary in leaf axils, unisexual, often a single female flower and some male flowers together, sometimes arranged on leafless shoots and those then seemingly long racemes, with 5(–6) perianth lobes and 5(–6) disk glands; male flowers with 5(–6) stamens; female flowers with a superior subglobose ovary, crowned by 2-lobed styles. Fruit a depressed-globose berry, up to 7 mm in diameter, usually blueish-black when ripe with dark purplish pulp, 6–many-seeded. Seeds trigonous, up to 2 mm long, blackish.
P. reticulatus generally flowers throughout the year. The indumentum of leaves, stems and flowers is variable, from glabrous to densely pubescent. In Africa, 2 varieties have been distinguished: var. *reticulatus* with pubescent flowering shoots and sometimes also leaves and stems, and var. *glaber* (Thwaites) Muell. Arg. with all parts glabrous.



Phyllanthus reticulatus Poiret – flowering branch.

Ecology *P. reticulatus* frequently grows along watercourses, but also in scrub and hedges, on waste places, and in mixed evergreen forest. It is found in India and Taiwan up to 2000 m altitude. In Malesia it is usually confined to the lowlands, up to 800 m. This species is often common in moist places.

Prospects Very little is known about this plant.

Chemical analysis is needed to elucidate the interesting dyeing and medicinal properties of this extremely widespread species.

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L. Phuphathanaphong

Rhizophora mucronata Poiret

Lamk, Encycl. 6(1): 189 (1804).
RHIZOPHORACEAE
$2n = 36$

Synonyms *Rhizophora macrorrhiza* Griffith (1836), *Rhizophora latifolia* Miq. (1861), *Rhizophora mucronata* var. *typica* A. Schimper (1891).

Vernacular names Brunei: bakau kurap, lenggayong. Indonesia: bakau, bakau hitam (general). Malaysia: bakau hitam, bakau jangkar, bakau kurap. Papua New Guinea: mangoro (Pidgin). Philippines: bakáu (many languages), bakáuan (Tagalog, Bisaya), tong (Bisaya). Singapore: bakau laut, belukap. Burma: pyoo. Cambodia: doeum prasak. Thailand: kon gkang bai yai, phangka. Vietnam: dung, duoc bop, duoc rung cam.

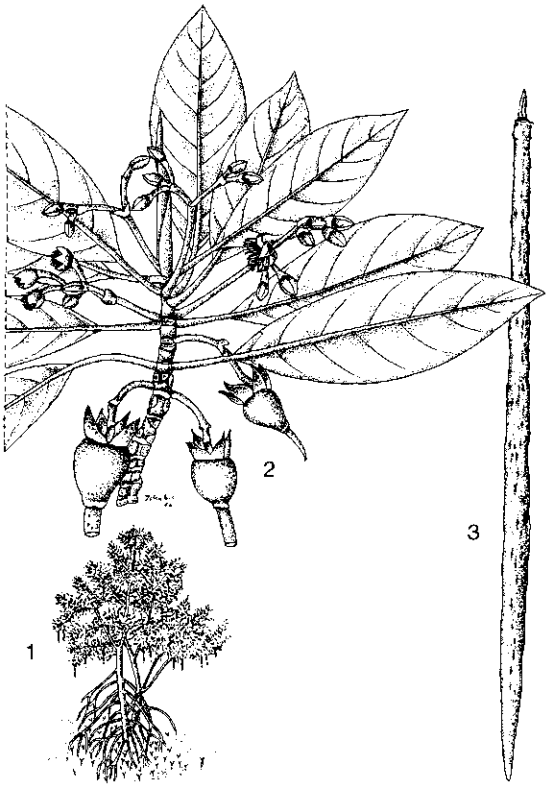
Origin and geograpic distribution Trees of *R. mucronata* grow on the shores of the Old World tropics, from East Africa through Madagascar, islands of the Indian Ocean, the south-eastern mainland of Asia, Indonesia and the Philippines, to north-eastern Australia and the South Pacific islands as far as the Tonga group. In 1922 this species was introduced into Hawaii and is naturalized there.

Uses In the Malesian Archipelago, the bark of mangrove trees (chiefly *R. mucronata* and/or *R. apiculata* Blume) is an important source of tannin. It is used for tanning leather and to toughen and dye lines, nets, and ropes used by fishermen. According to laboratory investigations, mangrove tannin extracted from the bark could be used to produce adhesive for the manufacture of plywood and particle board. It is used also occasionally as medicine in cases of haematuria. The trees are important for producing good quality charcoal and for firewood. A great advantage of *Rhizophora* L. in the eyes of firewood dealers is that it can easily be split. The trees are also used for fish-traps. The use of the wood is limited because of its light weight, poor durability and small size of the trunk.

Production and international trade *R. mucronata* is hardly cultivated for commercial purposes. It is grown on a very small scale for firewood, chiefly for local consumption, e.g. in Luzon (the Philippines).

Properties The quantity of tannin in the bark may vary greatly. In air-dried bark the tannin content varies from 8–40%. The tannin is sometimes extracted and concentrated into cutch. The bark, according to some chemical analyses, appears to contain high percentages of pentosans and furfurol. The ash, after the cutch has been extracted, consists mainly of lime (18%) and calcium carbonate (70%), and can be used as fertilizer. The tannin of *Rhizophora* is associated with a substance which darkens gradually; it is used as a deep brown or black dye. The wood shows a beautiful silver grain on radial section and the heartwood is dark orange-red.

Description Tree up to 27(–30) m tall and with trunk 50–70 cm in diameter; taproot usually abortive; lateral roots numerous, developed from base of the trunk, much branched, usually called stilt roots, hoop or pile-like, supporting the tree; hanging air-roots are sometimes also produced from the lower branches; stem in closed forest cylindrical, or developing a straggling or semi-prostrate habit especially in unfavourable conditions; bark almost black or reddish, rough or sometimes scaly, with prominent, horizontal cracks almost encircling the stem. Leaves leathery, broadly elliptic to oblong-elliptic, (8.5–)11–18(–23) cm × 5–10.5(–15) cm, with very distinct black dots on the undersurface, tapered at both ends and tipped with a fine spine, glossy green above and paler beneath; petiole 2.5–5.5 cm long; stipules large, 5.5–8.5 cm long, pinkish or reddish, sticky. Inflorescences axillary, 2 or 3 times forked, rather loosely (1–)3–5(–12)-flowered; peduncles 2.5–5 cm long; flowers with 4–8 mm long pedicels and united, cup-shaped bracteoles at the base; calyx deeply lobed, 13–19 mm long, pale yellow or almost white; petals lanceolate, 9 mm long, light yellowish, densely hairy along the margins, sparsely hairy on the back; stamens 8, sessile, equal, anthers 6–8 mm long; ovary semi-inferior, free part high conical, 2.5–3 mm high, style very short,



Rhizophora mucronata Poiret – 1, habit of the tree; 2, flowering and fruiting branch; 3, young seedling.

0.5–1.5 mm long, obscurely 2-lobed. Mature fruit an elongately ovoid berry, 5–7 cm × 2.5–3.5 cm, with hardly contracted apex and often rugose base, dull brown-green. Seedlings with cotyledons 2–4 cm protruding from the fruit; hypocotyls hanging, cylindrical, 36–64(–over 100) cm × 1.8–2.5 cm, tuberculate, usually straight, gradually narrowed upwards into a hard, sharp point.

Growth and development Mangrove trees of *Rhizophora* have a characteristic development of the seed. One seed is developed per fruit and starts to germinate when the fruit is still attached or hanging on the tree; this phenomenon is known as viviparous germination and is common among mangrove plants. The root (radicle) gradually protrudes from the fruit, at first like a green cigar, then grows into a rod-like structure. In *R. mucronata*, such a seedling root (hypocotyl) with a rough and warty surface may attain a considerable length (sometimes over 100 cm), the largest and longest in the genus. Later the seedling falls out of the fruit, drops into the mud and sooner or later begins to grow. The seedlings that have fallen into the water at high tide commonly drift to another place or are washed up on the shore; they retain their vitality for several months, and will survive and grow if the spot is ecologically suitable. The main root of the seedling is usually abortive and lateral roots take over its function.

Rhizophora is usually wind-pollinated. The flowers are bisexual, self-compatible and therefore may be able to self-pollinate. Insects (e.g. bees) have been observed sometimes visiting flowers to look for pollen.

Other botanical information One should keep in mind that, at least in Malesia, botanical information on *R. mucronata* can often also be applied to a closely allied, also common, widely distributed species *R. apiculata* Blume. The latter species can be distinguished from *R. mucronata* in the field by some easily observed characters. The bark is grey, almost smooth, with vertical fissures. Inflorescences are shorter, fork only once, and are always 2-flowered. Seedling hypocotyls are usually less than 30 cm long, smooth.

In western Malaysia and west from New Guinea a few specimens occur with characters intermediate between *R. mucronata*, *R. apiculata* and a third species, *R. stylosa* Griffith. Hybridization might occur in nature between these species.

Ecology Plants of *R. mucronata* are most profusely developed, generally gregariously, on the banks of tidal creeks, in estuaries and on low coastal areas flooded by normal, daily, high tides. In general they prefer deep soft mud rich in humus with suitable salinity and they are often found well developed in wet climates. The trees of this species form a rather uniform, evergreen fringe to the mangrove forest. In certain favourable regions in Malesia they may occupy considerable large areas, sometimes associated with *R. apiculata*, sometimes forming almost pure stands. Communities of the two common species of *Rhizophora* can sometimes be identified at a glance by their different shades of green.

Propagation and planting Natural regeneration always occurs near mature trees. There is a form of vegetative spread of the trees by horizontal growth of the lower branches supported by stilt roots; these branches can continue to grow if the parent trunk dies. Young seedlings can be used for planting.

Husbandry The tree grows slowly. In Peninsular Malaysia it takes 35–40 years to reach up to 19 cm in diameter. A 40-year rotation is favourable.

Diseases and pests The radicles and hypocotyls of germinated *R. mucronata* seeds occasionally

suffer from a peculiar disease which is characterized by a brown discolouration and dying of the tissues.
Crabs are great enemies to seedlings and will damage plantations. In the Philippines it has been reported that drying the seedlings for several days in the shade before planting can stave off crab attack. Beetles (e.g. from the family Scolythidae) may damage the root tips, resulting in deformed roots.

Harvesting For tannin production the bark is removed by hand from living trees or from trees just felled for firewood, charcoal or timber.

Yield In Malesia the bulk of the mangrove bark used for tannin appears to originate from *R. mucronata*, which has a considerably higher proportion of bark and tannin content than *R. apiculata*. It was reported that *R. mucronata* is likely to be the most profitable species and its yield of bark is 23–27% of the volume or 18–20% of the weight.

Handling after harvest The bark stripped off from the tree should not be allowed to become dry, otherwise it will be regarded as worthless. If it is not required for immediate use, it should be stacked and kept moist by frequent watering.

Prospects As frequently stripping most of the bark from the bole kills the tree, it is better to integrate bark production with the production of firewood and charcoal. Felling the trees should be well planned and care must be taken not to destroy the possibilities for natural regeneration. Too much mangrove forest has been destroyed in recent years.

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D. Hou

Rubia cordifolia L.

Syst. nat. ed. 12,3 (add.): 229 (1768).
RUBIACEAE
$2n = 22$ (44, 66)

Synonyms *Rubia munjista* Roxb. (1820), *Rubia javana* DC. (1830), *Rubia mitis* Miq. (1867).

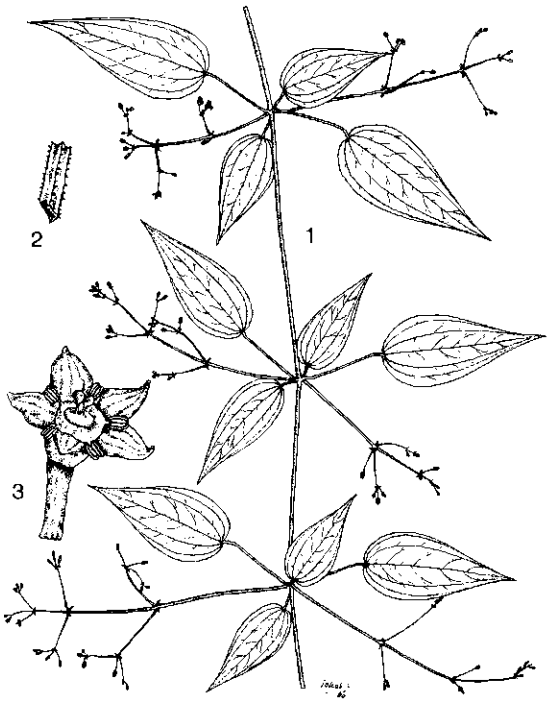
Vernacular names Indian madder (En). Indonesia: letah meong (Sundanese), kletak (Javanese). Philippines: kamagut, mankit (Igorot), pantig-pantig (Bagobo). Vietnam: thiên can.

Origin and geographic distribution Indian madder has an extremely large area of distribution, ranging from Africa through Central Asia to the Soviet Union, India, Japan, China, Indo-China, Malaysia (Sabah), the Philippines, parts of Indonesia (Sumatra, Java), and northern Australia.

Uses Extracts from the root and the stem have long been used to dye coarse cotton fabrics, blankets and carpets. The orange or red colour obtained is brighter than that from madder root (*Rubia tinctorum* L.), though less permanent. The colouring power of *R. cordifolia* is less than that of *R. tinctorum*. To dye a piece of cloth, it is steeped in an infusion of the root or stem in water, being mordanted with alum. As a dye, Indian madder has largely been replaced, first by madder root, later by synthetic dyes.
Indian madder has several medicinal uses, for instance in Ayurvedic and Chinese medicine. Roots are credited with astringent and antidysenteric properties. They are said to be active against *Staphylococcus aureus* and are made into a paste, which is applied to ulcers and skin infections. A decoction of the leaves and stems is used as a vermifuge e.g. in the Philippines. An extract of the plant is used as one of the components of a medicine used against nasal infections. The leaves of the plant are eaten in Java as a side dish with rice (lalab).

Properties The colouring matter in the roots is a mixture of alizarin (1,2-dihydroxy-anthraquinone), purpurin (1,2,3-trihydroxy-anthraquinone), purpuroxanthin (1,3-dihydroxy-anthraquinone) and munjistin (1,3-dihydroxy-2-methoxy-anthraquinone). Small amounts of several other anthraquinones and derivatives have been reported.

Botany An extremely variable species. Climbing or creeping herb up to 10 m long. Rootstock perennial, roots long, cylindrical, flexuose with thin red bark. Stem with long internodes, quadrangular, sometimes prickly or hispid, often glabrous. Leaves simple, (2–)4(–8) together in whorls, leaf blade cordate to (narrowly) ovate, 2.5–10 cm × 1–4 cm, veins 3–9-palmate, cordate or rounded at base, acute or acuminate at apex, entire, surface smooth or retrorsely scabrid or hairy or strigose; petiole usually long, 5–8 cm, sometimes as short as 0.5 cm. Flowers in axillary and terminal cymose, trichotomously branching, long-peduncled panicles, 3.5–4.5 mm in diameter, with colour variable



Rubia cordifolia L. – 1, habit of flowering plant; 2, part of stem; 3, flower.

from greenish-white to purple-red, (4–)5-merous; stamens epipetalous; ovary inferior, 2-celled, styles 2. Fruit a globose or 2-lobed berry, 4–5 mm × 3.5–5 mm, blueish-black, sometimes red or purple, 1–2-seeded.

Considering the entire area of distribution, the variability of *R. cordifolia* is extraordinary. Attempts to split the species into several taxa have failed, and much experimental taxonomic work would be needed to unravel the systematics of this species and its allies. Subdivisions of the species have been based on variable characters such as the nature of the surface of stems and leaves (prickly to glabrous), shape of the leaves, colour of flowers and fruits, and epigeal or hypogeal germination.

A form, described as var. *khasiana* Watt, is reported to contain more dye than other forms. It has mostly 5 veins and a smooth surface of the leaves, and occurs in north-eastern India, Bangladesh, Nepal and Sikkim. *R. tinctorum*, the European madder or madder root and *R. sikkimensis* Kurz are related species, containing similar dye components.

R. cordifolia should not be confused with *Oldenlandia umbellata* L., also called Indian madder and containing very similar dyeing components.

Ecology The vast area over which *R. cordifolia* occurs indicates its adaptability. In South-East Asia it occurs mostly in humid areas, 500–2500 m above sea-level, mostly in secondary vegetation.

Handling after harvest Roots and stems are collected, apparently exclusively from the wild, dried and chopped into small pieces. These are mixed with water to prepare the dye.

Prospects *R. cordifolia* has at present nearly lost its importance as a dye-producing plant. However, its pharmaceutical importance seems to be increasing. The possibility of using cell cultures to produce anthraquinones for pharmaceutical purposes is being tested.

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L.P.A. Oyen

Sophora japonica L.

Mant. Pl. 1: 68 (1767).

LEGUMINOSAE

$2n = 28$

Synonyms *Styphnolobium japonicum* (L.) Schott (1830).

Vernacular names Japanese pagoda tree, umbrella tree, Chinese scholar tree (En). Indonesia: sari kuning, sari cina. Vietnam: hoè.

Origin and geographic distribution In contradiction to the scientific name and an English vernacular name, this tree is not indigenous to Japan but is a native of central and northern China, and Korea. It is widely cultivated in temperate and subtropical regions, and rarely in highlands in the tropics.

Uses The flower buds can be used for dyeing yellow or a beautiful granite-grey. The pods are rarely used for this purpose. In China and Vietnam this dye was only used to colour silk, embroidery thread and hat tassels, but not for other materials because of the many flower buds needed to prepare

a dye-bath. Mixed with indigo, the dye gives a green colour. In Java, dried flower buds were imported from China for the batik industry. In the fine 'soga-batik' process they were used in the last fixing and colouring bath after the real colouring process, in a mixture together with rice flour, camphor, lime juice, sugar and water. Nowadays much cheaper synthetic dyes are used instead.

In temperate and subtropical regions the Japanese pagoda tree is commonly cultivated as an ornamental in gardens and parks, and as a road-side tree. The wood is durable and tough and can be used for window and door frames, and for implements.

Several medicinal uses have been reported. The flowers and pods possess styptic properties, and the pods can also be used to lower blood pressure. The plant may have oestrogenic activity.

The shoots, including the pods, seem to be suitable as fodder, but some plant parts, especially the pods and seeds, have been reported to be poisonous. In China an extract of the leaves and pods is used to adulterate opium. A gum similar to that from carob (*Ceratonia siliqua* L.) can be extracted from the seeds.

Properties The Japanese pagoda tree is a source of rutin drugs. Flower buds contain an abundance of the pigment rutin (ca. 20% on dry weight base), which is a glycoside of quercetin and has a strengthening effect on capillary blood vessels. The flowers are bitter, astringent, but aromatic. In the pods kaempferol derivates have been demonstrated. In common with other *Sophora* species, several flavonoid and isoflavonoid compounds have been isolated from the pods, which in some cases have been held responsible for the poisoning of cattle, sheep and goats. The leaf protein concentrate, used as fodder, is a product relatively poor in protein and carotenoid pigments, and very rich in lipids.

Botany A medium-sized, deciduous tree, up to 15(–25) m tall, with corrugated, dark greenish-brown bark and spreading branches. Leaves pinnately compound, 15–25 cm long; leaflets 9–15 per leaf, (narrowly) ovate, 2.5–5 cm × 1–2.5 cm, rounded at base, acute at apex. Flowers in terminal, 15–30 cm long panicles, yellowish-white; calyx 3–5 mm, corolla 12–15 mm long; stamens 10, more or less free. Fruit a 5–8 cm long pod, jointed, long-stalked, indehiscent and (1–)4–6-seeded. Seeds ellipsoid to nearly globose, yellowish-brown.

Seeds germinate quickly, usually within about 4 days. The plant is slow-growing, and usually starts flowering only when about 30–40 years old. Several cultivars are grown as ornamentals.

Sophora japonica L. – 1, flowering branch; 2, part of inflorescence; 3, fruit.

Ecology Japanese pagoda tree is well adapted to dry weather conditions and to a great variety of soils, and even waste land, but it thrives best in well-drained, sandy loam. It is a plant of temperate and subtropical regions, and cultivation in tropical regions is only possible at high altitudes.

Agronomy Propagation can best be done by seeds, which should first be scarified and soaked. Grafting, layering and greenwood cuttings are used for ornamental cultivars.

Among the pests and diseases reported are leaf-miners such as *Odontota dorsalis*, aphids (*Aphis* spp.), and fungi such as *Uromyces truncicola* which cause a canker disease in seedlings.

Prospects Japanese pagoda tree is rarely used for dyeing nowadays. The labour required to collect enough flower buds to prepare a dye bath makes the product very expensive, and comparatively cheap synthetic dyes have taken over the place of the natural dye. The dye gives beautiful colours and was important in traditional hand-

work in several countries. Knowledge of this dye plant should be saved for the future, when a new interest in traditional dyes may develop.

Japanese pagoda tree has been advocated as a very suitable fuel tree because of its adaptability to various climates (even to dry climates) and to a great variety of soils, and also because it is capable of regrowth from stumps. However, its possibilities are limited in the tropics because of its ecological requirements.

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H. Sangat-Roemantyo & Wirdateti

Symplocos Jacq.

Enum. Fl. Carib. 5: 24 (1760).

SYMPLOCACEAE

$x = 11$; $2n = 22$: *S. fasciculata*, *S. lucida*; $2n = 22 + 1$ or 2 B: *S. cochinchinensis* ssp. *laurina* var. *laurina*; $2n$ = unknown: *S. adenophylla* var. *adenophylla*, *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis*, *S. odoratissima* var. *odoratissima*

Major species and synonyms

- *Symplocos adenophylla* Wallich ex G. Don, Gen. Syst. 4: 3 (1837) var. *adenophylla*, synonyms: *S. fulvosa* King & Gamble (1906), *S. palawanensis* Brand (1908), *S. pruniflora* Ridley (1909);
- *Symplocos cochinchinensis* (Lour.) S. Moore, J. Bot. 52: 148 (1914) ssp. *cochinchinensis* var. *cochinchinensis*, synonyms: *S. ferruginea* Roxb. (1832), *S. javanica* Kurz (1871);
- *Symplocos cochinchinensis* (Lour.) S. Moore ssp. *laurina* (Retz.) Nooteb. var. *laurina*, Leiden Bot. Series 1: 156 (1975), synonyms: *S. spicata* Roxb. (1832), *S. laurina* Wallich ex G. Don (1837);
- *Symplocos fasciculata* Zoll., Syst. Verz. 2: 136 (1854);
- *Symplocos lucida* (Thunb.) Zuccarini, Fl. Jap. 1: 55, t. 24 (1835), synonyms: *S. theaefolia* Buch.-Ham. ex D. Don (1825), *S. japonica* DC. (1844);
- *Symplocos odoratissima* (Blume) Choisy ex Zoll., Syst. Verz. 2: 136 (1854) var. *odoratissima*, synonyms: *S. villarii* Vidal (1886), *S. floridissima* Brand (1901), *S. pulgarensis* Elmer (1913).

Vernacular names

- *S. adenophylla* var. *adenophylla*: Indonesia: kayu lattan, kayu porugis (Sumatra), kayu kain (western Kalimantan). Malaysia: mendong, menugan.
- *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis*: Indonesia: jirak sapi (Sundanese, Javanese). Malaysia: medang hitam. Philippines: tabu (Ifiago).
- *S. cochinchinensis* ssp. *laurina* var. *laurina*: Indonesia: jirak, jirak sasah (Sundanese), jirek (Javanese). Malaysia: pokok api-api.
- *S. fasciculata*: Indonesia: kaju loba-loba (Sumatra), jirek (Javanese), jirak (Sundanese). Malaysia: merpadi paya, nasi-nasi, pokok lukut.
- *S. lucida*: Indonesia: kayu hotir (Sumatra), jirak lulub (Sundanese), jirek (Javanese).
- *S. odoratissima* var. *odoratissima*: Indonesia: ki sariawan (Sundanese).

Origin and geographic distribution The large genus of about 250 species is distributed in the eastern parts of the Old World, in Australia reaching as far as New South Wales and Lord Howe Island, and in the Pacific as far as Fiji. In the New World species are found from the United States (Washington) to southern Brazil.

S. adenophylla var. *adenophylla* is distributed in China, Vietnam, Laos, Cambodia, Malaysia, the Philippines and Indonesia (except in Java, the Lesser Sunda Islands and Irian Jaya). *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis* occurs in continental South-East Asia and Malesia except the Lesser Sunda Islands, Sulawesi and the Moluccas, whereas ssp. *laurina* var. *laurina* is distributed over a large area from India and Sri Lanka to China and Japan in the north, and to Sumatra, Java, Borneo and Sulawesi in the south. *S. fasciculata* is found in the most southern part of Thailand, in Malaysia, the Philippines and Indonesia (except east from Sulawesi and Java). *S. lucida* occurs in northern India, northern Burma, northern Thailand to China and Japan, and in Vietnam, Malaysia, the Philippines and in the western part of Indonesia. *S. odoratissima* var. *odoratissima* occurs in Malaysia, the Philippines and Indonesia (except Irian Jaya).

Symplocos is rarely in cultivation. *S. odoratissima* was cultivated in Java.

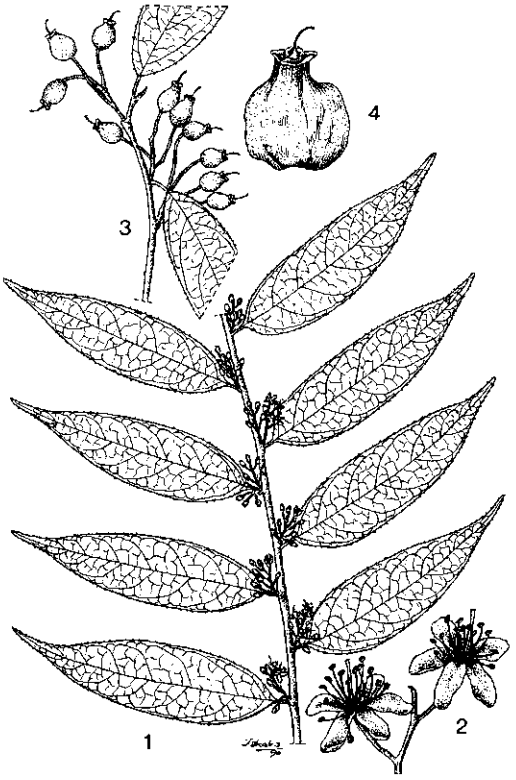
Uses The inner bark of *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis* and *S. fasciculata* was often used as a mordant in the batik industry and, mixed with other plants, as a dye. It gives a yellow colour by itself but is more frequently used in the preparation of reds derived from *Morinda* spp., *Caesalpinia sappan* L., *Butea* spp., and other dye plants. Also the leaves are used as a yellow dye or mordant, as in *S. cochinchinensis* ssp. *laurina* var. *laurina* and *S. lucida*. From the vernacular name of *S. adenophylla* var. *adenophylla* in western Borneo the use as a mordant or dye can be inferred. Most species do not reach a volume adequate for timber, but in Vietnam the wood of *S. adenophylla* var. *adenophylla* is reportedly very hard and good for columns; usually the wood is reported as soft and light and used for light construction. The wood of *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis* and *S. lucida* is used for houseposts, furniture and frames of houses; the wood of *S. cochinchinensis* ssp. *laurina* var. *laurina* is used for matches, and *S. fasciculata* wood is used for carving.

The young red leaves of several species, e.g. *S. odoratissima* var. *odoratissima*, are eaten as a vegetable. The bark and leaves are used as a medicine. The powdered bark of *S. cochinchinensis* ssp. *laurina* var. *laurina* is given with honey to cure biliousness, haemorrhages, diarrhoea, gonorrhoea, and diseases of the eyes; a paste of the leaves, boiled in oil, is applied to diseases of the scalp. In western Java the inner bark of *S. odoratissima* var. *odoratissima*, known as 'kulit seriawan', is exhibited in every drugstore. It is pulped and rubbed on the gums to cure thrush. An infusion of the leaves of this variety is used for the same purpose. Pulped leaves are also applied to the lips and to the abdomen after childbirth, and taken internally in a decoction. Rosaries are made from the dried fruits of *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis*.

Properties All or nearly all the species contain large amounts of aluminium, up to 50% of the ash, and this is the origin of the action as a mordant. Gallic and ellagic acid are common. Leucoanthocyanins occur in varying amounts, quercetin and caffeic acid have also been demonstrated. A mixture of triterpenoid saponins has been obtained from the bark of *S. cochinchinensis* ssp. *laurina* var. *laurina*, and 2[1]-0 ß-glucodise of phloretin has been isolated from the leaves of this variety. It has been demonstrated that the arabino-galactan from the leaves of *S. cochinchinensis* ssp. *laurina* var. *laurina* contains L-arabinose and D-galactose in the ratio 5:3. Ethanolic extract of leaves of *S. lucida* produced hypoglycemic activity in rats, and anti-cancer activity against Friend virus leukemia in mice, and extracts of the leaves and stem show activity against human epidermoid carcinoma of the nasopharynx in tissue culture.

The wood of *Symplocos* is usually soft and light. It has a volumetric mass of 780 kg/m^3 air dry in *S. adenophylla* var. *adenophylla*; the grain is straight or interlocked, the texture fine and even; sapwood and heartwood are not differentiated, light pink-brown. The timber of *S. cochinchinensis* ssp. *cochinchinensis* var. *cochinchinensis* is of slight value with a clear red colour and a grain suggesting oak. The wood of *S. cochinchinensis* ssp. *laurina* var. *laurina* is white, soft, and evenly grained, 593 kg/m^3, the wood of *S. fasciculata* is also rather soft and white, as that of *S. lucida*, which has a volumetric mass of 580 kg/m^3.

Description Shrubs to (rarely) large trees. Leaves simple, often with leathery bud scales, glabrous or with simple hairs, alternate or spirally arranged, rarely pseudo-verticillate, exstipulate,



Symplocos fasciculata Zoll. – 1, flowering branch; 2, flowers; 3, fruiting branch; 4, fruit.

penninerved, petioled (rarely almost sessile). Inflorescence a spike, raceme, or panicle, sometimes condensed to clusters, usually in the upper leaf axils; flowers subtended by a bract and two bracteoles, actinomorphic, bisexual (rarely by reduction unisexual), often fragrant; calyx with short tube, the limb 3–5-lobed; corolla sympetalous, often divided nearly to the base, whitish, bluish or purplish; stamens many, connate in a long monadelphous tube or only at the very base and then monadelphous or pentadelphous; anthers globose, 2-celled, lengthwise dehiscent, introrse; ovary inferior, 2–5-celled, style 1, stigma punctiform or peltate; ovules 2–4 in each cell. Fruit a drupe, crowned by the persistent calyx lobes, of various shapes. Seeds straight or curved, 1 in each developed cell, with copious endosperm.

S. adenophylla var. *adenophylla*: Shrub or tree up to 20 m tall and 50 cm diameter; young twigs pulverulent puberulous, glabrescent; leaves pulverulent beneath.

S. cochinchinensis ssp. *cochinchinensis* var. *cochinchinensis*: Shrub or small tree, 9–22 m tall and up to 30 cm diameter, rarely to 45 m tall and up to 80 cm diameter; twigs rusty tomentose or velvety, glabrescent; leaves with glandular dentate margin and acuminate apex, 12–25 cm × 3–10 cm with 10–16 pairs of conspicuous strictly parallel nerves and with 5–17 mm long petiole; inflorescence a spike, bract and bracteoles forming a calycle hiding the ovary; calyx lobes hairy.

S. cochinchinensis ssp. *laurina* var. *laurina*: Shrub or small tree, 6–14 m tall and up to 30 cm diameter. It differs from the preceding taxon in the glabrous leaves and twigs, leaves having 6–9 pairs of not strictly parallel nerves, bracts and bracteoles enveloping only the base of the ovary, and the glabrous calyx.

S. fasciculata: Shrub or less often a tree to 22 m tall and 50 cm diameter; twigs sparsely pilose, puberulous, or appressedly pubescent; leaves alternately or on the leaders spirally arranged, 5–13 cm × 2–4.5 cm, with 6–8 pairs of nerves and 2–8 mm long petiole; inflorescence a fascicule of reduced, often branched racemes, up to 2.5 cm long.

S. lucida: Shrub or small tree up to 20 m tall and 25 cm diameter, generally entirely glabrous except the inflorescence; terminal buds with large glabrous scales; leaves coriaceous with prominent midrib above, 5–12 cm × 2–4.5 cm, and with 5–15 pairs of nerves, and 5–15 mm long petiole.

S. odoratissima var. *odoratissima*: Tree (or shrub) up to 30 m tall and 50 cm diameter; twigs glabrous or tomentellous to tomentose or pubescent; leaves glabrous or pubescent beneath, 7–20 cm × 5–10 cm, with a stout 10–50 mm long petiole; inflorescence a mostly many-flowered, rusty tomentellous panicle, 5–30 cm long.

Growth and development The flowers on one tree are almost all open at the same time. Dwarfed specimens hardly 1 m tall may flower, for instance on young volcanic soils. Pollination is probably carried out by insects such as bees and bumblebees, but self-pollination has also been suggested. Although birds and bats may sometimes eat the fruits, abundant dispersal of the fruits by these animals is not very likely. For some species dispersal by water has been noticed.

Other botanical information All species used in the dyeing processes belong to subgenus *Hopea* (L.) Clarke, in which many species contain aluminium compounds. In herbarium material leaves usually have a yellow colour as a result of the aluminium compound reacting with flavonols in the drying leaves. *Symplocos racemosa* Roxb. is used as a mordant in Indo-China; in India a yellow dye is prepared from the leaves and bark of this species.

Ecology *Symplocos* species grow under tropical to temperate conditions in mixed evergreen rain forest, never under arid conditions. Most species, e.g. *S. adenophylla*, *S. cochinchinensis* (both taxa cited), *S. fasciculata* and *S. odoratissima* have a fair altitudinal range from sea-level up to 3000 m, in New Guinea even up to 4000 m. *S. lucida* grows in high and low mountain forest, 1500–3000 m. The species are usually rather indifferent to soils, and some of them even grow on young volcanic soils, often as dwarf shrubs.

Prospects Like other dye plants, *Symplocos* is now rarely used in dyeing processes. It has almost completely been replaced by synthetic dyes and salts of metals as a mordant. Problems of environmental pollution by these latter substances might give new chances to the vegetable mordants.

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1980. Vegetables of the Dutch East Indies. A. Asher & Co., Amsterdam. pp. 696–697, fig. 422. 6 Tiwari, R.D. & Tripathi, H.L., 1976. The structure of an arabinogalactan from the leaves of Symplocos spicata. Planta Medica 29: 376–379.

H.P. Nooteboom

Terminalia bellirica (Gaertner) Roxb.

Pl. Corom. 2: 54, tab. 198 (1805; 'bellerica').
COMBRETACEAE
$2n$ = 24, 48; once recorded as 26

Synonyms *Terminalia belerica* var. *laurinoides* Clarke (1878).

Vernacular names Beleric myrobalan, belliric myrabolan, bedda nut tree (En). Myrobalan belleric (Fr). Indonesia: jaha kebo, jaha sapi (Javanese), jaha (Madura). Malaysia: jelawai, mentalun. Burma: thitsein. Cambodia: srâmââ piphéék. Laos: hèèn. Thailand: si-ba-duu (Karen, Chiang Mai), haen (northern), samo phi phek (central). Vietnam: bàng hôi, bàng mộc, nhú't.

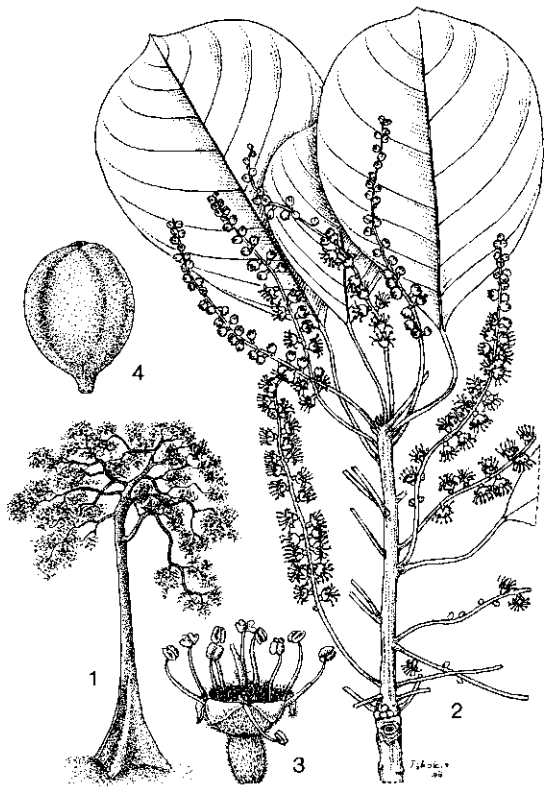
Origin and geographic distribution Beleric myrobalan is found in Nepal, India, Sri Lanka, Burma, Thailand, Indo-China, and throughout Malesia, but is apparently absent in the Philippines and New Guinea. This species is only rarely cultivated.

Uses The fruits are commercially used for tanning hides into leather, often in combination with other tanning materials. Beleric myrobalan is principally used in the production of sole leather.
The fruits yield a dye that is occasionally used together with iron sulphate for dyeing black cloth and matting, as a cheap substitute for indigo, and for the preparation of ink.
The kernels can be eaten, but they possess narcotic properties. The oil extracted from the kernels is used for hair-oil and in the manufacture of soap.
The fruits are much applied in local medicine, for instance in Java and India. Unripe fruits are purgative, whereas ripe fruits are astringent and often employed in a mixture with chebulic myrobalan (*Terminalia chebula* Retz.) in cases of diarrhoea, haemorrhoids and dropsy.
The wood is considered to be of little value. It is used for construction in regions where other timber is scarce or expensive. Large-sized stems are used for dug-outs.

Production and international trade No data are available on international trade of beleric myrobalan fruits. For the tanning industry in India, beleric myrobalan is much less important than chebulic myrobalan, and it is likely that it forms part of the production figures given for *T. chebula*.

Properties The dried fruit-pulp contains somewhat less tannin than chebulic myrobalan, ca. 20–25%. The tannin can be classified in the ellagitannins, and is fairly similar to that of *T. chebula*, but it lacks corilagin and chebulic acid. It is often used as a substitute for chebulic myrobalans. The kernels yield about 40% of a clear yellow oil, composed of 12% palmitic acid, 16% stearic acid, 43% oleic acid and 29% linoleic acid. Excellent soap can be prepared using a mixture of 60% of this oil, 25% coconut oil and 15% groundnut oil.
The timber is yellowish-grey, lacking heartwood, light to moderately heavy (volumetric mass 570–750 kg/m^3), without characteristic odour or taste, fairly straight-grained, very coarse-textured. It is not durable, and very prone to insect attack. Growth rings are fairly distinct when viewed through a lens. Vessels extremely large to medium-sized, fairly evenly distributed, few to moderately few (2–7/mm), the majority solitary and in radial groups of 2–4, occasionally in larger or even double rows, round to oval in outline, open; lumina occasionally with yellow or brownish-yellow gum, tyloses lacking, perforations simple, nearly horizontal to oblique. Parenchyma paratracheal, apotracheal and terminal, abundant, distinct to the naked eye, mostly in numerous, fairly wide, sometimes broken wavy or straight tangential bands partially or completely enclosing the vessels, rarely aliform with short lateral extensions; lumina with large crystals, starch deposits abundant in outer layers of wood. Fibres non-septate with simple pits. Rays fine to very fine, indistinct to the naked eye.

Description A large deciduous tree, up to 50 m tall, with a straight clean bole up to 20 m long, with a diameter at breast height of up to 2(–3) m, buttressed when large; bark blueish or ashy grey, with numerous fine longitudinal cracks, yellowish inside; young branches thick, initially densely pubescent. Leaves spirally arranged or crowded at the ends of the branchlets, thin-coriaceous, broadly elliptic or obovate-elliptic, 4–20 cm × 2–11 cm, rounded to cuneate at base, rounded or obtuse, more rarely acuminate at apex, entire; petiole 2–5(–9) cm long. Flowers in axillary 3–15 cm long spikes, 6–7 mm across, yellowish, with a distinct disk and 5 recurved, deltoid calyx-lobes; corolla absent; stamens 10, exserted; ovary inferior, unilocular, 2-ovuled. Fruit a subglobose to broadly ellipsoid drupe, 2–3.5 cm long, 5-angular, minutely stipitate at base, densely and very finely



Terminalia bellirica (Gaertner) Roxb. – 1, habit of the tree; 2, flowering branch; 3, flower; 4, fruit.

pubescent; exocarp hard, endocarp sclerenchymatous. Germination is hypogeal, seedling with a long, thick, tapering taproot, an indistinct hypocotyl and thick fleshy cotyledons; first leaves opposite or alternate, small, subsequent leaves alternate and larger.

Growth and development The germination rate is quite high for fresh seeds, 85–100%, but declines rapidly when seeds have been stored for some time. Germination usually takes 2–5 weeks. Seedling growth is moderate during the first growing season, but this improves afterwards under good conditions. A long stout taproot is formed, and the young stem is erect, unlike many other *Terminalia* species. Young trees grow rapidly, and have a straight and terete stem; buttresses are formed in older trees. Volume increment is moderate. In a closed stand the crowns are small and the foliage is thin; fruiting is sparse. When growing in the open, crowns are dense, large and spherical, and fruiting is more abundant.

In experimental plantations in Java on good soil, trees had reached a height of 20–25 m in 15 years, after a few thinnings. In Java, flowering takes place in October–November, fruits are set in February and ripen in August–December. Trees are leafless for a short period (some weeks) in the dry season.

Pollination may be done by insects, as the flowers have an unpleasant odour, which attracts flies. Dispersal of seeds is by many animals, both arboreal and terrestrial ones like pigs, deer and goats. The stones in the fruits are often completely disgorged by ruminants, aiding in such dispersal, but the seeds are often destroyed by rodents and insect pests.

Ecology *T. bellirica* occurs scattered in deciduous forest, in dry regions associated with teak, sometimes in considerable numbers. It is seldom found in evergreen forest. The species prefers periodically dry soils. It has a wide ecological range, but does not grow above 600 m altitude. The species is light-demanding, but is somewhat shade-tolerant in youth. It is fairly sensitive to frost, though seedlings can survive, particularly when covered with grass; it is moderately drought-tolerant. In its natural area of distribution mean annual precipitation varies from 1000 to over 3000 mm.

Propagation and planting Seeds may be sown directly in the field when conditions are favourable. Usually depulped and sun-dried, but not too old stones are used. Soaking in cold water for 24 hours before sowing has been reported to be beneficial. Buried seeds have a better chance of successful germination. Germination needs much moisture. When seedlings are raised in the nursery, transplanting to the field before the taproot has developed is strongly preferable, and mostly successful. Clipping of roots and shoots checks growth considerably, stumping is not advised. For good results, plantations have to be established on fertile soils, and spacing has to be fairly wide.

Husbandry Experimental plantations on Java, with spacing 3 m × 1 m, closed their canopy within 5 years, but an undergrowth could maintain itself quite well. Mixed planting was tried, but beleric myrobalan outcompeted other species fairly rapidly. Pruning wounds closed well. As the timber value is marginal and myrobalan production is poor in closed plantations, such planting is not advised. In India it has been found to react well to coppicing, but pollarding gave no good results; increment was found to be moderate.

Diseases and pests Living trees have few diseases and pests. The seeds and the timber are attacked frequently by borers.

Handling after harvest When fruits are dried

after picking, they are conserved satisfactorily for tanning purposes, even for long-distance shipping. Tanning extracts may be prepared in the same way as described for chebulic myrobalans.

The timber seasons fairly rapidly to moderately slowly, with almost no degradation. Durability may be increased by steeping in water for some time. The timber is difficult to plane smoothly, but is fair in mortising, shaping and boring. Turning is reported to be poor. Preboring for nails is advised, to avoid splitting. Sanding works well. The timber absorbs much polish, and soon loses its lustre. Peeling is very easy, and veneer is good. Preservatives do not always penetrate well.

Prospects Compared with the harvesting of tanning bark, collecting myrobalan fruits is an easy way to obtain tannins, whereby also the tree source is spared. Beleric myrobalan is indigenous to large parts of South-East Asia, but it usually grows scattered in the forest and is rarely very common. This makes it difficult to collect satisfactory amounts of fruits from the wild for tanning purposes, as is done in India for chebulic myrobalan. It was found in Java that the trees only grew well on rich soils, and that it took a long time before they started fruiting. Moreover, fruiting was sparse in close stands. However, in more open, mixed forest, attempts might be made to improve regeneration of this species, by sowing seeds in favourable places, as was done fairly successfully in places in India for *T. chebula*. More research on regeneration, growth and development, and potential uses of beleric myrobalan is needed, as much less is known about this species than about chebulic myrobalan.

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J.M. Fundter, N.R. de Graaf, J.W. Hildebrand & J.L.C.H. van Valkenburg

Terminalia catappa L.

Mant. Pl. 1: 128, in: Syst. Nat. ed. 12, 2: 674 (err. 638) (1767).

COMBRETACEAE

$2n = 24$

Synonyms *Terminalia moluccana* Lamk (1783), *Terminalia procera* Roxb. (1832), *Terminalia latifolia* Blanco, non Swartz (1837).

Vernacular names Indian almond, Singapore almond (En). Badamier (Fr). Indonesia: ketapang (general). Malaysia: ketapang (general), lingkak (Peninsular). Papua New Guinea: reddish-brown terminalia (Pidgin). Philippines: talisai (Tagalog, Bisaya), dalinsi (Bicol), logo (Ilokano). Cambodia: châm'bâk barang'. Laos: huu kwaang, sômz moox dông. Thailand: khon (Narathiwat), dat mue (Trang), taa-pang (Phitsanulok, Satun). Vietnam: bàng biên, bàng nu'ó'c.

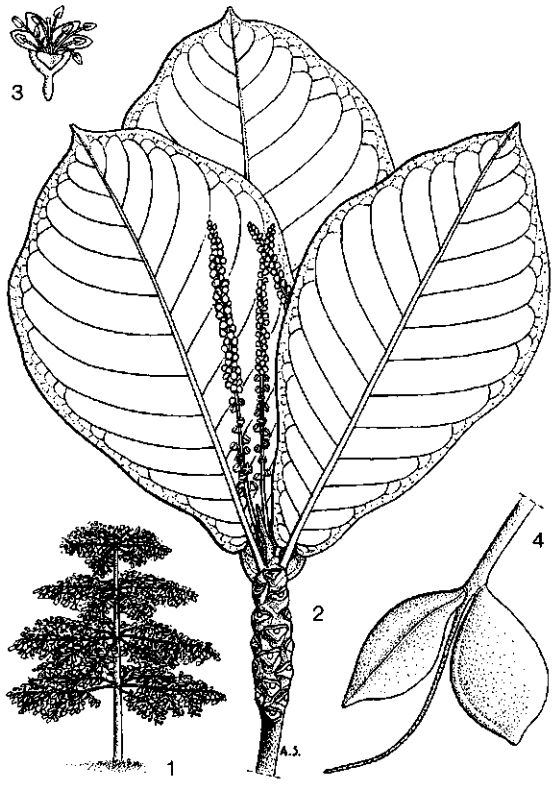
Origin and geographic distribution Indian almond is native to South-East Asia, where it is common throughout the area, but apparently rare in Sumatra and in Borneo. Indian almond is commonly planted in northern Australia, Polynesia, as well as in Pakistan, India, East and West Africa, Madagascar and the lowlands of South and Central America.

Uses Indian almond is a multipurpose tree. The bark and leaves and sometimes roots and green fruits are locally used for tanning leather and provide a black dye, used for dyeing cottons and rattan and as ink. The timber is of good quality and is used for house and boat building. It is susceptible to termites. The seed is edible and considered delicious, and contains a pale odourless oil, similar to almond oil. The oil is employed medicinally as a substitute for true almond oil to relieve abdominal inflammations, and, cooked with the leaves, in treating leprosy, scabies and other skin diseases. The flesh of the fruit is also edible, but is often fibrous and not tasty in spite of the pleasant smell. The tree is often planted in avenues and gardens as a shade tree. It is very well suited for this purpose because of its pagoda-like habit, with long, horizontal branches and large leaves. The leaves have a sudorific action and are applied to rheumatic joints. The tannin from bark and leaves is used as an astringent in dysentery and thrush. It is also regarded as diuretic and cardiotonic and is applied externally on skin eruptions. In the Phi-

lippines a decoction of the leaves is employed as a vermifuge.

Properties The bark yields a brownish-yellow to olive-grey dye and contains 11–23% tannin. Bark and wood contain (+)catechin, (−)epicatechin, gallic acid, ellagic acid, and (+)leucocyanidin. In the leaves a total of 12 hydrolyzable tannins have been detected. Leaves and fruits contain gallic acid, ellagic acid, corilagin, and brevifolin carboxylic acid. The flesh of the fruit contains 75% moisture and 5% protein. The sun-dried kernel yields up to half of its weight as a yellow oil, that contains several fatty acids such as palmitic acid (55.5%), oleic acid (23.3%), linoleic acid (7.6%), stearic acid (6.3%) and myristic acid (1.6%). The protein and sugar content of dried kernels are 25% and 6% respectively, and about 16 amino-acids have been demonstrated.

The heartwood is light brick red to brownish-red, light to moderately heavy, with a volumetric mass of 465–675 kg/m^3, fairly hard and tough, but not very durable; the sapwood is greyish, often blotched with yellow, in young trees, in old trees hardly distinguishable from the heartwood; texture medium; grain shallowly interlocked, often curly or twisted; without characteristic odour or taste.



Terminalia catappa L. – 1, habit of the tree; 2, flowering branch; 3, flower; 4, fruits.

Description Deciduous, moderate-sized tree, 10–25(–35) m tall, with pagoda-like habit, particularly when the tree is young. Stem often buttressed at the base, diameter up to 1.5 m; bark dark grey-brown, fissured; branches arranged in tiers, spaced 1–2 m apart, long and horizontal, giving the tree a curiously regular appearance; young branches thickened, densely pilose, but usually quickly glabrescent. Leaves alternate, short-petioled, clustered at branch tips, usually obovate, but sometimes more or less elliptic, (8–)15–25(–38) cm × (5–)8–15(–24) cm, papery to thinly leathery, shiny, more or less glabrous and minutely verruculose, with a subcordate base usually provided with 2 glands, and a rounded or shortly acuminate apex. Flowers in axillary 8–16 cm long spikes, in which the majority is male, a few bisexual flowers being present only towards the base, very small, greenish-white, with a barbate disk, 5 calyx lobes, usually 10 stamens and a style; petals absent. Fruit an ovoid or ellipsoid drupe, 3.5–7 cm × 2–5(–5.5) cm, slightly flattened, with a prominent keel, usually glabrous, green to yellow and red at maturity. Stone surrounded by a 3–6 mm thick layer of juicy flesh. The Indian almond can generally be recognized at once by its stiff outstanding branches and its big leaves arranged in rosettes.

Growth and development Seeds may remain viable for a long time. They germinate readily, even after floating in salt water for a considerable period, and may be dispersed by sea-water over long distances. The buoyancy is caused by the corky rind and the numerous tiny air cavities in the outer part of the stone. They are also dispersed by fructivorous bats. With adequate rainfall the tree is fast-growing. It sheds its leaves all at once, after they have turned yellow to red, in South-East Asia usually twice a year, e.g. January–February and July–August in Peninsular Malaysia. When all twigs develop new leaves, the tree becomes conspicuous because of the vivid fresh foliage. Indian almond flowers irregularly, but the tree never flowers when defoliated.

Other botanical information Fruits vary greatly in shape, size and colour. The quality of the fruits differs considerably, the flesh being edible and sweet to bitter. The leaves are also variable in shape. Apparently there has been some selection, especially towards large-fruited, good tasting cultivars, although no registered cultivar names are known.

Ecology Indian almond occurs naturally on sandy or rocky beaches. It is tolerant of saline soils

and not averse to ocean spray; it is very wind-resistant and it prefers full sun or medium shade. It survives only in tropical and near-tropical regions with a more or less humid climate. In its natural habitat the annual precipitation is about 3000 mm. Indian almond grows well on all soils providing there is good drainage. It is frequently cultivated up to 800 m altitude.

Propagation and planting Often fresh entire fruits are planted in nurseries, as the stone cannot be easily separated from the flesh. Germination rate is then about 25%. Seeds should be set 25 cm × 25 cm apart in nursery beds. Transplanting to the field is done during the rainy season in the next year.

Husbandry Before planting, fertilizers are applied to poor soils. A recommended mixture is 15–20 l of horse manure, 200 g superphosphate, 150 g chloride of potassium, 300 g bonemeal, 100 g ammonium sulphate or potash, and 500–800 g of lime per hole. Weeding is necessary for a few months after planting but there will soon be sufficient cover to shade out competition.

Diseases and pests Indian almond does not suffer much from diseases and pests. Seedlings defoliated by grass hoppers, beetles and thrips have been recorded, and in Thailand full-grown trees are sometimes a host to fruit flies (*Dacus dorsalis* and *D. correctus*). In Papua New Guinea there is a record of trees being killed after attack by beetles of the genus *Agrilus* which are cambial feeders.

Harvesting The bark is usually stripped off only when trees are felled for their timber. Depending on area and climate, there may be one or two crops of fruits per year, or there is more or less constant fruiting. Ripe fruits are usually gathered from the ground.

Handling after harvest The unripe, green fruits of Indian almond are sometimes collected for tanning, as are the fruits of other *Terminalia* species such as *T. chebula* Retz. and *T. bellirica* (Gaertner) Roxb., collectively called myrabolans or myrobalans. They are spread out in a single layer on a bare piece of ground, and regularly turned to facilitate drying. The dried fruits are sold to tanneries, but sometimes they are first crushed and stoned. When collected for the kernel, fruits are defleshed and sun-dried. Thoroughly dried stones can be cracked by a sharp blow on the keel or when hit with a hammer on the pointed apex. The kernel needs no roasting and may be used like any other nut.

Rattan material is dyed black by burying the wickerwork in mud for some days and then, after drying, dipping it in a decoction of the bark and burying it again in mud.

The timber has to be sawn into boards and kiln-dried as soon as possible after felling to avoid splitting. The sawn material needs to be open-stacked and well protected from hot wind and the sun.

Prospects The uses of Indian almond as dye and tan-stuff are limited. The tannin content is comparatively low, and synthetic dyes are easily available and easier to apply. However, the versatility of the uses justifies more extensive planting in the future, especially where soil salinity limits other options. Selection of types with large fruits having palatable flesh and large kernels, and development of methods for vegetative propagation deserve research priority.

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J.L.C.H. van Valkenburg & Eko B. Waluyo

Terminalia chebula Retz.

Obs. Bot. 5: 31 (1788).

COMBRETACEAE

$2n$ = variously recorded as 14, 24, 26, 36, 48, 72

Vernacular names Chebulic myrobalan, chebulic myrabolan, black myrobalan (En). Myrobalan noir, myrobolan noir (Fr). Malaysia: manja lawai, manja puteri (unripe fruits), manja patut (ripe fruits). Cambodia: srâmâă, sa mao tchet. Laos: sômz moox kh'ôôk. Thailand: maa-nae (Karen, Chiang Mai), samo thai (central), maaknae (Karen, Mae Hong Son). Vietnam: cà lich, chiêu liêu xanh.

Origin and geographic distribution Chebulic myrobalan occurs naturally from the sub-Himalayan region of Nepal and northern India, through India to Sri Lanka, Burma, Thailand, Indo-China and southern China. It has been introduced to Singapore, where it failed, but it was planted successfully in the botanical garden in Bogor, Java.

Uses The fruits are rich in tannin, and are used on a large scale in India in the leather industry,

usually combined with syntans and with other vegetable tanning materials such as black wattle (*Acacia mearnsii* De Wild.), avaram (*Cassia auriculata* L.) and *Ceriops tagal* (Perr.) C.B. Robinson. Chebulic myrobalan is used in the production of sole leather, and also in a last tannage after chrome tanning to give the leather weight and a fast colour. An extract is suitable for pretannage of cattle hides. A yellow dye can be prepared from the fruits plus alum; a black dye and ink can be prepared from the fruits plus iron. Myrobalans are also used as a mordant for the basic aniline dyes.

The fruits have numerous medicinal properties: laxative, stomachic, tonic, and alterative. They are often used in combination with emblic myrobalan (*Phyllanthus emblica* L.) and beleric myrobalan (*Terminalia bellirica* (Gaertner) Roxb.). They show antibacterial and antifungal activity, and are used to cure inflamed gums and as a relief in asthma.

The wood is used as construction timber and for furniture, carts and implements, but is not of much value.

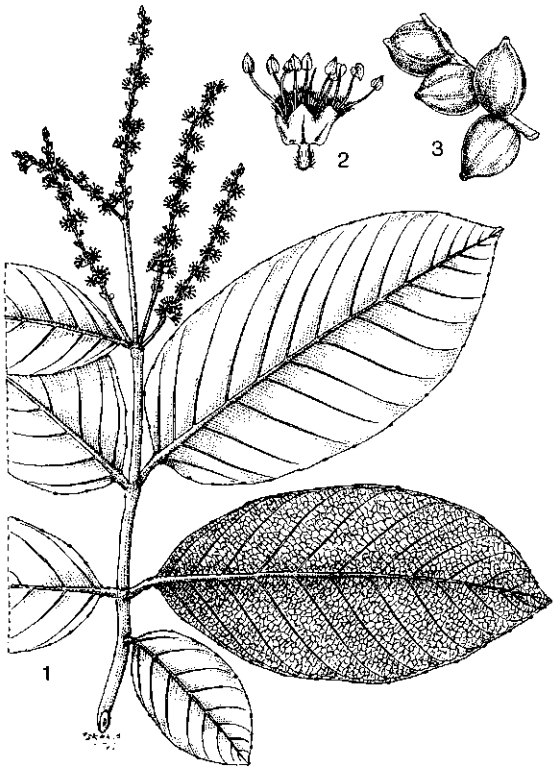
Production and international trade India is by far the main producing country. The production of dried fruits in 1981 was estimated at more than 100000 t. Only a fraction (about 20%) of this was exported, as dried fruits, complete or crushed, or as extract, not only to countries in the region, but also to Europe and the United States. In trade, fruits are usually known by place of origin, those from Salem (India) considered the best.

Usually the tree is felled only when no longer important for fruit production. No data are available on the amounts of timber produced.

Properties The dried fruit-pulp has an average tannin content of 30–32%, but the content varies considerably with the place of origin. Poor samples may register less than 20% tannin, good ones over 40%. Other parts of the plant such as roots, bark, wood and leaves, also contain tannin, but less than the fruits. The tannin is specified as an ellagitannin and is quite complex in nature. The major constituents are chebulagic acid, chebulinic acid and corilagin. Various proportions of products of hydrolysis are present, such as chebulic acid, ellagic acid and gallic acid. Myrobalans contain more sugar-like components than most other tanning materials, ca. 3–5%, which causes ready fermentation and satisfactory plumping of the hide in the early stages of tanning. They produce a brownish deposit on the leather, called bloom. The tannin is of a 'mild' type and penetrates hides slowly. Used alone in tanning, myrobalans produce a soft, spongy, light yellow leather of poor wearing quality. They are usually mixed with tannins of the proanthocyanidin group, such as extracts of wattle and mangrove bark or quebracho wood, to give the leather more weight. Solid extracts as well as spray-dried myrobalan extracts are prepared, containing 58–60% tannin.

In the timber, the sapwood is sharply differentiated from the heartwood; it is yellowish-grey to grey, sometimes with a greenish tinge, whereas the heartwood is small, dark brown to reddish-brown, very hard and heavy to very heavy, with a volumetric mass of 810–1050 kg/m^3. The timber is strong and tough, diffuse-porous, with interlocked grain; texture medium fine to fine, sometimes with curly grain, not durable in contact with the ground, but durable under cover; very difficult to season, and refractory to work.

Description A medium-sized, up to 25 m tall, deciduous tree of variable appearance, with a usually short cylindric bole of 5–10 m length, 60–80 cm in diameter at breast height; crown rounded, with spreading branches; bark dark



Terminalia chebula Retz. – 1, flowering branch; 2, flower; 3, fruits.

brown, usually longitudinally cracked with woody scales; branchlets rusty-villous or glabrescent. Leaves alternate or opposite, thin-coriaceous, ovate or elliptic-obovate, 7–12 cm × 4–6.5 cm, rounded at base, obtuse to subacute at apex, entire, pubescent beneath; petiole up to 2 cm long, provided with 2 glands at the base of the leaf blade. Flowers in axillary 5–7 cm long spikes, simple or sometimes branched, about 4 mm across, yellowish-white and unpleasantly scented; calyx 5-lobed, corolla absent; stamens 10, exserted; ovary inferior, 1-celled. Fruit an obovoid or oblong–ellipsoid drupe, 2.5–5 cm long, faintly 5-angular, yellow to orange-brown when ripe, glabrous. Germination is epigeal, seedling with a long, fairly thin primary root, a short and thick hypocotyl, and glabrous cotyledons with 3 prominent and 2 less conspicuous veins.

Growth and development The germinative power of the seed is poor. Viability of the seed is retained for about 1 year. Seedling growth is comparatively slow, with 10–20 cm height attained by the end of the first season, and 25–50 cm by the end of the second season. Rate of growth is slow in later stages too. The flowers appear together with the new leaves after the tree has been leafless for several months. Fruits ripen some 8 months later, and fall soon after ripening.

Ecology *T. chebula* occurs in mixed deciduous forest, extending into forests of comparatively dry types. It ascends to considerable elevations, up to 1500 m or even 2000 m. In Thailand and Burma, it is found together with teak. The species is found on a variety of soils, clayey as well as sandy. The tree is a light-demander, but withstands some shade in youth, and may benefit then from protection from the sun. It is fairly tolerant of frost and drought, and withstands fire, recovering well from burning and also from coppicing. Regeneration is usually poor, maybe because people harvest the fruit but also because of predation by animals.

Propagation and planting The fallen fruits are collected and dried thoroughly first. Later the hardened flesh is removed. Fermentation of the stones gives the best germinative results, but clipping the broad end of the stone without damaging the embryo, followed by soaking in cold water for 36 hours gives good results too. Direct sowing is not advisable, because of the risk of predation and because the seeds germinate poorly. In India, seeds are usually sown in boxes or nursery beds before the rainy season, covered with soil, and watered regularly. A mere 20% success is reported. Transplanting from the nursery into the field can be done in the first or second rainy season. Shading is desirable in early stages in the nursery and after transplanting. Propagation by cuttings is possible, but less successful than transplanting nursery-raised seedlings into the field. In the forest, regeneration is facilitated by creating small gaps in the canopy, and this is supplemented by sowing seeds in the clearings.

Husbandry The tree coppices well. The resulting shoots are 2–3 m long after 5 years.

Diseases and pests The tree itself does not suffer from any serious disease or pest, although some defoliators have been reported. Fallen fruits are heavily predated by rodents and insects. The timber is attacked by borers.

Handling after harvest Fruits are collected from the time they begin to turn yellow until they are quite yellow and ripe. They are sun-dried, avoiding wetting by rain, and they shrivel considerably during drying. Myrobalans are transported as whole fruits, or crushed without the stones, or as extracts.

For the extraction of tannin and the preparation of extracts the crushed fruits are infused for 8–10 hours with hot water in a series of vats. The tan-liquor is left to settle in a tank at a temperature of 60°C. To prevent fermentation, bleaching agents such as sodium hydrosulphite, alum and oxalic acid are often added; sometimes sodium acetate or formate are also added. The tan-liquor is concentrated in evaporators. The concentrated solution is fed into vacuum pans for preparing solid extracts, or through an atomizer for preparing spray-dried extracts. Various methods of reducing sludge formation in the tan-liquor and of utilizing the tannin more efficiently have been suggested. They include solvent-extraction of the fruits with chloroform or acetone, heating the extract at ca. 120°C, ultraviolet irradiation of the powdery extract, passing chlorine through the tan-liquor, and reducing the acidity of the liquor by treating it with salts and acetate buffers. The control of the pH of the tan-liquor seems to be the most promising method.

Whenever possible, the timber should be sawn when the wood is still green. Slow seasoning in protected and close-stacked piles is best to avoid cracking and splitting.

Prospects *T. chebula* might be an interesting source of tanning material for South-East Asia. Because it is the fruit that yields the tannin, harvesting is not injurious to the trees, as is the case for many bark-yielding species. This species from mainland Asia is probably not suited to the climate

of many parts of South-East Asia, unlike *T. bellirica*. However, as it has been grown for many years in the botanical garden in Bogor (Java), and as it has better tanning properties than the latter species, it might be worthwhile trying in cultivation.

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J.M. Fundter, N.R. de Graaf & J.W. Hildebrand

Uncaria gambir (Hunter) Roxb.

Hort. Beng.: 86 (1814).
RUBIACEAE
$2n$ = unknown

Vernacular names Gambier, white cutch, pale catechu (En). Indonesia: gambir (general). Malaysia: gambir, gambier, kancu.

Origin and geographic distribution The origin of gambier is uncertain. Rumphius reported its cultivation in the Moluccas in the middle of the 18th Century. It is cultivated in Peninsular Malaysia and Indonesia (Sumatra, Java, Bali, Kalimantan, Moluccas). Plants which are probably truly wild have been collected in Sumatra and Borneo.

Uses The resinous substance extracted from the leaves and young branches of gambier is crystallized and traded in small cubes or blocks. It has three major uses: for tanning leather; as a stimulant chewed with betel nut (*Areca catechu* L.), lime and the leaf of *Piper betle* L.; and as a medicine. Minor uses are as a dye in the traditional batik industry and for dyeing silk black; as a clearing agent for beer, and as a remover of scale from boilers. The leaves are also used fresh for medicinal purposes. As a medicinal plant, gambier is used as an astringent. An infusion of fresh leaves is given against diarrhoea, dysentery, and as a gargle for sore throats. Gambier is also used as a styptic, and against inflamed gums. It is applied externally in lotions for burns and in a paste for scurf. External application against sciatica and lumbago is reported from Borneo.

Production and international trade In the period 1920–1940 the total production of gambier in Indonesia was approximately 15000 t/year, of which one-third was exported primarily to Britain and the United States, with smaller markets in Germany, the Netherlands and Singapore. Peninsular Malaysia was producing less during this period, exporting about 3000 t/year, half of which went to India. The market price of the finished product, i.e. small cubes or blocks, fluctuated between US$ 100–400/t during this period. In Indonesia, about 8 large estates with a total area of 1750–2000 ha accounted for most of the exports, and many smallholdings produced gambier for local consumption; some 6000–10000 ha were probably involved.

After the Second World War gambier lost most of its importance as an export product. In tanneries in Europe and the United States, it was largely replaced by other vegetable tanning materials and syntans. In South-East Asia gambier has never been used on a large scale as a tannin. However, gambier has continued to have some local importance as a masticatory, medicinal and dye plant. No recent production data are available, but production must be considerable as block gambier is still available in fairly large quantities on Indonesian markets, for instance in central Java and Kalimantan. In 1985, about 1200 t of gambier worth approximately US$ 1 million was exported from Indonesia. The main exporting areas are Sumatra and Riau, with average exports in 1985 and 1986 of 340 and 620 t/year, respectively.

Properties The tannins in the leaves of gambier belong to the proanthocyanidin type. The leaves contain catechin, poorly soluble in cold water but readily soluble in hot water, and catechu-tannic acid which is soluble in cold water. Catechu-tannic acid is not desirable in gambier used for chewing and is removed. Consequently gambier is manufactured in different ways; the final product is either suitable for tanning purposes or for betel chewing. Block gambier used for tanning in Europe contained 35–40% tannin. With modern methods of extraction, much higher tannin percentages have been obtained. Now block gambier containing up to 65% catechin and lacking catechu-tannic acid (thus suitable for chewing) can be produced. The maximum yield of crude gambier is 6.5% of the leaf weight.

When used alone in tanning, gambier produces a rather spongy leather. However, it is very suitable for both light and heavy leathers if mixed or blended with other tanning materials such as wat-

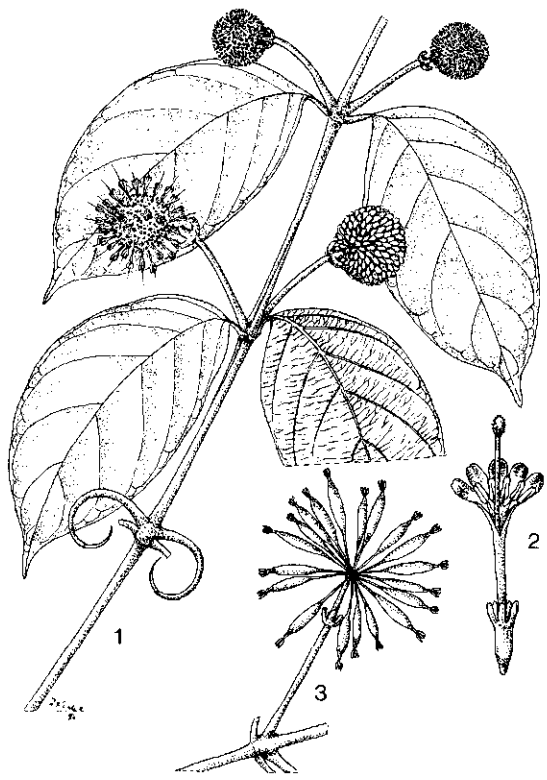
tle (*Acacia* spp.) extract or myrobalans (*Terminalia* spp.). Gambier is also suitable for preserving fishing nets.

The tannin has algicidal properties, as well as antibacterial and antifungal activity. Antiherpetic activity has also been reported. Several indole alkaloids, some unidentified, have been extracted from leaf materials. These may have a narcotic effect.

Gambier is used for 'soga batik' dyeing, but the brownish colour only develops if a diazonium salt is added.

The seeds are very light; 1 kg contains about 25000000 seeds.

Description A liana often cultivated as a straggling shrub, with square young stems and erect main stems bearing horizontal branches with recurved hooks (modified peduncles of inflorescences). Leaves opposite, subcoriaceous, and entire, ovate to (broadly) elliptic, (6–)9–12(–15) cm × (3.5–)5–7(–8) cm, rounded to subcordate at base, acute at apex, glabrous, with 5–6 pairs of lateral nerves, raised below and with hairy domatia. Flowers in heads on horizontal plagiotropic branches; heads (3.5–)4–5 cm in diameter (across corollas), receptacle densely hairy, interfloral bracteoles absent; pedicel up to 3 mm long, hypanthium 1–2 mm in diameter, densely yellow-brown hairy; calyx 3–4.5 mm long, with 5 trigonal, 1–2 mm long lobes, finely pubescent, persistent; corolla hypocrateriform with 8–10(–12) mm long tube, exterior sparsely to densely pubescent, and 5 oblong, 2–3 mm long lobes, exterior densely yellow-brown sericeous, quickly falling off from the heads; stamens 5, adnate to the corolla; ovary inferior, style exserted 5–7 mm, stigma obovoid to clavate, ca. 2 mm. Fruiting head (50–)60–80 mm in diameter, fruitlets (capsules) 14–18 mm long, sparsely pubescent and crowned by the calyx, many seeded; fruit stalks up to 20 mm long. Seeds very tiny, silvery-grey.



Uncaria gambir (Hunter) Roxb. – 1, flowering branch; 2, flower; 3, infructescence.

Growth and development Seeds take about 2 weeks to germinate. After about 10 weeks, seedlings are 3–4 cm tall. The first harvest is usually obtained when plants are 12 to 18 months old. During harvesting the orthotropic shoots are topped at about 2 m, resulting in reiteration of shoots developing from dormant buds below the plagiotropic shoots. The climbing plant can thus be induced to make a shrub-like form. Plantations are usually maintained for (8–)12–15(–20) years. Gambier plants have been recorded to reach an age of 60 years.

Other botanical information *Uncaria gambir* is frequently confused with other related species, particularly *Uncaria callophylla* Blume ex Korth., *Uncaria acida* (Hunter) Roxb. and *Uncaria elliptica* R. Br. ex G. Don (synonym: *Uncaria dasyoneura* Korth.). These species have been reported to have been incidentally used in gambier production.

Recently a plant from Sumatra with denser foliage, called 'Uncaria payakumbuh', has been mentioned as a gambier source. The catechin content of this plant is somewhat less than that of 'true' gambier.

Ecology Gambier can be cultivated in areas with high rainfall throughout the year. Usually it grows well at altitudes of 0–200 m, but cultivation up to 1000 m is possible. The plant does not tolerate waterlogging. Gambier has no special soil requirements, but it is usually cultivated on soils with a rich humus layer, or containing much clay. Wild gambier is most commonly found in secondary forest. It does not occur in dry regions or at higher altitudes.

Propagation and planting Propagation is usually by seeds. The very small and light seeds

rapidly lose their viability. Seeds are usually sown in seed-beds. To achieve a uniform dispersal, the seeds are often blown into the seed-beds. On slopes, the vertical walls of terraces are sometimes used as seed-beds and the seeds are blown to the walls. Horizontal seed-beds need protection from sun and rain. Usually seedlings are transplanted into the field 2–7 months after sowing, depending on the region. Planting distance is 2 m × 3 m or 3 m × 3 m. The seedlings are usually planted in the edge of a hole, and the hole is not filled with soil.

Gambier may be propagated vegetatively by cuttings, by layering, or by grafting. Vegetative methods of propagation usually result in an advanced first harvest. However, these plants are recorded to contain less tannin at harvest.

Gambier can be intercropped as a cash crop in rubber and oil palm plantations.

Husbandry No special practices are necessary except weeding during the first year. Fertilizers are usually not applied. Although gambier is a natural climber, no support is needed for cultivated plants when the crop is managed properly.

Diseases and pests In smallholdings, gambier is usually free from serious diseases and pests. However, in large monocultures plagues of caterpillars and beetles have been reported. A mite causes monstrous inflorescences and also attacks the leaves.

Harvesting The orthotropic main shoots are cut back to 1.3–1.5 m from the ground, and the shoots are dried, usually in the shade, and are bundled and transported to the factory. The first harvest takes place after about 1.5 years with plants grown from seed. Improved cultivation methods allow harvesting to take place 9 months after sowing, even when plants have been grown from cuttings. When grown in pure stands, harvesting is usually twice per year. However, when the plant is grown as a cash crop between rubber or other crops, it can be harvested up to 4 times a year.

Yield There is a great variation in yield, depending on the harvesting frequencies. Generally, smallholdings obtain a yield of block gambier of 180–200(–700) kg/ha per year, whereas larger plantations have achieved 1000–3000 kg/ha per year.

Handling after harvest The most widespread method of fabrication of gambier is the so-called Chinese method. Crushed leaves and twigs are boiled in water for about 1 hour, after which the plant fragments are removed from the decoction. The decoction is further concentrated by boiling and evaporation for about 3 hours. The concentrate is transferred to smaller containers, seeded with catechin crystals and allowed to solidify into a treacle-like mass. To make 'cake' gambier, this mass is poured into simple moulds and after about 12 hours it solidifies into a solid cake which is cut into blocks and sun-dried to form sticky red-brown blocks. Cube gambier for chewing is made by pouring the decoction into bottomless wooden frames placed on an absorbant cloth which removes the water. By simple manipulation of strings the mass is further divided into cubes. Further drying at low temperatures takes about 10 days.

Local production still occurs as an unsophisticated modification of the above process using bamboo as a mould. The bamboo is removed and the mass is cut into disks, often with a fabricant stamp. Such products, however, have not been seen on local markets recently. Larger plantations use a modification of the Chinese method with more efficient ovens and equipment. Modern methods of extraction have been developed in Indonesia. Leaves of gambier are extracted by steaming or boiling, and then pressed with a hydraulic press at a pressure of 18000 kg/cm^2, after which they are dried for 3–4 days. The best quality of gambier is obtained by steaming for 5 minutes. The catechin content of the product is higher when steaming is used rather than boiling (up to 65% as compared with up to 55%).

Prospects As a tanning material, gambier is now far less important than it was at the beginning of the 20th Century. Gambier has never been used on a large scale in local tanneries in South-East Asia. However, it has good prospects as a source of tanning material. Gambier produces leather of good quality, especially when mixed with other vegetable tanning materials. The plant is easy and fast to grow and the leaves contain tannin which ensures a regular harvest without destroying the crop.

It maintains importance as a masticatory in South-East Asia, especially for older people; however, younger people are less addicted to betel chewing. Research priorities should focus on selection and breeding of good quality plants. Cultivated plants are very similar to wild plants and there do not seem to be any different cultivars. Gambier may also be useful in agroforestry systems.

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4 Sastrapradja (Editor), 1978. Tanaman industri [Industrial crops]. National Biological Institute, Bogor, Indonesia. 132 pp. 5 Sudibyo, A., Pardede, J.J. & Suprapto, 1988. Pengurah varitas dan cara penyarian terhadap rendemen dan kadar catechin gambir (Uncaria gambir Roxb.) [The effect of variety and methods of extraction on the yield and content of catechin of gambier (Uncaria gambir Roxb.)]. Warta Industri Hasil Pertanian. Journal of Agro-based Industry 5(1): 28–31. 6 Zeijlstra, H.H., 1949. Sirih, pinang en gambir. In: van Hall, C.J.J. & van de Koppel, C. (Editors): De Landbouw in de Indische Archipel [Agriculture in the Indonesian Archipelago]. Vol 2B. W. van Hoeve, 's-Gravenhage, the Netherlands. pp. 578–619.

C.E. Ridsdale

Xylocarpus Koenig

Naturforscher (Halle) 20: 2 (1784).
MELIACEAE
$2n = 52$: *X. granatum*, *X. moluccensis*

Major species and synonyms

- *Xylocarpus granatum* Koenig, Naturforscher 20: 2 (1784), synonyms: *Carapa obovata* Blume (1825), *Xylocarpus obovatus* (Blume) Juss. (1830).
- *Xylocarpus mekongensis* Pierre, Fl. For. Cochinch.: pl. 359 B (1897), synonyms: *Carapa moluccensis* Watson (1928) non Lamk, *Xylocarpus gangeticus* (Prain) Parkinson (1934), *Xylocarpus australasicus* Ridley (1938).
- *Xylocarpus moluccensis* (Lamk) M. Roemer, Prospect Fam. nat. syn. monogr. 1 (Hesper.): 124 (1846), synonym: *Carapa moluccensis* Lamk (1785).

Vernacular names

- *X. granatum*: Indonesia: nyiri (northern Sumatra). Malaysia: nyireh hudang, nyireh bunga, niris bunga. Philippines: tabigi (Tagalog, Bisaya), piagau (Tagalog), kolimbaning (Ilokano). Singapore: nyireh bunga. Cambodia: châm'-puu praèk, t'bôôn. Thailand: kra buun khaao, ta buun, ta buun khaao (central, peninsular). Vietnam: xu'o'ng cá, dang dinh.
- *X. moluccensis*: Indonesia: nyiri batu (northern Sumatra), nyiri gundik (Java). Malaysia: nyireh batu, nyiris, delima wanita. Philippines: piagau (Tagalog, Bisaya), migi (Pampango). Singapore: nyirih batu. Thailand: ta buun dam (general), ta ban (central, peninsular). Vietnam: xu'o'ng cá.

Confusion of the species in the vernacular names cannot be excluded, and is probably even common. Vernacular names for *X. granatum* and *X. moluccensis* are certainly also used for *X. mekongensis*.

Origin and geographic distribution *X. granatum* and *X. moluccensis* have very large areas of distribution, from East Africa and Madagascar through India, Sri Lanka, and South-East Asia to tropical Australia and Polynesia. *X. mekongensis* is found from India to Papua New Guinea and tropical Australia. The three species are all found throughout South-East Asia.

Uses The bark of the bole is rich in tannin. It is used for tanning heavy hides into sole and heavy leather, and for toughening fishing-nets. It is sometimes used to dye cloth brown.

The wood is a good mahogany-like timber, but as the trunk is usually crooked and hollow, long straight pieces cannot be cut. It is used in boat building, and for nails, house-posts, small objects like tool handles, and for furniture, but it is not resistant to termites. In India the wood is found suitable for second grade pencils. It can also be used as firewood.

The astringent bark has some medicinal uses. It is reported to cure dysentery, diarrhoea and other abdominal troubles, and as a febrifuge. The seeds are also used medicinally.

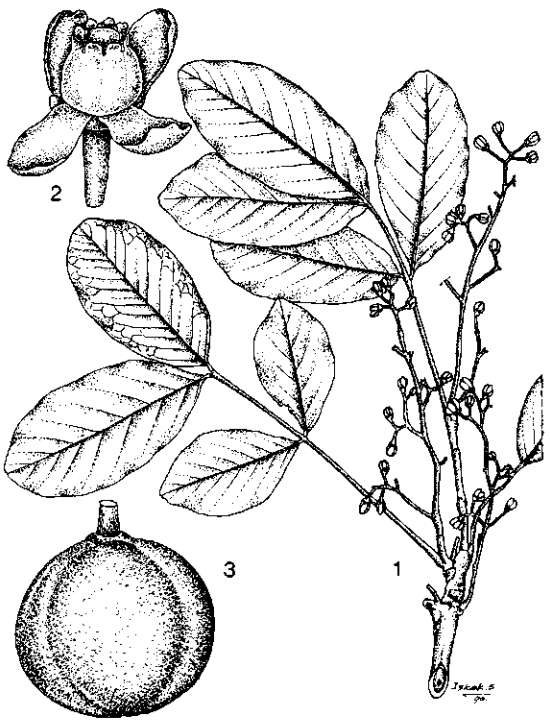
Production and international trade The bark is used only locally for tanning purposes because natural supply is not abundant. *Xylocarpus* is usually not found in pure stands and its bark is thin. The wood is also of local importance only.

Properties Different parts of the plant contain tannin: bark, wood, leaves, and fruits. However, the bark of mature trees is richest in tannin, containing 20–34% on dry matter base. The tannin produces a reddish, tough leather, but nothing is known about its constitution.

The seeds yield small quantities (1–2%) of oil. The wood is reported to contain 0.1% gedunin.

The wood is moderately heavy, 630–790 kg/m^3, hard and durable. It has a brown to red colour (sapwood brownish-white), shrinks little and is reported difficult to saw and finish. It is straight or interlocked-grained. Vessels moderately small to medium-sized. Parenchyma with terminal bands, diffuse parenchyma consisting almost entirely of scattered files of crystalliferous cells, other parenchyma scarce to vasicentric. Rays 4–6 cells wide.

Description Medium-sized, evergreen or deciduous, glabrous trees, up to 22 m tall, and with trunk up to 1 m diameter, sometimes buttressed;



Xylocarpus granatum Koenig – 1, flowering branch; 2, female flower; 3, fruit.

root system often developing either pneumatophores or ribbon-like surface roots; bark fissured or scaly. Leaves alternate, paripinnately compound, with (1–)2–3 pairs of leaflets, exstipulate; leaflets elliptic or (ob)ovate, 4–17 cm × 2–9 cm. Flowers in axillary panicles, functionally unisexual, 4-merous, 3–5 mm in diameter, with a well-developed disk, shortly united sepals and more or less free, creamy-white petals; stamens 8, united into a tube; ovary 4-locular, style short, stigma capitate, large. Fruit a globose, woody capsule, up to 25 cm in diameter, 6–18-seeded. Seeds more or less tetrahedral, up to 6 cm long, brown. Germination hypogeal, seedling initially with scale leaves, first leaves simple.

X. granatum: root system elaborated above the ground with narrow, undulating, ribbon-like extensions; buttresses well-developed; trunk surface smooth, pale, blotched greenish or yellowish, peeling in patches; leaflets more or less elliptic and obtuse-rounded; fruit up to 20 cm in diameter.

X. mekongensis: root system developing blunt, not ribbon-like pneumatophores; buttresses very short or even absent; trunk surface rough, dark brown, fissured, peeling in narrow strips; leaflets more or less elliptic and obtuse-rounded; fruit up to 12 cm in diameter.

X. moluccensis: root system not elaborated; trunk lacking buttresses and with a longitudinally fissured surface; leaflets more or less ovate and subacuminate; fruit up to 8 cm in diameter.

Growth and development Trees are usually evergreen, even in seasonal climates, but are sometimes reported as deciduous, for instance in the non-seasonal climate of Sarawak. They sucker basally when they are damaged, and depauperate plants may develop several trunks.

Flowers are functionally unisexual, male flowers having a nonfunctional, rather slender ovary, female flowers having nonfunctional stamens either never dehiscent or with sterile pollen. It has been observed that certain individuals, although flowering profusely, never produce fruit; this suggests that dioecism sometimes occurs. Flowers are probably pollinated by short-tongued insects like bees.

The corky testa of the seed represents an adaption to dispersal by water, and seeds may start to germinate while still floating.

Other botanical information The three species are very similar, and consequently have often been confused. Therefore, interpretation of data from literature is difficult, and it is impossible to disentangle the species completely. However, it is likely that species which are probably closely related will have many properties in common. The species differ most clearly in bark and root characters, and should easily be distinguishable in the field, but not in the herbarium.

It has been suggested that *X. mekongensis* may have arisen through hybridization between the other two species. In fact, intermediates between *X. granatum* and *X. moluccensis* appear to be widespread and locally numerous. More information is needed on their botany, ecology and distribution, including the occurrence of hybrids.

Ecology *X. granatum* and *X. mekongensis* are mangrove plants, found in tidal mud of mangrove swamps, especially towards their upper limits. *X. moluccensis* usually grows on sandy or rocky beaches, in coastal scrub just above the high-water mark, but it has also been reported from typically mangrove environments. *X. granatum* in Indonesian mangrove forest has been recorded to tolerate a salinity of 0.1–3%.

Harvesting The bark is peeled from the tree for use in local tanneries. The tree recovers easily from the peeling. Usually the bark is directly used in the tannery or for toughening nets.

Prospects The cultivation of *Xylocarpus* in the more dry mangrove areas is worth considering. They might be interesting plants for industrial tannage because the trees recover easily after the bark has been removed. In addition, they are easy to propagate and they have a comparatively high tannin content.

Literature [1] Bhatnagar, S.S. (Editor), 1950. The wealth of India. Raw materials. Vol. 2. New Delhi. pp. 74–75. [2] Tomlinson, P.B., 1986. The botany of mangroves. Cambridge University Press, Cambridge, Great Britain. pp. 274–282. [3] Watson, J.G., 1928. Mangrove forests of the Malay Peninsula. Malayan Forest Records 6: 1–275. [4] White, F. & Styles, B.T., 1963. Meliaceae. In: Exell, A.W., Fernandes, A. & Wild, H. (Editors): Flora Zambesiaca. Vol. 2(1). pp. 293–297, tab. 57.

Rudjiman

Ziziphus oenoplia (L.) Miller

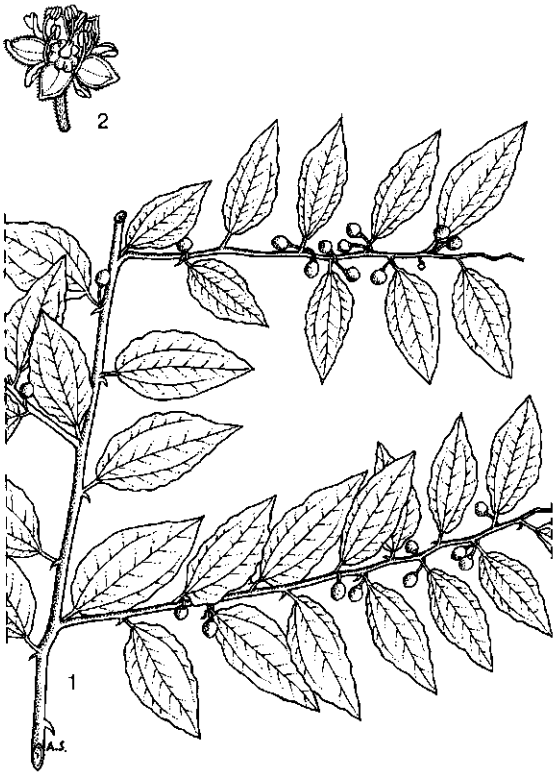
Gard. Dict., ed. 8, No 3 (1768).
RHAMNACEAE
$2n$ = recorded as 20, 24 and 48
Synonyms *Ziziphus rufula* Miq. (1855).
Vernacular names Jackal jujube (En). Indonesia: kukuhelang, bidara letek (Java). Malaysia: akar kuku balam, kuku lang, akar kuku tupai. Burma: taw-zee-nway. Cambodia: sângkhoo. Laos: léb mèèw. Thailand: lep yieo (central), taa-chuumae (Karen, Chiang Mai), ma tan kho (northern). Vietnam: táo rù'ng.

Origin and geographic distribution Jackal jujube is indigenous to a large part of southern Asia, from India and Sri Lanka through Burma, Thailand, Indo-China, and the whole of Malesia. It is also found in northern Australia. In Malesia it is common in Peninsular Malaysia and Singapore, and in Java, probably also in the Philippines and in other areas, but the distribution of the species is incompletely known.

Uses The bark contains tannin and is used occasionally in India for tanning hides into leather. The bark has several medicinal uses, common for plants containing tannin; it is used for healing wounds and stomachache. The roots serve as a remedy against hyperacidity and *Ascaris* infection. The fruits are edible. In India, jackal jujube is locally much used for fences, but it can also be a noxious weed forming almost impenetrable masses of prickly stems. The stems are sometimes used as fuelwood.

Properties The tannin content of the bark is not very high, only about 12%. This makes the bark suitable for direct use in the tannery, but not for the preparation of tannin extracts. The bark of stems and roots contain betulinic acid and a number of cyclopeptide alkaloids, called zizi-phines.

Botany An evergreen, sometimes leaf-shedding, spiny scandent shrub or liana, up to 10 m, rarely up to 30 m long; branches initially densely brownish pubescent, with recurved stipular thorns at the base of petioles. Leaves alternate and simple, herbaceous, ovate-lanceolate, 2.5–6 cm × 1.5–3.5 cm, oblique at base, more or less acute at apex, finely serrulate or subentire, with 3–5 prominent veins from the leaf-base, pubescent beneath, shortly petiolate. Flowers in (sub)sessile axillary cymes, 5-merous and yellowish-green, with triangular-ovate calyx segments and minute, shortly clawed petals embracing the stamens, a disk filling the calyx tube and surrounding the 2-celled ovary, and 2 styles connate to near their tops. Fruit an ellipsoid to almost globose drupe, ca. 8 mm in diameter, glabrous, dark blue or black when ripe.
The distinction of *Ziziphus oenoplia* from allied



Ziziphus oenoplia (L.) Miller – 1, fruiting branches; 2, flower.

species is still obscure. This makes correct interpretation of literature, delimitation of the exact area of distribution and ascertainment of a complete synonymy very difficult.

Bark and especially fruits of *Ziziphus xylopyra* Willd. contain tannin. The fruits of this species are used locally in India for tanning, yielding a good leather, but they produce much mucilage. The bark of *Ziziphus rugosa* Lamk is used in the same way in Indo-China.

Ecology Jackal jujube occurs naturally in light secondary forests, in thickets and hedges, and also in savannas, usually in the lowland, in Java up to 300 m altitude, in India up to 1000 m. It grows well in fairly dry climates. In mainland Asia, it is confined to the hotter parts.

Prospects Not much is known about this species. The quality and properties of the tannin have never been studied in detail, and a taxonomic study of *Ziziphus* species in Asia is badly needed. Recent phytochemical studies indicate some interesting medicinal properties. However, jackal jujube could be useful to man in several ways, and further studies of this species, which has such a large area of distribution and which is locally very common, could be worth considering.

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C. Phengklai

3 Minor dye and tannin-producing plants

Acacia pycnantha Benth.

LEGUMINOSAE

Vernacular names Golden wattle (En).

Distribution Native of southern Australia; planted in the mountainous regions of Java.

Uses The bark is used for tanning. The tree is planted as an ornamental, the flowers are used for perfume.

Observations A small to medium-sized tree with stalked phyllodes instead of normal leaves. The thin bark is rich in tannin (up to 40%) and gum.

Selected sources 7, 12, 17, 22, 24, 31, 45.

Aegialites R. Br.

PLUMBAGINACEAE

Major species and synonyms

- *Aegialites annulata* R. Br.;
- *Aegialites rotundifolia* Roxb.

Distribution

- *A. annulata:* native to eastern Malesia (the Lesser Sunda Islands, the Moluccas, New Guinea) and northern Australia.
- *A. rotundifolia*: eastern India, Burma, Thailand and the Andaman Islands.

Uses The bark may be used for tanning fishing nets.

Observations Shrubs or under-shrubs, 0.3–3 m tall. *A. annulata* differs from *A. rotundifolia* especially in the smaller flowers. The bark contains ca. 11% tannin on dry weight basis. The species grow in open mangroves; *A. annulata* especially in sandy and rocky places, *A. rotundifolia* in muddy places.

Selected sources 12, 45, 47.

Ardisia serrata (Cav.) Pers.

MYRSINACEAE

Vernacular names Malaysia: mata pelandok. Philippines: panabon (Tagalog), rogrogso (Ilokano), labat (Ibanag).

Distribution Native of the Philippines and Borneo; sometimes cultivated, e.g. in Indonesia (Java).

Uses The bark is used for tanning. Sometimes it is planted as an ornamental.

Observations A shrub or small tree, up to 10 m tall. Commonly found in primary forests at low and medium altitude, sometimes up to 1400 m.

Selected sources 7, 10, 12, 35.

Ardisia solanacea Roxb.

MYRSINACEAE

Vernacular names Malaysia: mata itek. Vietnam: co'm nguôi.

Distribution Nepal, India, western China, extending to Peninsular Malaysia. Cultivated in these areas, and also in Pakistan, Sri Lanka.

Uses The fruits are used for dyeing yellow. It is also planted as an ornamental.

Observations A shrub or small tree up to 12 m tall with showy pink flowers and black berries. The berries contain a pinkish juice, and provide a yellow dye which becomes brown on paper. The species is found in moist ravines and forests up to 1100 m altitude in India, and in forests in the hills of Peninsular Malaysia.

Selected sources 12, 20, 38, 42, 46.

Baphia nitida Lodd.

LEGUMINOSAE

Vernacular names Camwood, barwood (En).

Distribution Native of western tropical Africa. Formerly cultivated as a dyewood, especially in Sierra Leone; rarely planted in botanical gardens in South-East Asia.

Uses The heartwood is used for dyeing cotton and wool red. The plant is also used for hedges, and the leaves as fodder. The wood is suited for turnery.

Observations A shrub or small tree up to 10 m

tall. The principal dyeing substance in the wood is santalin. Camwood is reportedly easy to cultivate, and can be propagated by seeds and cuttings. It may have potential as a dye plant in South-East Asia.

Selected sources 12, 17, 28, 31, 49.

Bauhinia vahlii Wight & Arn.

LEGUMINOSAE

Distribution Native to the southern Himalayas of Nepal and India; also in the lowlands of eastern India, and extending to Burma (Tenasserim). Rarely cultivated in South-East Asia, e.g. in Peninsular Malaysia.

Uses The bark is used for tanning hides into leather. The leaves serve as fodder, the seeds are used as a pulse. The stems are used for matting, basketry and wickerwork, and also for medicinal purposes.

Observations A large climber or straggling shrub having abundant tendrils. The bark contains up to 17% tannin. The tannin cannot be extracted easily, but is of very good quality, penetrating hides quickly and producing a light-coloured, soft leather. Plants are fairly easy to grow, and may be a promising source of tanning material.

Selected sources 12, 20, 29, 45.

Berberis fortunei Lindley

BERBERIDACEAE

Distribution Native of China. Cultivated in western Java.

Uses Root and stem produce a dye which was used for dyeing cotton yellow or brown, e.g. for batik cloth in Indonesia. It is also used as a hedge plant.

Observations A usually much-branched shrub, up to 2 m tall. The colouring substance is possibly berberine, just as in other *Berberis* species. This species is well-established in mountainous areas in Java at altitudes of about 1000 m.

Selected sources 7, 12, 22, 43.

Bridelia stipularis (L.) Blume

EUPHORBIACEAE

Vernacular names Indonesia: kanyere badak, kandri kebo, daun kutu (Java). Malaysia: chenderai gajah, kenidai babi, kenidai samak. Philippines: kuto-kuto (Tagalog), karabaui (Ilokano), alub-alub (Sambali). Laos: salongx kh'oong. Thailand: makaa khruea (central), sa ai khruea (Yala), hatsa ai khruea (northern).

Distribution Nepal, India, southern China, Thailand, Indo-China, and Malesia. In Malesia in Peninsular Malaysia, Sumatra, Borneo, Java, the Lesser Sunda Islands, and the Philippines.

Uses The bark is occasionally used for tanning, the fruits for dyeing black. The leaves are used medicinally in poultices.

Observations A scrambling shrub or liana up to 15 m long, distinguished from related species by its comparatively large flowers (to 10 mm diameter) and fruits (to 11 mm), and softly tomentose indumentum. In Malesia it is found in lowlands (up to 400 m altitude) in secondary forests, thickets, bamboo forests, and along water courses.

Selected sources 2, 3, 4, 5, 7, 12, 20, 45.

Castanopsis curtisii King

FAGACEAE

Vernacular names Malaysia: berangan jantan.

Distribution *C. curtisii* occurs only in Peninsular Malaysia (Selangor, Penang).

Uses The bark may be used for tanning.

Observations A tree up to 20 m tall with trunk up to 30 cm in diameter. The bark of an old tree was found to contain ca. 16% tannin on dry weight basis. The species is found in lowland forest up to 300 m altitude. The prospects as source of tanbark are limited since it occurs only very locally, and it is not common. The bark of other *Castanopsis* species also may be used for tanning.

Selected sources 12, 47.

Eclipta alba (L.) Hassk.

COMPOSITAE

Synonyms *Eclipta prostrata* (L.) L.

Vernacular names False daisy (En). Indonesia: orang-aring (Javanese), urang-aring (Sundanese). Malaysia: biu, keremak jantan, nigus. Papua New Guinea: whiteheads (Pidgin). Philippines: higismanok (Tagalog), karim-buaya (Ilokano), pia (Ifugao). Laos: hoomz kèèwx. Thailand: kameng (central), yaa sap, hom kieo (northern). Vietnam: ngô.

Distribution Pantropical.

Uses The juice is used for dyeing hair black, and in tattooing. An extract of the leaves is given for

constipation but also against diarrhoea, and as a tonic. The plant has purgative and emetic properties, and possesses antibiotic activity. The leaves are used as vegetable.

Observations An annual or rather short-lived perennial herb, 10–80 cm tall with prostrate or erect branches and usually numerous, small, white heads. A very common weed of rice fields, sugarcane fields and coconut plantations; also found in humid localities along water courses and roadsides, from lowland up to 1500 m altitude.

Selected sources 7, 11, 14, 16, 25.

Eugenia rumphii Merr.

MYRTACEAE

Vernacular names Indonesia: kayu merah, ai kau bugulawan (Ambon).

Distribution Indonesia (Ambon).

Uses The tannin-yielding bark is used for toughening fishing nets. The wood is occasionally used.

Observations A small tree, up to ca. 16 m tall. Nets are dipped in a decoction of the bark, which is often mixed with the bark of mangrove trees. Possibly this species belongs in the genus *Syzygium* Gaertner.

Selected sources 22.

Glochidion Forster & Forster f.

EUPHORBIACEAE

Major species and synonyms

- *Glochidion brunneum* Hook.f., synonym: *G. goniocarpum* Hook.f.
- *Glochidion glomerulatum* (Miq.) Boerl., synonyms: *G. wallichianum* Muell. Arg., *G. desmocarpum* Hook.f.
- *Glochidion sumatranum* Miq., synonyms: *G. perakense* Hook.f., *G. zeylanicum* A. Juss. var. *malayanum* J.J. Smith.
- *Glochidion velutinum* Wight.

Vernacular names

- *G. brunneum:* Malaysia: ubah merah, ranang, kenidai paya.
- *G. glomerulatum:* Malaysia: ubah hitam, sebasah, samak serai. Thailand: rot nam (Surat Thani).
- *G. sumatranum:* Indonesia: kejel (general), mareme (Sundanese), dempul (Javanese). Malaysia: telungoh. Thailand: chum set, phung muu (Chumphon), man puu (Nakhon Si Thammarat).
- *G. velutinum:* Thailand: rak nam (peninsular), an (Chiang Rai).

Distribution

- *G. brunneum:* Peninsular Malaysia, Sumatra, Borneo, Natuna Islands, Kai Islands.
- *G. glomerulatum:* Thailand, Indo-China, Peninsular Malaysia, Sumatra, Bangka, Borneo, Java.
- *G. sumatranum:* Thailand, throughout Malesia to the Bismarck Archipelago and northern Australia.
- *G. velutinum*: Nepal, India, Burma, Thailand.

Uses The bark is used for tanning. The wood is little used, sometimes for rafters and as fuel.

Observations Shrubs or small trees up to 15 m, but usually much less. Other species of this large genus are fairly large trees used for timber. The species treated here differ from each other especially in the shape and size of fruits, style and inflorescences. In many places commonly found in lowland marshland; also in secondary forests and in open country.

Selected sources 2, 3, 4, 5, 7, 12, 13, 20, 22, 42, 52.

Gymnema tingens (Roxb.) Spreng.

ASCLEPIADACEAE

Synonyms *Bidaria tingens* (Roxb.) Decne.

Vernacular names Philippines: kalalaki-tidugep (Iloko).

Distribution Nepal, India, southern China, northern Vietnam, Laos, Thailand, Peninsular Malaysia, Philippines.

Uses The leaves yield a blue or greenish-blue dye.

Observations A woody climber up to 25 m long, or a slender climbing shrub with opposite, ovate leaves. Possibly the leaves contain indican or pseudoindican, just like other members of the family, e.g. *Marsdenia tinctoria* R. Br. *G. tingens* is locally common in thickets and secondary forest.

Selected sources 12, 14, 20, 21, 34, 35, 42, 45, 49.

Hydrocera triflora (L.) Wight & Arn.

BALSAMINACEAE

Synonyms *Hydrocera angustifolia* Blume.

Vernacular names Water balsam, marsh henna (En). Indonesia: pacar air, pacar cina. Malaysia: inai paya, tempinah, temegun. Thailand: kaeo nam (Nakhon Ratchasima, Prachin

Buri), thian naa, thian nam (central). Vietnam: bông lông dèn.

Distribution Southern India, Sri Lanka, southern China, Indo-China, Thailand, Peninsular Malaysia and Indonesia (Java, south-western Sulawesi).

Uses The flowers are used to prepare a red dye for fingernails as a substitute for henna (*Lawsonia inermis* L.)

Observations A semi-aquatic glabrous perennial herb, up to 1 m tall, with pink or purplish flowers. This species is sometimes confused with *Impatiens balsamina* L., which has the same use and which differs in the united petals and hairy fruit. Water balsam is found in ditches, pools, rice fields and marshy places, usually in the lowland, and is locally common.

Selected sources 6, 7, 12, 16, 42.

Impatiens griffithii Hook. f. & Thomson

BALSAMINACEAE

Vernacular names Malaysia: inai batu, inai bukit.

Distribution Peninsular Malaysia.

Uses The flowers may be used in the same way as the allied species *Impatiens balsamina* L. and *Hydrocera triflora* (L.) Wight & Arn., i.e. for dyeing fingernails red as a substitute for henna (*Lawsonia inermis* L.)

Observations A slender herb, up to 60 cm tall, with pink flowers. It is found very locally in damp places on mountains at about 1000 m altitude.

Selected sources 12, 23, 42.

Ixonanthes icosandra Jack

IXONANTHACEAE

Vernacular names Indonesia: pagar (general), kayu bulus (Bangka), kase beranak (Palembang). Malaysia: pagar anak, mepagar, mertajong (Peninsular). Thailand: aa sai (Pattani).

Distribution Thailand, Peninsular Malaysia, Sumatra.

Uses The bark is used for tanning purposes, usually only for toughening fishing nets, but sometimes also for the production of leather. The timber is sometimes used in house building. Leaves and roots are used in traditional medicine.

Observations A small to medium-sized tree, up to 30 m tall and with bole up to 1.3 m in diameter, but often much less; crown dense and conical, bark smooth or slightly fissured. The timber is considered of little value as it is not durable and is liable to split. The species in found in primary as well as secondary forests on slopes and ridges from sea-level up to 900 m.

Selected sources 12, 23, 47.

Ixora macrantha (Steudel) Bremek.

RUBIACEAE

Synonyms *Ixora longituba* (Miq.) Boerl.

Vernacular names Indonesia: soka nangta (Sundanese), polo (Minahasa).

Distribution Indonesia (Java, northern Sulawesi); very incompletely known.

Uses In Minahasa (Indonesia) the root sap is used for dyeing matting and basketry red, and a decoction of the twigs is used for dyeing rattan.

Observations A shrub or small tree, up to 6 m tall, with white or pink flowers having a very long (3.5 cm) corolla-tube. This species grows in humid forests in the mountains at 1000–1700 m altitude.

Selected sources 7, 9, 12, 22, 27, 43.

Lonchocarpus cyanescens (Schum. & Thonn.) Benth.

LEGUMINOSAE

Vernacular names Yoruba indigo, West African indigo (En).

Distribution West Africa; also cultivated there. Introduced in Peninsular Malaysia.

Uses From leaves and young twigs, and sometimes also fruits, a dark dye is prepared which is used in West Africa to dye cloth, leather, matting and hair. The plant is also used in traditional medicine.

Observations A woody climbing or straggling shrub, in cultivation a shrub about 2.5 m tall, having pinnately compound leaves and large panicles of reddish flowers turning blue. Just like the 'true' indigo (*Indigofera* spp.), yoruba indigo contains indican which can be hydrolized and oxidized to indigo-blue of good quality. It is reported to grow well in Malaysia.

Selected sources 12, 15, 26, 31, 40, 49.

Mahonia philippinensis Takeda

BERBERIDACEAE

Distribution The Philippines (Luzon).

Uses The plant provides a yellow dye which is

used locally. Mixed with indigo, the dye gives a green colour.

Observations A shrub with compound spiny leaves and slender racemes of small yellow flowers. The dye is berberine. This species occurs in damp thickets on limestone in the mountains, 1400–1800 m altitude.

Selected sources 10, 35.

Memecylon ovatum Smith

MELASTOMATACEAE

Vernacular names Philippines: kulis (Tagalog), sagingsing (Bisaya), kandong (Ilokano). Thailand: phlong kin luuk, phlong yai (Prachuap Khiri Khan).

Distribution Southern India, Burma, Thailand, Indo-China, Peninsular Malaysia and the Philippines.

Uses The leaves are used as a mordant before dyeing with sappanwood (*Caesalpinia sappan* L.), e.g. in the Philippines for fibre of talipot palm (*Corypha umbraculifera* L.). Leaves and roots are used as a medicine.

Observations A large shrub or small tree, up to 8(–14) m tall with blueish flowers and initially yellow fruits, turning red and finally black. *M. ovatum* is sometimes regarded as a variety of *Memecylon edule* Roxb., but the latter species differs in having pink flowers, yellow fruits turning black, and small leaves. However, the species are very close. Probably the leaves contain a lot of aluminium as is commonly found in Melastomataceae. *M. ovatum* is very common on rocky and sandy shores.

Selected sources 10, 13, 14, 21, 29, 35.

Morinda L.

RUBIACEAE

Major species and synonyms

- *Morinda angustifolia* Roxb.;
- *Morinda elliptica* Ridley;
- *Morinda tomentosa* Roth, synonyms: *M. tinctoria* Roxb., *M. coreia* Buch.-Ham.;
- *Morinda umbellata* L.

Vernacular names

- *M. angustifolia*: Burma: yai-yo. Thailand: khoh (Karen, Mae Hong Son), salak baan (northern), salak paa (central).
- *M. elliptica*: Malaysia: kenudu, mengkudu jantan (Peninsular). Thailand: ka-muu-duu (Malay, Pattani), muu duu (Malay, Narathiwat), yo thueen (Chumphon).
- *M. tomentosa*: Indonesia: kudu kras (Javanese). Cambodia: nhoër préi. Laos: nhoo kh'ôôk. Thailand: khu (Karen, Kanchanaburi), yo paa (general), salak paa (northern).
- *M. umbellata*: Malaysia: mengkudu hutan, mengkudu akar, mengkudu kecil. Philippines: halon (Tagalog). Thailand: yo yaan (peninsular). Vietnam: nhàu tán.

Distribution

- *M. angustifolia*: Nepal, India, Burma, northwestern Thailand, Laos.
- *M. elliptica*: southern Thailand and Peninsular Malaysia.
- *M. tomentosa*: India, Sri Lanka, Burma, Thailand, Indo-China, Indonesia (Java).
- *M. umbellata*: widespread; southern Asia from India to China, Japan and northern Australia; throughout Malesia.

Uses A dye can be obtained from the bark of roots and stem; it is used for colouring cotton cloth yellow, red or brown, just like the dye from the bark of *Morinda citrifolia* L. The species have numerous medicinal uses, especially *M. umbellata* and *M. elliptica*. The wood of *M. tomentosa* is sometimes used in India, e.g. for plates, dishes and implements. The fruits of *M. umbellata* and *M. tomentosa* are edible.

Observations Small to medium-sized trees, up to 15(–20) m tall, except *M. umbellata* which is a climbing shrub or liana up to 20 m long. *M. tomentosa* and *M. elliptica* resemble *M. citrifolia*. *M. tomentosa* differs from *M. citrifolia* especially in the glabrous corolla tube and smaller leaves and syncarp; *M. elliptica* also has smaller leaves and syncarp. It cannot be excluded that *M. tomentosa* and *M. elliptica* are conspecific. The bark contains morindin. The species are found in forests and thickets.

Selected sources 7, 12, 13, 14, 20, 22, 29, 31, 32, 35, 42, 45, 46.

Mucuna cyanosperma Schumann

LEGUMINOSAE

Vernacular names Indonesia: joa-joa.

Distribution Indonesia (Moluccas, Kai Islands, Irian Jaya), Papua New Guinea.

Uses The stem is used for dyeing cotton blue, or black when used in a mixture with *Tephrosia purpurea* (L.) Pers.

Observations An extensive climbing plant with

trifoliolate leaves, greenish-white flowers in axillary 10–30 cm long racemes, and fruits having irritant bristles but becoming glabrous. This species is found in secondary forests, old gardens, and sago swamps, up to 800(–1650) m altitude.

Selected sources 43, 48.

Persicaria tinctoria (Aiton) Spach

POLYGONACEAE

Synonyms *Polygonum tinctorium* Aiton.

Vernacular names Vietnam: nghê' nhuôm, nghê' cham.

Distribution *P. tinctorium* is native to China and northern Vietnam. It is cultivated in Vietnam, China and Japan, formerly also in the Soviet Union.

Uses From the leaves a dark blue dye ('Chinese indigo') can be prepared, used for dyeing cotton cloth.

Observations A little branched erect herb with terminal panicles, up to 15 cm long. The leaves contain indican just like 'true' indigo (*Indigofera* spp.), and this substance can be hydrolized and oxidized to indigo-blue. Plants can be harvested within a year after sowing.

Selected sources 12, 14, 21, 30, 31, 40, 44, 50.

Phyllanthus polyphyllus Willd.

EUPHORBIACEAE

Vernacular names Thailand: sieo yai (Udon Thani).

Distribution Southern India, Sri Lanka, northeastern Thailand.

Uses The bark is used for tanning in India.

Observations A deciduous shrub or small tree up to 12 m, but usually much less, up to 6 m. The twig bark contains 11–16% tannin. Plants from Thailand are regarded as a distinct variety, var. *siamensis* Airy Shaw. This species is found in the lowlands of Thailand up to 200 m, but in India ascending to 900 m altitude.

Selected sources 1, 2, 12, 24, 32, 45, 46.

Pittosporum pullifolium Burkill

PITTOSPORACEAE

Distribution New Guinea.

Uses The seed is a source of dye in Irian Jaya and Papua New Guinea.

Observations A shrub or small tree, in the lowland often hemi-epiphytic, up to 5 m tall, rarely a medium-sized tree, with simple, stiffly coriaceous leaves more or less in pseudo-whorls, 5-merous flowers arranged in (pseudo-)terminal racemes, and an ellipsoid capsule. The seeds are coated by a resinous, viscid, dark reddish fluid. The species is common in subalpine forests at 3200–3800 m altitude, but can also be found in rain forests or mossy forests at lower altitudes, 1200–2100 m, rarely as low as 100 m.

Selected sources 43, 47.

Pterospermum obliquum Blanco

STERCULIACEAE

Vernacular names Philippines: bayog (Tagalog, Bisaya), pangaltingaan (Ilokano).

Distribution Throughout the Philippines.

Uses The bark is locally used in dyeing brownish the cloth of fishermen. The bark may also be used for tanning. The wood is used in house building for interior work, and also for furniture, cabinetwork, and implements.

Observations A small to medium-sized tree up to 25 m tall with trunk diameter up to 70 cm; leaves oblique, flowers large and yellow, fruits about 6 cm long, divided near the base into several parts. The bark contains 7–28% tannin. The dye is not very permanent. The timber is moderately heavy and hard, and not durable when exposed to the weather or in contact with the ground. *P. obliquum* is common in many places in primary forest at low and medium altitudes in the Philippines.

Selected sources 10, 24, 35, 41.

Rothmannia macrophylla (Hook.f.) Bremek.

RUBIACEAE

Synonyms *Randia macrophylla* Hook.f.

Vernacular names Tree lily (En). Malaysia: kacubong hutan, kumatan, pecah pinggan (Peninsular).

Distribution Peninsular Malaysia, Sumatra.

Uses In Peninsular Malaysia, the juice may be used for blackening teeth.

Observations A slender, erect shrub up to 5 m tall with opposite narrowly elliptic leaves and very large, up to 15 cm long, white flowers blotched purple in the tube. Tree lily is common in lowland forest. It is a very conspicuous and beautiful plant

which might be promising as an ornamental.

Selected sources 12, 13, 42.

Schinopsis Engl.

ANACARDIACEAE

Major species and synonyms

- *Schinopsis balansae* Engl.;
- *Schinopsis haenkeana* Engl.;
- *Schinopsis quebracho-colorado* (Schldl.) F. Barkley & T. Meyer, synonym: *S. lorentzii* (Griseb.) Engl.

Vernacular names Quebracho (En).

Distribution

- *S. balansae*: south-western Brazil, Paraguay and northern Argentina.
- *S. haenkeana*: south-eastern Peru, Bolivia, and northern Argentina.
- *S. quebracho-colorado*: southern Bolivia, northern Argentina. Experimentally cultivated in Singapore.

Uses Quebracho extract, usually traded as powder, is one of the world's major vegetable tanning materials. It is used on a large scale in the production of leather all over the world, including South-East Asian countries. The wood is used in South America for railway sleepers and construction work.

Observations Trees up to 25 m tall with trunk diameter up to 1.5 m. The leaves of *S. balansae* are simple, but the other species have pinnately compound leaves. *S. quebracho-colorado* and *S. haenkeana* are closely related and differ merely in the shape of the leaves. The heartwood contains 16–25% tannin. The wood is very heavy and very hard. The trees are extremely slow growing, and trees younger than 40–50 years are usually considered not worthwhile for tannin extraction. For this reason, prospects for cultivation are not good. The wild stands of quebracho have been seriously depleted because of heavy felling.

Selected sources 12, 24, 37.

Securinega virosa (Roxb. ex Willd.) Baillon

EUPHORBIACEAE

Synonyms *Fluggea microcarpa* Blume, *Fluggea virosa* (Roxb. ex Willd.) Baillon.

Vernacular names Indonesia: sigar jalak, trembilutan (Javanese), simpeureum (Sundanese). Philippines: botolan (Tagalog), tulita-ngalong (Bisaya), arusit (Ilokano). Thailand: kaang khaao (general), daeng nam (Lampang), ma taek (northern). Vietnam: bong nô'.

Distribution Widespread in tropical Africa and Asia, from Pakistan to China and Japan; frequent in South-East Asia, in Malesia common in Peninsular Malaysia, the Philippines and Java, but very scarce in Borneo and eastern Indonesia.

Uses The bark is used as a tanning material and for dyeing matting black; also used as a fish poison. Fully ripe fruits are edible. The species is planted in hedges and as an ornamental. It is also used medicinally. The wood is used for stakes and sticks, and for charcoal.

Observations A dioecious shrub up to 10 m tall, but usually much less, sometimes thorny. In many areas the species is common in forest and scrub, but also in open vegetation from sea-level to 1000(–1700) m altitude. The closely related *Securinega melanthesoides* (Muell. Arg.) Airy Shaw occurs in New Guinea and northern Australia.

Selected sources 2, 3, 4, 5, 7, 12, 15, 18, 20, 22, 25, 31, 38.

Strobilanthes cusia (Nees) Kuntze

ACANTHACEAE

Synonyms *Strobilanthes flaccidifolia* Nees, *Baphicacanthus cusia* (Nees) Bremek.

Vernacular names Assam indigo, room (En). Malaysia: tarom, tarom siam (Peninsular). Laos: hoomz baanz. Thailand: khraam (general), san-yao (Karen, Mae Hong Son), hom (northern).

Distribution Probably native to Indo-China (Laos, Vietnam) and Thailand. It is, or was, cultivated and sometimes naturalized in India, Bangladesh, Sri Lanka, Burma, Thailand, Indo-China, southern China, Taiwan and Peninsular Malaysia.

Uses The twigs are used to prepare a dark blue dye for dyeing cloth. A green dye is prepared in combination with turmeric (*Curcuma longa* L.), and a purple dye in combination with safflower (*Carthamus tinctorius* L.). The plant is also used medicinally, e.g. in Malaysia as a poultice of leaves to treat ague.

Observations A shrub or subshrub up to 1 m tall with elliptic-ovate leaves and usually purplish flowers in panicles. The leaves contain 0.4–1.3% indican, which can be hydrolized and oxidized to indigo-blue. Leaves are astringent and diuretic, and have lithotriptic properties. Plants can be propagated by root cuttings, and they are pruned 2 or 3 times a year.

Selected sources 12, 14, 25, 29, 31, 40, 45.

Syzygium Gaertner

MYRTACEAE

Major species and synonyms

- *Syzygium gratum* (Wight) S.M. Mitra, synonym: *Eugenia grata* Wight;
- *Syzygium griffithii* (Duthie) Merr. & Perry, synonym: *Eugenia griffithii* Duthie.

Vernacular names

- *S. gratum*: Malaysia: gelam tikus. Thailand: khrai met (Chiang Mai), samet chun (central), samet (Satun, Sakon Nakhon).
- *S. griffithii*: Malaysia: kelat bising, kelat lapis, kelat merah.

Distribution

- *S. gratum*: southern Burma, Thailand, Peninsular Malaysia, Sumatra, possibly also India.
- *S. griffithii*: Peninsular Malaysia, possibly also Borneo.

Uses The tannin-yielding bark is used for toughening fishing nets and for colouring clothes reddish-brown or black. The wood is sometimes used for construction, but it is usually not considered of much value.

Observations Small to medium-sized trees, up to 25 m tall. The species are found in lowland forest, often on river banks or near the coast.

Selected sources 12, 13, 23, 36, 42, 43.

Terminalia arjuna (Roxb.) Wight & Arn.

COMBRETACEAE

Synonyms *Terminalia berryi* Wight & Arn., *Terminalia glabra* (Roxb.) Wight & Arn.

Vernacular names Thailand: rok faa khaao (Bangkok).

Distribution Native to India and Sri Lanka. Sometimes planted outside these regions, e.g. in Thailand and Indonesia (Java).

Uses In India the bark is locally used for tanning hides into leather. The wood is used for construction work. *T. arjuna* is planted as a shade tree, especially in coffee plantations. The bark is used medicinally.

Observations A large tree, usually up to 30 m tall, but sometimes up to 60 m, with a trunk diameter up to 2(–2.5) m; outer bark flaking off in pieces, inner bark whitish, exuding red resin; timber greyish-brown with dark streaks, hard and heavy. The bark contains 20–24% tannin and a great amount of calcium carbonate. The tannin produces a superior light brown leather. When the bark is carefully removed without damaging the cambium, it will grow again. Fruits also contain tannin and may be used in tanning. This species grows naturally on banks of streams and rivers, and is cultivated in Java at lower altitudes.

Selected sources 7, 12, 24, 31, 32, 45, 46, 51.

Terminalia nitens Presl

COMBRETACEAE

Vernacular names Philippines: sakat (Tagalog, Pampangan), anegep (Iloko), kalaotit (Igorot).

Distribution Throughout the Philippines.

Uses The bark may be used directly in tanneries, but the tannin content is not high enough for the manufacture of tannin extract. The wood is used for interior work.

Observations A large tree with trunk diameter up to 1 m; leaves (narrowly) obovate, flowers small, arranged in axillary spikes, fruit ellipsoid, 3–5 cm × 1.8–2 cm. The bark contains 9–33% tannin. The wood is moderately heavy (670–770 kg/m^3) and moderately hard, but perishable when exposed to the weather or in contact with the ground. *T. nitens* is commonly found in primary forests at low and medium altitudes.

Selected sources 10, 24, 35, 41, 47.

Trigonopleura malayana Hook.f.

EUPHORBIACEAE

Vernacular names Indonesia: pohon gambir (general), gambir utan, kayu gambir (Javanese). Malaysia: kelat paya, sebasah.

Distribution Malaysia and Indonesia: Peninsular Malaysia, Sumatra, Borneo; possibly also Sulawesi and the Philippines. Sometimes cultivated in Indonesia, e.g. in Kalimantan, Bangka and Billiton.

Uses The leaves are used as a substitute for gambier (*Uncaria gambir* (Hunter) Roxb.). From the leaves an extract which is very similar to 'true' gambier can be prepared; this extract can be used for the same purposes as gambier, and is sometimes mixed with the latter product.

Observations A medium-sized tree up to 25 m tall with alternate distichous and oblong leaves, 5-merous flowers and ellipsoid, slightly hexagonal fruits. *T. malayana* occurs naturally in primary forests in lowlands in Peninsular Malaysia up to 400 m altitude.

Selected sources 3, 4, 5, 12, 22, 23, 31, 42, 53.

Uncaria callophylla Blume ex Korth.

RUBIACEAE

Synonyms *Uncaria jasminiflora* Hook.f.

Distribution Peninsular Malaysia, Singapore, Borneo.

Uses The leaves may be used as a substitute for gambier (*Uncaria gambir* (Hunter) Roxb.)

Observations A woody forest climber with slender 4-angled branches, differing from *U. gambir* especially in the leathery leaves lacking hairy domatia, and smaller heads. The product is inferior to 'true' gambier.

Selected sources 12, 42.

Ventilago madraspatana Gaertner

RHAMNACEAE

Vernacular names Indonesia: lian, talibubu (Ambon).

Distribution This species occurs rather dispersed: southern India, Sri Lanka, southern Burma, Andaman Islands, Java and Moluccas (Indonesia).

Uses The root bark is used in India for colouring mordanted cotton, wool and silk. Reddish shades are obtained. In combination with the root of *Oldenlandia umbellata* L., a beautiful dark brown colour is obtained. The bark yields a fibre used for cordage, and is also used medicinally. Cooked seeds are eaten, and the seed oil is used for cooking. The wood is used as fuel.

Observations A large woody climber with extensive branches hanging down from the tops of trees; leaves distichous and simple, flowers in panicles, very small, fruit a nut with a large apical wing. The root bark contains a number of pigments, the most important being ventilagin, a reddish-brown resinous product, and emodin. The colours produced on clothes are fairly fast when a mordant is used. The wood is pale yellow, porous and soft. In Java, *V. madraspatana* occurs here and there in lowland forests.

Selected sources 7, 8, 12, 23, 29, 32, 45, 46.

Weinmannia luzoniensis Vidal

CUNONIACEAE

Vernacular names Philippines: bani (Tagalog), itangan, saiu (Igorot).

Distribution The Philippines (Luzon).

Uses The bark may be used for tanning. The wood is sometimes used.

Observations A medium-sized tree, up to 20 m tall with trunk diameter up to 50 cm; leaves opposite, pinnately compound, with toothed leaflets; flowers in racemes, fairly small. This species is locally common in forests at 600–1700 m altitude.

Selected sources 10, 35.

Wrightia tinctoria R. Br.

APOCYNACEAE

Vernacular names Pala indigo (En). Vietnam: thu'ng mu'c, thu'ng mu'c nhuôm.

Distribution Central and southern India, Burma, possibly also Indo-China. Timor is often also cited, but this is incorrect and applies to *Wrightia pubescens* R. Br. Rarely planted in gardens in South-East Asia, e.g. Java.

Uses From the leaves an indigo-like dye can be obtained which is used in India to dye cloths. In India the plant is also used medicinally, and for green manure. Flowers, leaves, fruits and seeds are eaten as vegetable. The wood is used for implements and wood carvings.

Observations A laticiferous small tree up to 18 m tall, but usually much smaller, with decussate, simple leaves, white or lilac fragrant flowers, and a fruit consisting of a pair of pendulous follicles. The leaves contain a substance which is indicated as 'pseudoindican'. The wood is white and hard, resembling ivory. About 100–200 kg of leaves are needed to prepare 1 kg of dye.

Selected sources 12, 14, 21, 23, 29, 30, 31, 32, 33, 38, 39, 40, 45, 49.

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4 Dye and tannin-producing plants with other primary use

In this list, the commodity group is given in parenthesis. Dye-producing plants are indicated by 'd', tannin-producing plants by 't'. Synonyms are given in the following, indented lines.

Acacia concinna (Willd.) A. DC. (ornamental plants) d,t
    Acacia rugata (Lamk) Buch.-Ham. ex Benth.
Acacia elata Cunn. ex Benth. (auxiliary plants in agriculture and forestry) d
Acacia farnesiana (L.) Willd. (essential-oil plants) t
Acacia pennata (L.) Willd. (medicinal & poisonous plants) t
Acmena acuminatissima (Blume) Merr. & Perry (timber trees) d
    Eugenia acuminatissima (Blume) Kurz
    Eugenia saligna (Miq.) C.B. Robinson
Adenanthera pavonina L.(timber trees) d,t
    Adenanthera bicolor Moon
    Adenanthera intermedia Merr.
    Adenanthera microsperma Teysm. & Binnend.
    Adenanthera tamarindifolia Pierre
Aegle marmelos (L.) Correa (edible fruits & nuts) d
Aglaia cucullata (Roxb.) Pellegrin (timber trees) t
    Amoora aherniana Merr.
    Amoora cucullata Roxb.
Agrostistachys longifolia (Wight) Benth. ex Hook.f. (plants producing exudates) d
    Agrostistachys borneensis Becc.
Ailanthus triphysa (Dennst.) Alston (plants producing exudates) d
    Ailanthus fauveliana Pierre
    Ailanthus malabarica DC.
    Ailanthus philippinensis Merr.
Albizia lebbek (L.) Benth. (forages) t
Albizia odoratissima (L.f.) Benth. (timber trees) d
Albizia procera (Roxb.) Benth. (timber trees) t
Allium cepa L. (vegetables) d
Alphitonia excelsa Reisseck ex Endlicher (timber trees) d,t
Alpinia galanga (L.) Willd. (spices & condiments) d
    Languas galanga (L.) Stuntz
Amaranthus tricolor L. (vegetables) d
    Amaranthus gangeticus L.
    Amaranthus melancholicus L.
    Amaranthus salicifolius Veitch
Ampelocissus cinnamomea (Wallich) Planchon (medicinal & poisonous plants) d
    Vitis cinnamomea Wallich

Anacardium occidentale L. (edible fruits & nuts) d
Ananas comosus (L.) Merr. (edible fruits & nuts) d
Annona reticulata L. (edible fruits & nuts) d,t
Annona squamosa L. (edible fruits & nuts) t
Anogeissus acuminata Wallich (timber trees) t
Anogeissus latifolia Wallich (timber trees) t
Antidesma bunius (L.) Sprengel (edible fruits & nuts) d
    Antidesma dallachyanum Baillon
    Antidesma rumphii Tulasne
Antidesma stipulare Blume (timber trees) d
Arcangelisia flava (L.) Merr. (medicinal & poisonous plants) d
    Arcangelisia loureiri (Pierre) Diels
Archidendron clypearia (Jack) Nielsen (timber trees) d,t
    Pithecellobium angulatum Benth.
    Pithecellobium clypearia (Jack) Benth.
    Pithecellobium subacutum Benth.
Archidendron pauciflorum (Benth.) Nielsen (spices & condiments) d
    Pithecellobium jiringa Prain
    Pithecellobium lobatum sensu Benth.
Areca catechu L. (stimulant plants) d,t
Arenga pinnata (Wurmb) Merr. (plants mainly producing carbohydrates) d
Artocarpus chaplasha Roxb. (edible fruits & nuts) d
Artocarpus heterophyllus Lamk (edible fruits & nuts) d
Artocarpus integer (Thunb.) Merr. (edible fruits & nuts) d
    Artocarpus champeden (Lour.) Stokes
Artocarpus lakoocha Roxb. (timber trees) d
Artocarpus lanceifolius Roxb. (timber trees) d
Avicennia alba Blume (timber trees) t
Avicennia lanata Ridley (timber trees) t
Avicennia marina (Forssk.) Vierh. (timber trees) t
    Avicennia intermedia Griffith
Avicennia officinalis L. (timber trees) t
Azadirachta indica Adr. Juss. (medicinal & poisonous plants) d
    Melia indica Brandis
Baccaurea javanica (Blume) Muell. Arg. (timber trees) d
    Baccaurea minahassae Koord.
Baccaurea motleyana (Muell. Arg.) Muell. Arg. (edible fruits & nuts) d
Baccaurea racemosa (Reinw. ex Blume) Muell. Arg. (edible fruits & nuts) d
    Baccaurea wallichii Hook.f.
Baccaurea ramiflora Lour. (edible fruits & nuts) d
    Baccaurea sapida (Roxb.) Muell. Arg.
    Baccaurea wrayi King ex Hook.f.
Barringtonia racemosa (L.) Sprengel (medicinal & poisonous plants) t
Basella alba L. (vegetables) d
    Basella rubra L.
Bauhinia malabarica Roxb. (timber trees) t
Bauhinia tomentosa L. (ornamental plants) d
Bischofia javanica Blume (timber trees) d,t

Boesenbergia rotunda (L.) Mansf. (spices & condiments) d
    Gastrochilus panduratum Ridley
Bombax ceiba L. (timber trees) t
    Bombax malabaricum DC.
    Gossampinus heptaphylla Bakh.
Borassus sundaica Becc. (plants mainly producing carbohydrates) d
Bridelia retusa (L.) Sprengel (timber trees) t
Bridelia tomentosa Blume (medicinal & poisonous plants) t
    Bridelia monoica Merr.
Bruguiera cylindrica (L.) Blume (auxiliary plants in agriculture and forestry) t
    Bruguiera caryophylloides Blume
Bruguiera parviflora (Roxb.) Wight & Arn. ex Griffith (timber trees) t
Buchanania arborescens (Blume) Blume (timber trees) t
    Buchanania lucida Blume
Butea superba Roxb. (medicinal & poisonous plants) d
Callistephus chinensis (L.) Nees (ornamental plants) d
Calophyllum blancoi Planchon & Triana (timber trees) d
Calophyllum inophyllum L. (timber trees) d,t
Camellia sinensis (L.) Kuntze (stimulant plants) d,t
    Thea sinensis L.
Canarium asperum Benth. (plants producing exudates) t
    Canarium legitimum Miq.
    Canarium villosum Bent. & Hook. ex Fernandez-Villar
    Canarium zollingeri Engl.
Canarium luzonicum (Blume) A. Gray (plants producing exudates) t
Capsicum annuum L. (spices & condiments) d
Capsicum frutescens L. (spices & condiments) d
Carapa guianensis Aublet (timber trees) t
Careya arborea Roxb. (timber trees) t
Carissa spinarum L. (ornamental plants) t
Carthamus tinctorius L. (vegetable oils & fats) d
Cassia fistula L. (medicinal & poisonous plants) t
Cassia javanica L. (timber trees) t
Cassia renigera Benth. (ornamental plants) t
Cassia siamea Lamk (timber trees) t
Cassia surattensis Burm. f. (medicinal & poisonous plants) t
Cassia tora L. (medicinal & poisonous plants) d
Cassine glauca (Rottb.) Kuntze (medicinal & poisonous plants) t
    Elaeodendron roxburghii Wight & Arn.
Castanopsis acuminatissima (Blume) A. DC. (timber trees) t
    Castanea acuminatissima Blume
Castanopsis argentea (Blume) A. DC. (timber trees) d
    Castanea argentea Blume
Castanopsis javanica (Blume) A. DC. (timber trees) t
    Castanea javanica Blume
    Quercus discocarpa Hance
Castanopsis lucida (Nees) Soepadmo (edible fruits & nuts) t
    Castanopsis hullettii King ex Hook.f.
Castanopsis wallichii King ex Hook.f. (edible fruits & nuts) t

Casuarina equisetifolia L. ssp. *equisetifolia* (auxiliary plants in agriculture and forestry) d,t
Catunaregam spinosa (Thunb.) Tirvengadum (medicinal & poisonous plants) d
Randia dumetorum Lamk
Ceiba pentandra (L.) Gaertner (fibre plants) d
Ceratonia siliqua L. (forages) d
Chrysobalanus icaco L. (edible fruits & nuts) t
Citrus hystrix DC. (edible fruits & nuts) d
Clitoria ternatea L. (auxiliary plants in agriculture and forestry) d
Coccoloba uvifera L. (edible fruits & nuts) t
Cocos nucifera L. (vegetable oils & fats) d,t
Codiaeum variegatum (L.) Blume (ornamental plants) t
Codonopsis javanica (Blume) Hook.f. (medicinal & poisonous plants) d
Campanumoea javanica Blume
Coelostegia griffithii Benth. (timber trees) t
Colona serratifolia Cav. (fibre plants) d
Columbia serratifolia DC.
Corypha utan Lamk (fibre plants) d
Corypha elata Roxb.
Coscinium blumeanum Miers ex Hook.f. & Thomson (medicinal & poisonous plants) d
Coscinium fenestratum (Gaertner) Colebr. (medicinal & poisonous plants) d
Coscinum wallichianum Miers
Cotylelobium melanoxylon (Hook.f.) Pierre (timber trees) d
Crotalaria mucronata Desv. (auxiliary plants in agriculture and forestry) d
Crotalaria striata DC.
Croton tiglium L. (medicinal & poisonous plants) t
Cryptocarya massoy (Oken) Kosterm. (spices & condiments) d
Massoia aromatica Becc.
Curcuma aeruginosa Roxb. (medicinal & poisonous plants) d
Curcuma aromatica Salisb. (plants mainly producing carbohydrates) d
Curcuma heyneana Valeton & Van Zyp (medicinal & poisonous plants) d
Curcuma longa L. (spices & condiments) d
Curcuma domestica Valeton
Curcuma mangga Valeton & Van Zyp (vegetables) d
Curcuma xanthorrhiza Roxb. (plants mainly producing carbohydrates) d
Dacrydium cupressinum Soland. (timber trees) t
Daemonorops spp. (rattans) d
Daucus carota L. (vegetables) d
Delonix regia (Bojer ex Hook.) Rafin. (ornamental plants) d
Poinciana regia Bojer ex Hook.
Dendrobium crumenatum Swartz (ornamental plants) d
Desmodium heterocarpon (L.) DC. (auxiliary plants in agriculture and forestry) d
Dialium laurinum Baker (timber trees) t
Dillenia philippinensis Rolfe (timber trees) d
Dioscorea hispida Dennstedt (plants mainly producing carbohydrates) d
Diospyros kaki L. (edible fruits & nuts) t
Dracaena angustifolia Roxb. (medicinal & poisonous plants) d
Pleomele angustifolia N.E. Brown

Duabanga moluccana Blume (timber trees) d
Durio griffithii (Masters) Bakh. (timber trees) t
Boschia griffithii Masters
Durio griffithii Bakh. var. *heteropyxis* Bakh.
Durio zibethinus Murr. (edible fruits & nuts) d
Dysoxylum acutangulum Miq. (timber trees) t
Dysoxylum cyrtobotryum Miq. (timber trees) t
Dysoxylum heyneanum Valeton
Dysoxylum venulosum King
Epipremnum pinnatum (L.) Engl. (forages) d
Rhaphidophora merrillii Engl.
Erythrina variegata L. (auxiliary plants in agriculture and forestry) d
Erythrophleum fordii Oliv. (timber trees) t
Etlingera elatior (Jack) R.M. Smith (spices & condiments) d
Nicolaia speciosa Horan.
Phaeomeria speciosa Koord.
Eucalyptus camaldulensis Dehnh. (timber trees) d
Eucalyptus rostrata Schldl.
Eugenia conglomerata Duthie (timber trees) d
Eugenia dombeyi (Sprengel) Skeels (edible fruits & nuts) t
Eugenia brasiliensis Lamk, non Aublet
Eugenia inophylla Roxb. (timber trees) d
Eugenia uniflora L. (edible fruits & nuts) t
Eugenia michelii Lamk
Eurya japonica Thunb. (auxiliary plants in agriculture and forestry) d
Evodia spp. (various commodity groups) d
Excoecaria agallocha L. (essential-oil plants) t
Ficus religiosa L. (medicinal & poisonous plants) d,t
Ficus semicordata Buch.-Ham. ex J.E. Smith (ornamental plants) t
Ficus cunia Buch.-Ham.
Ficus tinctoria Forst.f. ssp. *gibbosa* (Blume) Corner (fibre plants) t
Ficus gibbosa Blume
Flemingia grahamiana Wight & Arn. (plants mainly producing carbohydrates) d
Flemingia rhodocarpa Baker
Flemingia macrophylla (Willd.) Merr. (forages) d
Flemingia congesta Roxb.
Freycinetia funicularis (Lamk) Merr. (ornamental plants) d
Garcinia atroviridis Griffith ex T. Anderson (edible fruits & nuts) d
Garcinia cowa Roxb. (vegetables) d
Garcinia dulcis (Roxb.) Kurz (edible fruits & nuts) d
Garcinia mangostana L. (edible fruits & nuts) d,t
Garcinia xanthochymus Hook.f. ex T. Anderson (edible fruits & nuts) d
Garuga floribunda Decne. (timber trees) d
Garuga abilo Merr.
Garuga pinnata Roxb. (timber trees) t
Genipa americana L. (edible fruits & nuts) d
Glochidion arborescens Blume (timber trees) d,t
Glochidion rubrum Blume (medicinal & poisonous plants) t

Gluta elegans (Wallich) Hook.f. (timber trees) d
Gordonia excelsa (Blume) Blume (timber trees) d,t
Gordonia integerrima (Miq.) H. Keng (timber trees) d,t
    Laplacea integerrima Miq.
Gordonia multinervis King (timber trees) d
    Gordonia concentricicatrix Burkill
Harrisonia perforata (Blanco) Merr. (medicinal & poisonous plants) d
Helianthus annuus L. (vegetable oils & fats) d
Heliotropium indicum L. (medicinal & poisonous plants) d
Hemigraphis angustifolia Hallier f. (medicinal & poisonous plants) d
Heritiera littoralis Dryander ex Aiton (timber trees) t
    Heritiera minor Lamk
Hibiscus rosa-sinensis L. (ornamental plants) d
Hibiscus sabdariffa L. (vegetables) d
Hibiscus schizopetalus (Masters) Hook.f. (ornamental plants) d
Homonoia riparia Lour. (auxiliary plants in agriculture and forestry) d
Hopea odorata Roxb. (timber trees) t
Horsfieldia sucosa (King) Warb. (timber trees) t
Hullettia dumosa King ex Hook.f. (edible fruits & nuts) d
Intsia bakeri (Prain) Prain (timber trees) d
Intsia bijuga (Colebr.) Kuntze (timber trees) d
    Intsia amboinensis DC.
    Intsia retusa (Kurz) Kuntze
Ipomoea pes-caprae (L.) Sweet (medicinal & poisonous plants) d
Iresine herbstii Hook.f. (ornamental plants) d
Ixonanthes reticulata Jack (timber trees) t
    Ixonanthes grandiflora Hochr.
Jatropha curcas L. (medicinal & poisonous plants) d,t
Kaempferia galanga L. (medicinal & poisonous plants) d
Kandelia candel (L.) Druce (auxiliary plants in agriculture and forestry) t
    Kandelia rheedei Wight & Arn.
Kayea lepidota (T. Anderson) Pierre (timber trees) t
    Mesua lepidota T. Anderson
Knema angustifolia (Roxb.) Warb. (plants producing exudates) d,t
    Myristica gibbosa Hook.f. & Thomson
Koordersiodendron pinnatum (Blanco) Merr. (timber trees) d
Lactuca indica L. (vegetables) d
Lagerstroemia macrocarpa Kurz (timber trees) t
Lagerstroemia speciosa (L.) Pers. (timber trees) t
    Lagerstroemia reginae Roxb.
Lannea coromandelica (Houtt.) Merr. (ornamental plants) d,t
    Lannea grandis (Dennst.) Engl.
Lecythis ollaria Loefl. (vegetable oils & fats) t
Lecythis pisonis Cambess. (vegetable oils & fats) t
Lecythis zabucayo Aublet (vegetable oils & fats) t
Leea indica (Burm.f.) Merr. (medicinal & poisonous plants) d,t
    Leea gigantea Griffith
    Leea sambucina (L.) Willd.

Leucaena leucocephala (Lamk) de Wit (forages) t
Leucaena glauca Benth.
Limonia acidissima L. (edible fruits & nuts) d
Feronia elephantum Correa
Feronia limonia (L.) Swingle
Litchi chinensis Sonn. (edible fruits & nuts) t
Euphoria didyma Blanco
Litchi philippinensis Radlk.
Nephelium litchi Cambess.
Lithocarpus blumeanus (Korth.) Rehder (timber trees) t
Quercus blumeana Korth.
Lithocarpus encleisacarpus (Korth.) A. Camus (timber trees) d,t
Quercus encleisacarpa Korth.
Lithocarpus hystrix (Korth.) Rehder (timber trees) t
Quercus hystrix Korth.
Lithocarpus pseudomoluccus (Blume) Rehder (timber trees) t
Quercus pseudomolucca Blume
Ludwigia hyssopifolia (G. Don) Exell (medicinal & poisonous plants) d
Jussiaea linifolia Vahl
Lumnitzera littorea (Jack) Voigt (timber trees) d
Lumnitzera coccinea Wight & Arn.
Lumnitzera racemosa Willd. (timber trees) t
Macaranga gigantea (Reichb.f. & Zoll.) Muell. Arg. (timber trees) d,t
Macaranga incisa Gage
Macaranga mappa (L.) Muell. Arg. (timber trees) t
Mammea americana L. (edible fruits & nuts) t
Mangifera indica L. (edible fruits & nuts) d
Manilkara zapota (L.) P. van Royen (edible fruits & nuts) t
Achras zapota L.
Maniltoa polyandra (Roxb.) Harms (timber trees) d
Cynometra polyandra Roxb.
Medinilla radicans (Blume) Blume (medicinal & poisonous plants) d
Melanolepis multiglandulosa (Reinw. ex Blume) Reichb.f. & Zoll. (medicinal & poisonous plants) d
Mallotus moluccanus Muell. Arg.
Melanolepis moluccana Pax & K. Hoffm.
Melastoma malabathricum L. (medicinal & poisonous plants) d
Melastoma sanguineum Sims (medicinal & poisonous plants) d
Melastoma decemfidum Roxb.
Melia azedarach L. (medicinal & poisonous plants) d
Melia dubia Cav.
Memecylon edule Roxb. (timber trees) d
Mesua ferrea L. (timber trees) d
Mimusops elengi L. (timber trees) t
Mimusops elengi L. var. *parvifolia* (R. Br.) H.J. Lam
Mimusops parvifolia R. Br.
Monascus purpureus Went (lower plants) d
Moringa oleifera Lamk (spices & condiments) d

Musa balbisiana Colla (BB genome) (edible fruits & nuts) d
    Musa brachycarpa Backer
Musa ×*paradisiaca* L. (Musa AAB group) (edible fruits & nuts) d
    Musa paradisiaca L. var. *sapientum* Kuntze
    Musa sapientum L. var. *paradisiaca* Baker
Myristica fragrans Houtt. (spices & condiments) d
Nephelium lappaceum L. (edible fruits & nuts) d
Nigella sativa L. (spices & condiments) d
Nypa fruticans Wurmb (plants mainly producing carbohydrates) t
Octomeles sumatrana Miq. (timber trees) d
Oreocnide integrifolia Miq. (fibre plants) d
    Villebrunea integrifolia Gaudich.
    Villebrunea sylvatica Blume
Oreocnide rubescens Miq. (fibre plants) d
    Villebrunea rubescens Blume
    Villebrunea semierecta Blume
Oroxylum indicum (L.) Kurz (medicinal & poisonous plants) d,t
Oryza sativa L. (cereals) d
Pandanus amaryllifolius Roxb. (spices & condiments) d
    Pandanus latifolius Hassk.
    Pandanus odorus Ridley
Pandanus conoideus Lamk (edible fruits & nuts) d
Pangium edule Reinw. (medicinal & poisonous plants) d
Paraserianthes falcataria (L.) Nielsen (auxiliary plants in agriculture and forestry) t
    Albizia falcata sensu Backer
    Albizia falcataria (L.) Fosberg
Parkia javanica (Lamk) Merr. (medicinal & poisonous plants) t
Persicaria chinensis (L.) H. Gross (medicinal & poisonous plants) d
    Polygonum chinense L.
Peucedanum japonicum Thunb. (medicinal & poisonous plants) d
Phaseolus lunatus L. (pulses) d
Phoenix paludosa Roxb. (fibre plants) t
Phyllanthus fraternus Webster (medicinal & poisonous plants) d
    Phyllanthus niruri sensu auct. non L.
Pinus kesiya Royle ex Gordon (plants producing exudates) t
    Pinus insularis Endl.
Pistacia lentiscus L. (plants producing exudates) d,t
Pithecellobium dulce (Roxb.) Benth. (edible fruits & nuts) t
Plectranthus spp. (plants mainly producing carbohydrates, medicinal & poisonous plants) d
Pongamia pinnata (L.) Merr. (medicinal & poisonous plants) d,t
Prosopis juliflora (Sw.) DC. (forages) t
Prosopis spicigera L. (auxiliary plants in agriculture and forestry) t
Prunus grisea Kalkm. var. *grisea* (timber trees) d
    Pygeum celebilum Miq.
    Pygeum latifolium Miq.
    Pygeum preslii Merr.
    Pygeum vulgare (Koehne) Merr.

Prunus marsupialis Kalkm. (timber trees) d
Pygeum glandulosum Merr.
Psidium guajava L. (edible fruits & nuts) d
Psophocarpus tetragonolobus (L.) DC. (vegetables) d
Psychotria jackii Hook.f. (medicinal & poisonous plants) d
Psychotria viridiflora Reinw. ex Blume
Pterocarpus indicus Willd. (timber trees) d
Pterocarpus macrocarpus Kurz (timber trees) d
Pterocarpus santalinoides L'Herit. ex DC. (timber trees) d
Pterocarpus santalinus L. (timber trees) d
Pterospermum diversifolium Blume (timber trees) d,t
Pterospermum acerifolium Willd. sensu Heyne
Pterospermum niveum Vidal (fibre plants) d
Punica granatum L. (edible fruits & nuts) d,t
Quercus gemelliflora Blume (timber trees) t
Quercus turbinata Blume
Quercus lusitanica Lamk (medicinal & poisonous plants) t
Rheum rhabarbarum L. (vegetables) d
Rheum undulatum L.
Rhodamnia cinerea Jack (timber trees) d,t
Rhodamnia trinervia Blume
Rhodomyrtus tomentosa (Aiton) Hassk. (edible fruits & nuts) d
Rhus chinensis Miller (medicinal & poisonous plants) t
Rhus semialata Murray
Ricinus communis L. (vegetable oils & fats) d
Rothmannia schoemanii (Teysm. & Binnend.) Tirvengadum (timber trees) d
Randia exaltata Griffith
Sandoricum koetjape (Burm.f.) Merr. (edible fruits & nuts) t
Sandoricum indicum Cav.
Sandoricum nervosum Blume
Sapium sebiferum (L.) Roxb. (vegetable oils & fats) d
Sauropus androgynus (L.) Merr. (vegetables) d
Schizomeria serrata Hochr. (timber trees) d,t
Schleichera oleosa (Lour.) Oken (vegetable oils & fats) t
Scorodocarpus borneensis (Baillon) Becc. (timber trees) t
Semecarpus anacardium L.f. (edible fruits & nuts) d,t
Semecarpus cassuvium Roxb. (edible fruits & nuts) d
Sesamum orientale L. (vegetable oils & fats) d
Sesamum radiatum Schum. (vegetable oils & fats) d
Sesbania grandiflora (L.) Pers. (forages) d,t
Shorea leprosula Miq. (timber trees) t
Shorea negrosensis Foxw. (timber trees) t
Shorea obtusa Wallich (timber trees) t
Shorea robusta Gaertner f. (timber trees) t
Shorea roxburghii G. Don (timber trees) d
Shorea siamensis Miq. (timber trees) t
Pentacme siamensis (Miq.) Kurz
Sonneratia alba J. Smith (timber trees) t

Sonneratia caseolaris (L.) Engl. (vegetables) t
Sonneratia acida L.f.
Sonneratia griffithii Kurz (timber trees) t
Sorghum bicolor (L.) Moench (cereals) d
Andropogon sorghum Brot.
Sorghum vulgare Pers.
Soymida febrifuga Adr. Juss. (medicinal & poisonous plants) t
Spatholobus ferrugineus (Zoll. & Moritzi) Benth. (fibre plants) d
Sterculia foetida L. (timber trees) d
Sterculia treubii Hochr. (timber trees) d
Swietenia mahagoni Jacq. (timber trees) d
Symingtonia populnea (R. Br. ex Griffith) Steenis (timber trees) t
Bucklandia populnea R. Br. ex Griffith
Bucklandia tricuspis Hall.f.
Syzygium aromaticum (L.) Merr. & Perry (spices & condiments) d
Eugenia aromatica (L.) Baillon
Eugenia caryophyllata Thunb.
Syzygium cumini (L.) Skeels (edible fruits & nuts) t
Eugenia cumini (L.) Druce
Syzygium cymosum (Lamk) DC. (timber trees) d,t
Eugenia cymosa Lamk
Syzygium gracilis (Korth.) Amshoff (timber trees) d
Eugenia clavimyrtus Koord. & Valeton
Syzygium jambos (L.) Alston (edible fruits & nuts) t
Eugenia jambos L.
Syzygium lineatum (DC.) Merr. & Perry (timber trees) d,t
Eugenia lineata (DC.) Duthie
Eugenia longiflora Fischer
Syzygium palembanicum Miq. (timber trees) t
Eugenia lepidocarpa Wallich
Eugenia palembanica Merr.
Syzygium polyanthum (Wight) Walp. (spices & condiments) d,t
Eugenia polyantha Wight
Syzygium pycnanthum Merr. & Perry (edible fruits & nuts) d
Eugenia densiflora (Blume) Duthie
Syzygium pyrifolium (Bl.) DC. (timber trees) d
Eugenia salaccensis Koord. & Valeton
Eugenia striata Koord. & Valeton
Syzygium racemosum (Blume) DC. (timber trees) d
Eugenia jamboloides Koord. & Valeton
Syzygium syzygioides (Miq.) Amshoff (timber trees) d
Syzygium variifolium Miq. (timber trees) d
Eugenia variifolia Miq.
Syzygium zeylanicum (L.) DC. (timber trees) d
Eugenia spicata Lamk
Eugenia zeylanica (L.) Wight
Tabernaemontana divaricata (L.) R. Br. ex Roemer & Schultes (ornamental plants) d
Ervatamia coronaria (Jacq.) Stapf

Tabernaemontana pandacaqui Lamk (medicinal & poisonous plants) d
Tagetes erecta L. (ornamental plants) d
Tagetes patula L. (ornamental plants) d
Tamarindus indica L. (edible fruits & nuts) d,t
Tectona grandis L.f. (timber trees) d
Tephrosia purpurea (L.) Pers. (auxiliary plants in agriculture and forestry) d
Terminalia alata Heyne ex Roth (timber trees) d,t
Terminalia calamansanai (Blanco) Rolfe (timber trees) t
    Terminalia bialata King
Terminalia citrina (Gaertn.) Roxb. (timber trees) d,t
    Terminalia arborea Koord. & Valeton
    Terminalia comintana Merr.
Terminalia foetidissima Griffith (timber trees) d
    Terminalia oocarpa Merr.
    Terminalia sumatrana Miq.
Terminalia microcarpa Decne. (timber trees) t
    Terminalia edulis Blanco
Terminalia paniculata Roth (timber trees) t
Thespesia lampas (Cav.) Dalz. & Gibson (fibre plants) d
Thespesia populnea Sol. ex Correa (timber trees) d
Toddalia asiatica (L.) Lamk (spices & condiments) d
    Toddalia aculeata Pers.
Toona ciliata M.J. Roemer (timber trees) d
    Cedrela toona Roxb.
Trema orientalis (L.) Blume (auxiliary plants in agriculture and forestry) d,t
Uncaria cordata Merr. (timber trees) d
    Uncaria sclerophylla Roxb.
Vernicia fordii (Hemsley) Airy Shaw (vegetable oils & fats) t
    Aleurites fordii Hemsley
Vernicia montana Lour. (vegetable oils & fats) d
    Aleurites montana (Lour.) Wilson
Vigna unguiculata (L.) Walp. cv. group Unguiculata (pulses) d
    Dolichos unguiculatus L.
    Vigna sinensis (L.) Hassk.
    Vigna unguiculata (L.) Walp. ssp. *unguiculata*
Vitex pinnata L. (timber trees) d
    Vitex pubescens Vahl
Weinmannia sundana Miq. (spices & condiments) d
    Weinmannia sundaica Blume
Woodfordia floribunda Salisb. (medicinal & poisonous plants) d
    Woodfordia fruticosa (L.) Kurz
Xanthophyllum flavescens Roxb. (timber trees) d
    Xanthophyllum excelsum Miq.
Ximenia americana L. (edible fruits & nuts) t
Xylia xylocarpa (Roxb.) Taubert var. *xylocarpa* (timber trees) t
Zingiber officinale Roscoe (spices & condiments) d
Ziziphus jujuba Miller (edible fruits & nuts) t
    Ziziphus vulgaris Lamk
Ziziphus xylopyrus (Retz.) Willd. (edible fruits & nuts) d,t

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GLOSSARY

abortifacient: inducing abortion
actinomorphic: radially symmetrical; applied to flowers that can be bisected in more than one vertical plane
acuminate: ending in a narrowed, tapering point with concave sides
acute: sharp; ending in a point with straight or slightly convex sides
adnate: united with another part; with unlike parts fused, e.g., ovary and calyx tube
adventitious: not in the usual place, e.g. roots on stems, or buds produced elsewhere than in the axils of leaves or the extremities of stems
ague: a fever of malarial character marked by paroxysms of chills, fever, and sweating that recur at regular intervals
albumen: the nutritive material stored within the seed, and in many cases surrounding the embryo
algicidal: kills algae
aliform: wing-shaped
alkaloid: large group of organic bases containing nitrogen and usually oxygen that occur for the most part in the form of salts with acids; usually optically and biologically active
allelopathy: the reputed baneful influence of one living plant upon another due to secretion of toxic substances
alterative: a drug used empirically to alter favourably the course of an ailment and to restore healthy body functions
alternate: leaves, etc., inserted at different levels along the stem, as distinct from opposite or whorled
analgesic: producing insensibility to pain without loss of consciousness
anemophilous: wind-pollinated, the pollen being conveyed by the air
aniline: an oily liquid poisonous amine, colourless when pure
annual: a plant that completes its life cycle in one year
anther: the part of the stamen containing the pollen
anthelmintic: a drug or agent that destroys or causes expulsion of intestinal worms
antibiotic: combats variously disease-causing organisms such as bacteria, viruses, protozoa
antihepatotoxic: counteracts injuries to the liver
antiherpetic: combats virus diseases which are characterized by the formation of blisters on the skin or mucous membranes
anti-inflammatory: reducing the tendency to inflame or excite the senses
antimicrobial: inimical to microbes
antioxidant: a substance that opposes oxidation or inhibits reactions promoted by oxygen or peroxides; many of these substances are used as preservatives in various products

antiperiodic: prevents periodic returns of paroxysms or exacerbations of disease (as in intermittent fevers)
antipyretic: prevents, removes or allays fever
antiscorbutic: counteracts scurvy
antiseptic: inhibits or retards or prevents the growth and reproduction or arrests the development of bacteria and other micro-organisms that cause infection or other deleterious processes
apiculate: ending abruptly in a short point
apotracheal: not associated or contiguous with vessels or vascular tracheids
arborescent: attaining the size or character of a tree
areole: a space marked out on a surface; a small cell or cavity
aril: an expansion of the funicle enveloping the seed, arising from the placenta; sometimes occurring as a pulpy covering
ascending: directed upwards, as the stem; the axis is oblique at first, then erect
astringent: contracts muscle-fibres and condenses tissues
atonic: characterized by a lack of tonus or vital energy; weakness, especially of a contractile organ
auxin: an organic substance characterized by its ability in low concentrations to promote growth of plant shoots and to produce other effects such as root formation and bud inhibition
axil: the upper angle between the leaf and the stem
axillary: arising from the axil
axis: the main or central line of development of any plant or organ
Ayurvedic: traditional Hindu system of medicine based largely on homeopathy and naturopathy
bactericidal: destroys bacteria
barbate: bearded, having long weak hairs in tufts
bark: the tissues outside the cambium, frequently restricted to the periderm (outer bark), which is the cork cambium and its products
batik: an Indonesian method of hand-printing textiles by coating parts of the fabric with wax to resist dye, dipping in a cold dye solution, boiling off the wax, and repeating the process for each colour used
beak: a long, prominent and substantial point, applied particularly to prolongations of fruits
berry: a juicy indehiscent fruit with the seeds immersed in pulp; usually several-seeded without a stony layer surrounding the seeds
biennial: a plant which flowers, fruits and dies in its second year or season
bifid: cleft into two parts at the tip
bilabiate: two-lipped
biliousness: a situation marked or accompanied by disordered liver function due to or associated with excessive secretion of bile
bipinnate: when the primary divisions (pinnae) of a pinnate leaf are themselves pinnate
biramous: having two branches
bisexual: having both sexes present and functional in the same flower
blade: the expanded part of a leaf or petal
bole: the main trunk of a tree with a distinct stem
bract: a reduced leaf subtending a flower or flower stalk, or a part of an inflorescence

bracteole: a secondary bract on the pedicel or close under the flower
budding: inserting a bud from a plant of one kind into an opening in the bark of a plant of another kind, usually in order to propagate a desired cultivar
bulb: an underground storage organ with a much-shortened stem bearing fleshy leaf bases or scale leaves enclosing the next year's bud
bush: a low thick shrub without a distinct trunk
buttress: the knee-like growth of trunk or roots in certain trees
caducous: falling off early
calycle: a whorl of bracts outside the calyx simulating an additional calyx
calyx: the outer envelope of the flower, consisting of sepals, free or united
cambium: a layer of nascent tissue between the wood and bast, adding elements to both
campanulate: bell-shaped
capitate: headed, like the head of a pin in some stigmas, or collected into compact headlike clusters as in some inflorescences
capsule: a dry dehiscent fruit composed of two or more carpels and either splitting when ripe into valves, or opening by slits or pores
carcinogenic: producing or tending to produce cancer
carcinoma: a malignant tumor consisting of epithelial cells lying within the connective tissue framework of an organ or other structure
cardiotonic: tending to increase the tonus of heart muscle
carpel: one of the foliar units of a compound pistil or ovary; a simple pistil has only one carpel
carpophore: the part of the receptacle which is prolonged between the carpels as a central axis
catkin: a close bracteate, often pendulous spike, usually with unisexual flowers
cauliflorous: flowers borne on the stem from the old wood, separate from the leaves
chartaceous: papery
cholagogue: an agent that promotes an increased flow of bile
clavate: club-shaped or thickened towards the end
claw: the narrow part of a petal or sepal
coccous: referring to the parts of a lobed fruit
coherent: the incorporation of one part with another, as the petals to form a tubular corolla
colic: a paroxysm of acute abdominal pain localized in a hollow organ or tube and caused by spasm, obstruction, or twisting
collagen: an insoluble fibrous protein that occurs in vertebrates as the chief constituent of the fibrils of connective tissue, as in skin
collapse (in wood): a defect due to abnormal and irregular shrinkage and resulting in a wrinkled or corrugated appearance of the surface and sometimes also an internal honeycombing
column: a tube of connate stamen filaments
comose (of seeds): tufted with hairs at the end
compound: of two or more similar parts in one organ, as in a compound leaf or compound fruit
connate: united or joined
constipation: abnormally delayed or infrequent passage of dry hardened faeces associated with varying degrees of stasis of the lower bowel

contorted: twisted or bent
coppice: a small wood which is regularly cut at stated intervals, the new growth arising from the stools
cordate: heart-shaped, as seen at the base of a deeply notched leaf, etc.
coriaceous: of leathery texture
corm: a solid, short, swollen underground stem, usually erect and tunicated, of one year's duration, with that of the next year at the top or close to the old one
corolla: the inner envelope of the flower of free or united petals
corona: any body which intervenes between the corolla and stamens
corrugated: wrinkled
corymb: a flat-topped indeterminate inflorescence in which the branches or pedicels start from different points, but attain approximately the same level, with the outer flowers opening first
cotyledon: seed-leaf. Dicotyledons have two cotyledons in their embryos and monocotyledons have one
crenate: the margin notched with blunt or rounded teeth
crystalline: of the nature of or relating to a crystal
cultivar (cv., cvs): an agricultural or horticultural variety that has originated and persisted under cultivation, as distinct from a botanical variety. A cultivar name should always be written with an initial capital letter and given single quotation marks, e.g. *Gardenia jasminoides* Ellis 'Radicans'
cuneate: wedge-shaped; triangular, with the narrow end at the point of attachment, as the bases of leaves or petals
cupule: the cup of such fruits as the acorn, an involucre composed of bracts that are fused at their bases
cutting: the severed portion of a plant, used for propagation
cyme: a determinate inflorescence, often flat-topped, in which the central flowers open first
cymose: bearing cymes or relating to cymes
deciduous: shedding or prone to shedding, applied to leaves, petals, etc.
decurrent: extending down and adnate to the stem, as occurs in some leaves
decussate (of leaves): arranged in opposite pairs on the stem, with each pair perpendicular to the preceding pair
dehiscent: opening spontaneously when ripe, e.g., capsules, anthers
deltoid: shaped like an equilateral triangle
dentate: margin prominently toothed with the pointed teeth directed outwards
denticulate: finely dentate
determinate: when the terminal or central flower of an inflorescence opens first and the prolongation of the axis is arrested; for pulses also used to indicate bush-shaped plants with short duration flowering in one plane
dextrorotatory: rotating the plane of polarization of light towards the right
diabetes: an abnormal condition characterized by the secretion and excretion of excessive amounts of urine
diaphoretic: an agent inducing sweating, having the power to increase perspiration
dicotyledon: angiosperm with two cotyledons or seed-leaves
dimorphic: of two forms, as may occur with branches, etc.

dioecious: with unisexual flowers and with the staminate and pistillate flowers on different plants
disk: a fleshy or elevated development of the receptacle within the calyx, or corolla or stamens, often lobed and nectiferous
dispersal: the various ways by which seeds are scattered, e.g. by wind, birds, adhesion to animals
distichous: regularly arranged in two opposite rows on either side of the stem
diuretic: promotes flow of urine
domatia: modified projections that provide shelter for other organisms
double-flowered: petals monstrously increased at the expense of other organs, especially the stamens
dropsy: an abnormal accumulation of serous fluid in connective tissue, causing puffy swelling
drupe: a fleshy one-seeded indehiscent fruit with the seed enclosed in a strong endocarp
dyspepsia: a condition of disturbed digestion
ellipsoid: an elliptic solid
elliptic: oval in outline but widest about the middle
emarginate: notched at the extremity
embryo: the rudimentary plant still enclosed in the seed which arises from the zygote
emetic: induces vomiting
emmenagogue: substance promoting flow of menstrual discharge
emollient: soothes, softens, relaxes and protects the skin
endocarp: the innermost layer of the pericarp or fruit wall
endosperm: the starchy or oily nutritive material stored within some seeds, sometimes referred to as albumen; it is triploid, having arisen from the triple fusion of a sperm nucleus and the two polar nuclei of the embryo sac
entire: an even margin without teeth, lobes, etc.
epicotyl: the young stem above the cotyledons
epiderm: the true cellular skin or covering of a plant below the cuticle
epidermoid: belonging to or resembling the epiderm
epigeal: above ground; in epigeal germination the cotyledons are raised above the ground
epipetalous: borne upon the petals or placed before the petals
epiphyte: a plant that grows on another plant but without deriving nourishment from it
exocarp: the outer layer of the pericarp or fruit wall
expectorant: controls cough by increasing or decreasing bronchial secretions
exserted: projecting beyond, as stamens from a perianth
exstipulate: without stipules
fascicle: a cluster of flowers, leaves, etc., arising from the same point
febrifuge: serving to reduce fever
fermentation: a chemical change accompanied by effervescence and suggestive of changes produced in organic materials by yeasts
ferralitic (of soil): deeply weathered reddish clayey soil rich in aluminium and iron ions
fertile (of stamens): bearing pollen which fecundates the ovules
fertilization: union of the gametes (egg and sperm) to form a zygote

filament: thread; the stalk supporting the anther
filiform: slender; threadlike
flaky: lamelliform, in the shape of a plate or scale
fleshy: succulent
flexuous, flexuose: zigzag; bent alternately in opposite directions
foliolate (2–, 3–, 4– etc.): with 2–, 3–, 4– leaflets
follicle: a fruit of one carpel, opening by a ventral suture to which the seeds are attached
free: neither adhering nor united
fungicidal: destroys fungi
funnelform: salver-shaped
fusiform: spindle-shaped; tapering at each end from a swollen middle
gamete: a unisexual protoplasmic body, incapable of giving rise to another individual until after conjugation with another gamete
gene: the unit of inheritance located on the chromosome
genus: the smallest natural group containing distinct species
glabrescent: becoming glabrous or nearly so
glabrous: devoid of hairs
glandular: having or bearing secreting organs or glands
glaucous: pale bluish-green, or with a whitish bloom which rubs off
globose: spherical or nearly so
glucosidase: an enzyme that hydrolyses a glucoside
glucosides: compounds that are acetal derivatives of sugars and that on hydrolysis yield glucose
glycosides: compounds that are acetal derivatives of sugars and that on hydrolysis yield one or more molecules of a sugar and often a noncarbohydrate
graft: a union of different individuals by apposition, the rooted plant being termed the stock, the portion inserted the scion
greenwood cutting: a cutting of immature and still soft and pliable tissue
gum: colloidal polysaccharide substances that are gelatinous when moist but harden on drying; gum is exuded by plants or extracted from them
haematuria: the presence of blood or blood cells in the urine
haemoptysis: expectoration of blood from some part of the respiratory tract
haemorrhage: bleeding; an escape of blood from blood vessels
haemorrhoid: a mass of dilated tortuous veins in swollen tissue situated at the anal margin or within the anal canal
haemostatic: an agent that shortens the clotting time of blood
hardwood cutting: a cutting consisting of mature woody tissue
head: a dense inflorescence of small crowded often stalkless flowers (a capitulum)
heartwood: wood from the inner portion of a tree in which the cells are dead and no longer engaged in sap conduction and food storage
hemi: in composition means half
hemiparasite: a facultative parasite; a parasitic plant that contains some chlorophyll and is therefore capable of photosynthesis
hepatotoxic: causing injury to the liver
herb: any vascular plant which is not woody
herbaceous: with the texture, colour and properties of a herb
herbivore: a plant-eating animal

hermaphrodite: bisexual; in flowers, with stamens and pistil in the same flower
heterogeneous: lacking in uniformity; exhibiting variability
heterostylous: having styles of two or more distinct forms or of different lengths
hexagonal: having six angles and six sides
hirsute: with rather coarse stiff hairs
hispid: beset with rough hairs or bristles
histological: relating to the microscopic structure of the tissues of organisms
homogeneous: uniform as to kind; showing no variability
hybrid: the first generation offspring of a cross between two individuals differing in one or more genes
hybridization: the crossing of individuals of unlike genetic constitution
hydrolysis: a chemical reaction of water in which a bond in the reactant other than water is split and hydrogen and hydroxyl are added
hydrophobic: resistant to or avoiding wetting
hydrophilic: having a strong affinity for water
hygroscopic: readily taking up and retaining moisture
hypanthium: the cup-like receptacle usually derived from the fusion of the floral envelopes and androecium on which are seemingly borne the calyx, corolla and stamens
hyperacidity: excessive acidity
hypocotyl: the young stem below the cotyledons
hypocrateriform: salver-shaped
hypogeal: below ground; in hypogeal germination the cotyledons remain below ground within the testa
hypoglycemic: decreasing the amount of sugar in the blood
imbricate: overlapping like tiles; in a flower bud when one sepal or petal is wholly external and one wholly internal and the others overlapping at the edges only
imparipinnate: pinnate with an odd terminal leaflet
indehiscent: not opening when ripe
indeterminate: an inflorescence in which the terminal flowers are the last to open, so that the floral axis may be prolonged indefinitely by a terminal bud; in pulses also used to indicate plants with climbing stems with long-duration flowering
indigenous: native to a particular area or region
indumentum: a covering, as of hairs, scales, etc.
inferior: beneath, lower, below; an inferior ovary is one which is below the sepals, petals and stamens
inflorescence: the arrangement and mode of development of the flowers on the floral axis
inoculation: grafting, more properly budding, a single bud only being inserted
insecticidal: destroying or controlling insects
intercostal: between the ribs or nerves of a leaf
interfloral: between the flowers
interlocked grain: a wood grain in which the fibres incline in one direction in a number of annual rings and in a reverse direction in succeeding rings
internode: the portion of the stem between two nodes
introrse: of anthers whose line of dehiscence faces towards the centre of the flower

involucre: whorls of bracts beneath a flower or flower cluster
isomer: a compound, radical or ion containing the same numbers of atoms of the same elements in the molecule as one or more others, and hence having the same molecular formula, but differing in the structural arrangement of the atoms and consequently in one or more properties
jaundice: yellowness of the skin, lining tissues, and secretions caused by bile pigments in the blood
keel: the two inner united petals of a papilionaceous flower; a ridge like the keel of a boat, e.g. on fruits
kernel: the nucellus of an ovule or of a seed, that is, the whole body within the coats
kino: gum of various trees, resembling catechu, and used in medicine and tanning as astringent
lac insect: a scale insect (*Laccifer lacca*) that produces lac, a resinous substance
lanceolate: lance-shaped; much longer than broad, being widest at the base and tapering to the apex
lateral: on or at the side
latex: a milky, usually white, fluid produced by cells of various seed plants
laticiferous: latex-bearing
laxative: having a tendency to loosen or relax; producing bowel movements and relieving constipation
layer: a branch caused to root whilst still connected to the parent, and used for propagation
leaflet: one part of a compound leaf
lenticel: lenticular corky spots on young bark, corresponding to epidermal stomata
leucorrhoea: a discharge of whitish mucus and pus from the female genitals
leukemia: a disease of unknown cause that involves the blood-forming organs
liana: a woody climbing vine
lignification: the action or process of being converted into wood or woody tissue
limb: the border or expanded part of the corolla, as distinct from the tube or throat; the lamina of a leaf or of a petal
linear: long and narrow with parallel sides
lithotriptic: having the quality of or used for dissolving or destroying stone in the bladder or kidneys
lobed: of leaves: divided, but not into separate leaflets
locule: the cavity of an ovary or anther
log: a section cross-cut from a tree or a branch of a tree. Round log: bark, branches and protuberances removed. Squared log: if a log has been sawn to an approximately rectangular cross-section
lumbago: muscular rheumatism involving the lumbar muscles
lumen, pl. lumina: the space enclosed by the walls of a cell
Malesia: the biogeographical region including Malaysia, Indonesia, the Philippines, Singapore, Brunei and Papua New Guinea
mangrove: a brackish-water coastal swamp of tropical and subtropical areas that is partly inundated by tidal flow
marcotting: layering in which the rooting medium is bound to the plant rather than enclosed in a pot
masticatory: used for chewing

median: belonging to the middle
membranaceous, membranous: thin and semi-transparent, like a fine membrane
merous (4–, 5– etc.): with 4, 5 etc. parts or numbers of sepals, petals etc.
metabolism: the chemical changes in living cells by which energy is provided for the vital processes and activities, and new material is assimilated to repair the waste
metabolite: a substance essential to the metabolism of a particular organism or to a particular metabolic process
midrib: the main vein of a leaf which is a continuation of the petiole
mildew: a superficial, usually whitish growth on living plants produced by fungi
mistletoe: any of numerous hemiparasitic plants of the family Loranthaceae
molluscicidal: destroying molluscs such as snails
monadelphous: of stamens which are united into one group by their filaments
monocotyledon: angiosperm having a single cotyledon or seed-leaf
monoculture: the cultivation during an extended period of time of a single product to the exclusion of other possible uses of the land
monoecious: with unisexual flowers but borne on the same plant
monomer: the simple unpolymerized form of a chemical compound having relatively low molecular weight
mordant: a compound that serves to fix a dye in or on a substance, e.g. a textile fibre; often a salt or hydroxide of chromium, aluminium or tin
mucilage: a gelatinous substance that is similar to gums but that swells in water without dissolving and forms a slimy mass
mucous: secreting or containing a viscous matter
mucronate: ending abruptly in a short stiff point
nasopharynx: the upper part of the alimentary canal continuous with the nasal passages
naturalize: introduced into a new area and established there, giving an effect of wild growth
nausea: an uncomfortable feeling in and about the stomach associated with aversion to food and a need to vomit
nerve: a strand of strengthening or conducting tissue running through a leaf, which starts from the midrib and diverges or branches throughout the blade
neuralgia: an acute paroxysmal pain radiating along the course of one or more nerves
node: the point on the stem or branch at which a leaf or branch is borne
nodule: a small knot or rounded body, often in roots of leguminous plants, where bacteria of the genus *Rhizobium* are active
nucleus, pl. nuclei: an organized proteid body of complex substance in the protoplasm of cells; the central point in a starch granule
nut: properly a one-seeded indehiscent fruit with a hard dry pericarp or shell
ob-: the reverse condition (obtriangular, obcordate, etc.)
oblique: of unequal sides
oblong: longer than broad, with the sides parallel or almost so
obovate: reverse of ovate
obtuse: blunt or rounded at the end
oestrogen: a sex hormone produced especially in the ovaries
oligomer: a chemical compound formed by polymerization and consisting essentially of a limited number of repeating structural units

opposite: of leaves and branches when two are borne at the same node on opposite sides of the stem
orbicular: flat with a more or less circular outline
orthotropic: vertical growth; tendency to elongate vertically
ovary: that part of the pistil, usually the enlarged base, which contains the ovules and eventually becomes the fruit
ovate: egg-shaped; a flat surface which is scarcely twice as long as broad with the widest portion below the middle
ovoid: a solid object which is egg-shaped (ovate) in section
ovule: the immature seeds in the ovary before fertilization
oxidation: the processes of combining a compound with oxygen, dehydrogenating, or increasing the proportion of the electro-negative part
oxytocic: inducing contraction of uterine smooth muscle and hastening childbirth
palmate: lobed or divided like the palm of the hand
panacea: a universal remedy
panicle: an indeterminate branched racemose inflorescence
paniculate: resembling a panicle
papilionaceous flower: butterfly-like, pea-like flower, with standard, wings and keel
papillose: covered with minute nipple-like protuberances
parasitic: deriving nourishment from some other organism
paratracheal: applied to wood-elements arranged about the vessels
parenchyma: tissue composed of more or less isodiametric cells, e.g. the pith and mesophyll
paripinnate: a pinnate leaf without the odd terminal leaflet
patent: spreading out widely
pedicel: stalk of each individual flower of an inflorescence
peduncle: the stalk of an inflorescence or partial inflorescence
peltate: of a leaf with the stalk attached to the under surface, not at the edge
pendulous: drooping; hanging down
penninerved: pinnately veined
pentadelphous: with five bundles of stamens
perennial: living for many years and usually flowering each year
perianth: the floral leaves as a whole, including both sepals and petals if both are present
persistent: remaining attached; not falling off
petal: a member of the inner series of perianth segments which are often brightly coloured
petaloid: petal-like
petiole: the stalk of a leaf
phlobaphene: a reddish-brown complex substance found in oak bark, or a similar substance obtained from bark or from tannins
photo-oxidation: oxidation under the influence of radiant energy such as light
photosensitive: sensitive to the action of radiant energy such as light
phyllode: a petiole taking on the form and functions of a leaf
phylogenetic: based on natural evolutionary relationships
pilose: hairy with rather long soft hairs
pinna, pl. pinnae: a primary division or leaflet of a pinnate leaf

pinnate: a compound leaf with the leaflets arranged along each side of a common rachis
pistil: the female part of a flower (gynoecium) of one or more carpels, consisting, when complete, of ovary (or ovaries), style(s) and stigma(s)
pistillate: a unisexual flower with pistil, but no stamens
pith: the soft core occurring in the structural centre of a log; the tissue, sometimes soft, in the centre of the stem of a non-woody dicotyledon
plagiotropic: having the lateral branches inclined away from the vertical line
plumule: the primary bud of an embryo or germinating seed
pneumatophore: used of air vessels of any description; a root often functioning as a respiratory organ in a marsh plant
pod: a general term for a dry dehiscent fruit
pollarding: cutting back to produce a mop-headed growth
pollen: spores or grains borne by the anthers containing the male element (gametophyte)
pollination: the transfer of pollen from the dehiscing anther to the receptive stigma
polyene: an organic chemical compound containing many double bonds
polygamous: with unisexual and bisexual flowers in the same plant
polyhydric: containing more than one atom of acid hydrogen
polymerize: to combine small molecules chemically into larger molecules
polyol: a compound containing several alcoholic hydroxyl groups
polyphenol: a polyhydroxy phenol
polyvalent: having a valence or oxidation state greater than two, or having variable valence or oxidation state
prickle: a sharp relatively stout outgrowth from the outer layers
propagule: a plant part that becomes detached from the rest of the plant and grows into a new plant
prophyll: the bracteole at the base of an individual flower
prostrate: lying flat on the ground
pruning: cutting off the superfluous branches or shoots of a plant for better shaped or more fruitful growth
puberulous: minutely pubescent
pubescent: covered with soft short hairs
pulses: dry edible seeds of legumes
pulverulent: powdered, as if dusted over
punctiform: in the form of a point or dot
purgative: causing vigorous evacuation of the bowels
quadrangular: four-cornered
raceme: an unbranched elongated indeterminate inflorescence with stalked flowers opening from the base upwards
racemose: raceme-like
rachis: the principal axis or an inflorescence or a compound leaf
radial: radiating, as from a centre
radicle: the first root of an embryo or germinating seed
ramiflorous: flowering on the branches
ratoon: new shoots from perennial crops, such as sugar cane after the first crop, used for the production of the second and subsequent crops (ratoon crops)

rays (in wood): ribbons of parenchymatous tissue which are seen on a cross section of timber as lighter coloured lines radiating from the pith outwards, and extending right up to the bark
receptacle: the flat, concave or convex part of the stem from which the parts of the flower arise
recurved: bent or curved downward or backward
redox: oxidation-reduction
reflexed: abruptly recurved; bent downwards or backwards
reniform: kidney-shaped
resins: solid to soft semisolid amorphous fusible flammable substances obtained as exudates or as extracts of plants
resupinate: upside down or apparently so
reticulate: netted, as when the smallest veins of a leaf are connected together
retrorse: directed backward or downward
retuse: with a shallow notch at a rounded apex
rhizobia: bacteria of the genus *Rhizobium* capable of forming symbiotic nodules on the roots of leguminous plants and able to fix atmospheric nitrogen
rhizome: an underground stem which is distinguished from a root by the presence of nodes, buds, and leaves or scales
rhombic: shaped like a rhomb, an equilateral oblique-angled figure
rhomboid: quadrangular, with the lateral angles obtuse
rudimentary: of organs which are imperfectly developed and nonfunctional
rugose: wrinkled
ruminate: of mottled appearance, as in seeds with infolding of darker perisperm into the paler endosperm
sapraemia: a toxic state in which toxic products of putrefactive bacteria are present in the blood
saprophyte: a plant which derives its food from dead organic matter
sapwood: the outer layers of wood adjacent to the bark which in the living tree contain living cells and reserve materials
scabrid, scabrous: rough to the touch
scalariform: having markings suggestive of a ladder
scale: a thin scarious body, often a degenerate leaf or of epidermal origin
scandent: climbing
scarify: to treat a hard-coated seed by mechanical abrasion or with acid to facilitate germination
sciatica: pain in the lower back, buttocks, hips or adjacent parts of the body
sclerenchymatous tissue: composed of thick-walled cells
season (of timber): to reduce the moisture content of timber either by air-drying (air-season) or kiln-drying (kiln-season). Timber is fully seasoned when the moisture content has dropped to the equilibrium moisture content of the ambient climate
sedative: tending to calm, moderate or tranquilize
seed: the reproductive unit formed from a fertilized ovule, consisting of embryo and seed-coat, and, in some cases, also endosperm
self-compatible: capable of effective self-pollination that results in the production of fruits and seeds
self-pollination: pollination with pollen from the same flower or from other flowers of the same plant

semi: half; incompletely, e.g. semi-inferior
semi-aquatic: a water-plant which roots in the soil, but produces aquatic leaves, otherwise living as land-plants
sepal: a member of the outer series of perianth segments
septate: divided by one or more partitions
sericeous: silky
serrate: toothed like a saw, with regular pointed teeth pointing forwards
serrulate: serrate with minute teeth
sessile: without a stalk
sheath: a tubular structure surrounding an organ or part, as the lower part of the leaf clasping the stem in grasses
shellac: a purified lac resin prepared by heating and filtering lac from lac insects
shrub: a woody plant with branches from the base and not reaching any great size
simple: not compound, as in leaves with a single blade
sinker roots: roots growing straight downward
slash: a long cut or stroke along the stem of a tree to reveal exudates and colours of bark and sapwood
sludge: a muddy or slushy deposit or sediment
soga-batik: fine batik using traditional patterns and commonly vegetable dyes; it is especially employed in central Java (Indonesia)
spathe: a large bract enclosing a spadix, or two or more bracts enclosing a flower cluster
spike: a simple indeterminate inflorescence with sessile flowers along a single axis
spine: a short stiff straight sharp-pointed hard structure
spiral: as though wound round an axis
spur: a hollow and slender extension of some part of the flower, usually nectariferous
stamen: one of the male reproductive organs of a flower; a unit of the androecium
staminate: a flower bearing stamens but no pistil
standard: the upper and outermost petal of a papilionaceous flower
stellate: star-shaped, as of hairs with radiating branches
stem: the main ascending axis of a plant
sterile: failing to complete fertilization and produce seed as a result of defective pollen or ovules; not producing seed capable of germination; lacking functional sexual organs
stick lac: lac in its natural state that encrusts small twigs and the bodies of lac insects
stigma: the portion of the pistil which receives the pollen
stilt root: a prop root (aerial root) of mangrove trees
stipe: the stalk supporting a carpel or gynoecium
stipel: small secondary stipule at the base of a leaflet
stipitate: borne on a stipe or short stalk
stipule: a scale-like or leaf-like appendage at the base of a leaf petiole
stone: the hard endocarp of a drupe
straggling: extremely divergent, spreading very far apart
striate: marked with fine longitudinal parallel lines, as grooves or ridges
strigose: with short stiff hairs lying close along the surface

style: the part of the pistil connecting the ovary with the stigma
styptic: tending to check bleeding
sub: somewhat or slightly, e.g. subacute
subalpine: relating to high upland slopes immediately below the timber line
subshrub: a small shrub which may have partially herbaceous stems
subspecies: a subdivision of a species, in rank between a variety and a species
subulate: awl-shaped
sucker: a shoot of subterranean origin
sudorific: causing or inducing sweat
superior: of an ovary with the perianth inserted below or around its base, the ovary being attached at its base only
suture: the line of junction of two carpels; the line or mark of splitting open
sympetalous: with united petals
sympodial: of a stem in which the growing point either terminates in an inflorescence or dies, growth being continued by a new lateral growing point
syncarp: a multiple or fleshy aggregate fruit
syntan: a synthetic tanning material
tangential: at right angles to the radial rays
tanniferous: yielding or containing tannin
taproot: the primary descending root, forming a direct continuation of the radicle
taxon, pl. taxa: a term applied to any taxonomic unit irrespective of its classification level
tendril: a thread-like climbing organ formed from the whole or part of a stem, leaf or petiole
terete: cylindrical; circular in transverse section
terminal: borne at the end or apex
terrestrial: on or in the ground
testa: the outer coat of the seed
tetrahedral: having or made up of four sides
thorn: a woody sharp-pointed structure formed from a modified branch
titration: a determination of the reactive capacity of a solution
tomentellous: minutely tomentose
tomentose: densely covered with short soft hairs
tonic: medicinal preparation believed to have the power of restoring normal activity
tortuous: bent or twisted in different directions
trapezoid: like a trapezium, a figure of four unequal sides
tree: a perennial woody plant with an evident trunk
trichotomous: three-forked, branching into three divisions
trifoliolate: with three leaflets
trigonous: three-angled, with plane faces
triploid: having three times (*3n*) the basic number of chromosomes
truncate: cut off more or less squarely at the end
trunk: the main stem of a tree apart from its limbs and roots
tuber: the swollen portion of an underground stem or root which acts as a storage organ and propagule; it is usually of one year's duration, those of successive years not arising directly from the old ones nor bearing any constant relation to them

tubercle: a small tuber-like excrescence
tuberculate: covered with warty protuberances
tunic: the coat of a bulb
twining: winding spirally
tylose: a cell intruding into a duct
umbel: an indeterminate, often flat-topped inflorescence whose divergent peduncles (rays) and pedicels arise from a common point; in a compound umbel each ray itself bears an umbel
umbelliform: umbrella-shaped
unarmed: devoid of thorns, spines or prickles
under-shrub: a low shrub, often partially herbaceous
undulate: wavy on the margin in a plane at right angles to the surface
unifoliolate: with one leaflet only
uninucleate: having a single nucleus
unisexual: of one sex, having stamens or pistils only
valve: one of the parts produced by a dehiscing capsule; in grasses the glume next to the flower
variety: botanical variety which is a subdivision of a species; an agricultural or horticultural variety is referred to as a cultivar
vasicentric: with parenchyma round the vessel
vein: a strand of vascular tissue in a flat organ, as a leaf
velvety: with a coating of fine soft hairs
vermifuge: serving to destroy or expel parasitic worms of the intestine
verruculose: very warty, much covered with warts
verticillate: of leaves in a whorl of several arising at the same node
viability: ability to live, grow and develop
villous: shaggy; with long weak hairs
vine: a plant having a stem that is too slender to hold itself erect and that supports itself by climbing over an object
viscid: sticky
viscous: glutinous, or very sticky
viviparous: germinating or sprouting from seed while attached to the parent plant
vulnerary: promoting the healing of wounds
warp: distortion of a piece of sawn timber usually occurring during seasoning
warty: covered with hard and firm excrescences
whorl: more than two organs of the same kind arising at the same level
wing: the lateral petal of a papilionaceous flower
xerophytic: relating to a plant structurally adapted for life and growth with a limited water supply
zygote: a body produced by fertilization or conjugation of two gametes

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The Prosea Programme (Plant Resources of South-East Asia)

Name, location, legal status, and structure

- Prosea is a foundation under Indonesian law, with an international charter, domiciled in Bogor. It is an autonomous, non-profit, international agency, governed by a Board of Trustees. It seeks linkages with existing regional and international organizations;
- Prosea is an international programme focusing on the documentation of information on plant resources of South-East Asia;
- Prosea consists of a Network Office at Bogor (Indonesia) coordinating 5 Country Offices in South-East Asia, and a Publication Office in Wageningen (the Netherlands).

Participating Institutions

- Forest Research Institute of Malaysia (FRIM), Karung Berkunci 201, Jalan FRI Kepong, 52109 Kuala Lumpur, Malaysia;
- Indonesian Institute of Sciences (LIPI), Widya Graha, Jalan Gatot Subroto 10, Jakarta 12180, Indonesia;
- Papua New Guinea University of Technology (UNITECH), Private Mail Bag, Lae, Papua New Guinea;
- Philippine Council for Agriculture, Forestry and Natural Resources Research & Development (PCARRD), Los Baños, Laguna, the Philippines;
- Thailand Institute of Scientific and Technological Research (TISTR), 196 Phahonyothin Road, Bang Khen, Bangkok 10900, Thailand;
- Wageningen Agricultural University (WAU), Costerweg 50, 6701 BH Wageningen, the Netherlands.

Objectives

- to document and make available the existing wealth of information on the plant resources of South-East Asia for education, extension work, research and industry;
- to make operational a computerized data bank on the plant resources of South-East Asia;
- to publish the results in the form of an illustrated, multi-volume handbook in English;
- to promote the dissemination of the information gathered.

Target groups

- those professionally concerned with plant resources in South-East Asia and

working in education, extension work, research and commercial production (direct users);
- those in South-East Asia depending directly on plant resources, obtaining relevant information through extension (indirect users).

Activities

- the establishment and operation of data bases;
- the publication of books;
- the sponsorship, support and organization of training courses;
- research into topics relevant to Prosea's purpose;
- the publication and disseminaton of reports and the research results.

Implementation

The programme period has been tentatively divided into 3 phases:
- preliminary phase (1985–1986): publication of 'Plant Resources of South-East Asia, Proposal for a Handbook' (1986);
- preparatory phase (1987–1990): establishing cooperation with South-East Asia through internationalization, documentation, consultation and publication; reaching agreement on the scientific, organizational and financial structure of Prosea;
- implementation phase (1991–1995): compiling, editing and publishing of the handbook; making operational the computerized data bank with the texts and additional information; promoting the dissemination of the information obtained.

Documentation

A documentation system has been developed for information storage and retrieval called SAPRIS (South-East Asian Plant Resources Information System). It consists of 6 data bases:
- BASELIST: primarily a checklist of more than 6200 plant species;
- CATALOG: references to secondary literature;
- PREPHASE: references to literature from South-East Asia;
- ORGANYM: references to institutions and their research activities;
- PERSONYM: references to specialists;
- TEXTFILE: all PROSEA publications and additional information.

Publication

The following publications have been issued so far:
- *Basic list of species and commodity grouping*, Version 1 (1989);
- *A selection*, dealing with 86 plant resources, being a cross-section of the commodity groups (1989);
- *Pulses (PROSEA 1)*, being the first volume of the handbook (1989); low price edition 1990;
- *Proceedings of the First PROSEA International Symposium* (1989);
- *Bibliography 1: Pulses (Edition 1) (1990).*

– *Dye and tannin-producing plants (PROSEA 3);*

The following publications are to be published in 1991:

– *Edible fruits and nuts (PROSEA 2)*;
– *Basic list of species and commodity grouping*, Final Version.

The following publications are foreseen for the period 1991–1992:

– *Forages (PROSEA 4)*;
– *Timber trees. Major commercial timbers (PROSEA 5(1))*;
– *Rattans (PROSEA 6)*;
– *Bamboos (PROSEA 7)*;
– *Vegetables (PROSEA 8).*

In brief, Prosea is

– an international programme, focused on plant resources of South-East Asia;
– interdisciplinary, covering the fields of agriculture, forestry, horticulture and botany;
– a research programme, making knowledge available for education and extension;
– ecologically focused on promoting plant resources for sustainable tropical land-use systems;
– committed to conservation of biodiversity;
– committed to rural development through diversification of resources and application of farmers' knowledge.

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PROSEA – PLANT RESOURCES OF SOUTH-EAST ASIA

The handbook (blue cover, hardbound)
- No 1. Pulses. L.J.G. van der Maesen and Sadikin Somaatmadja (Editors). Pudoc, Wageningen. 1989.
- No 2. Edible fruits and nuts. E.W.M. Verheij and R.E. Coronel (Editors). Pudoc, Wageningen. 1991.
- No 3. Dye and tannin-producing plants. R.H.M.J. Lemmens and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1991.

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- No 1. Pulses. L.J.G. van der Maesen and Sadikin Somaatmadja (Editors). ESCAP CGPRT Centre, Bogor. 1990. (only for sale in developing countries of South-East Asia and the Pacific)

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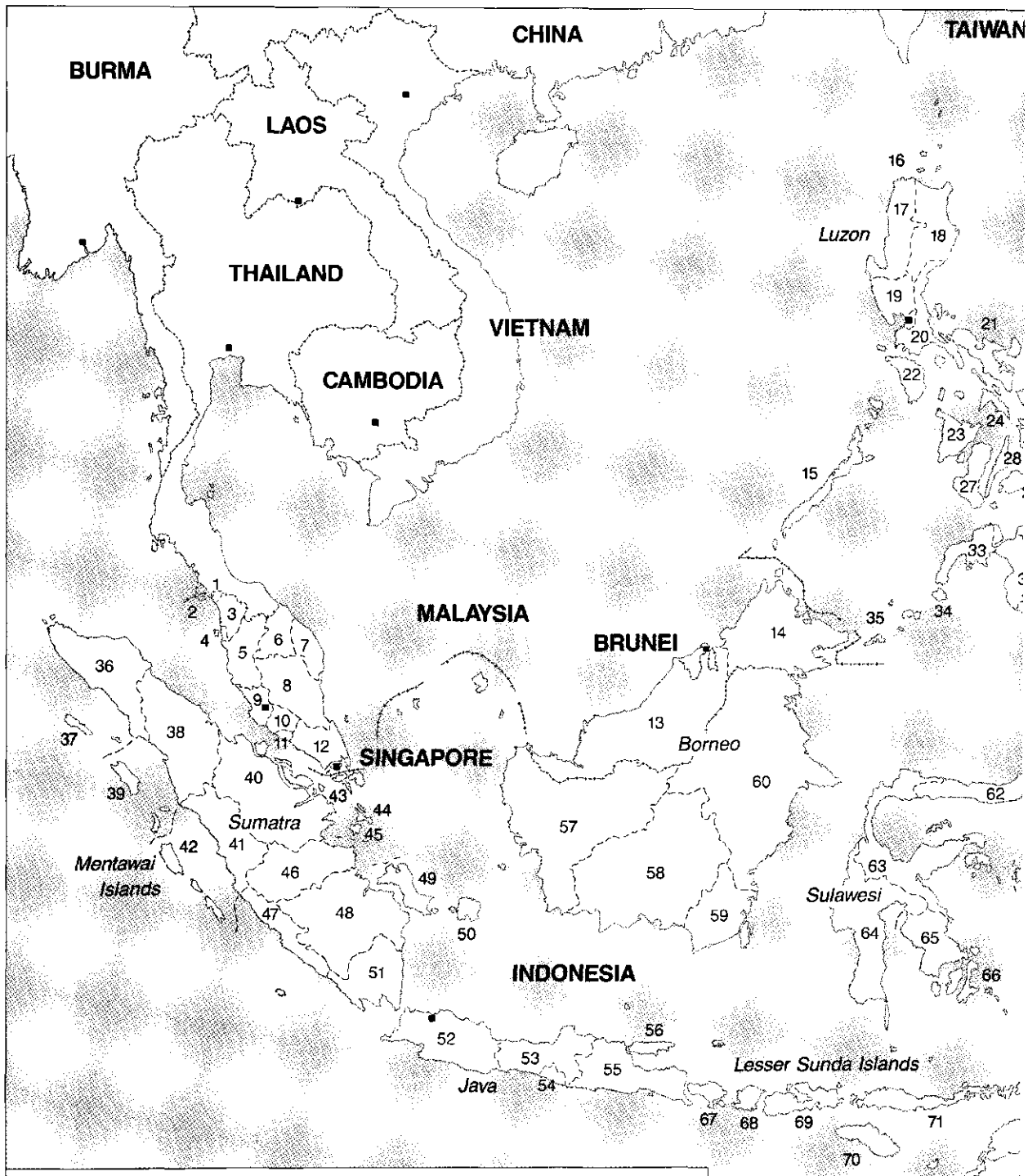
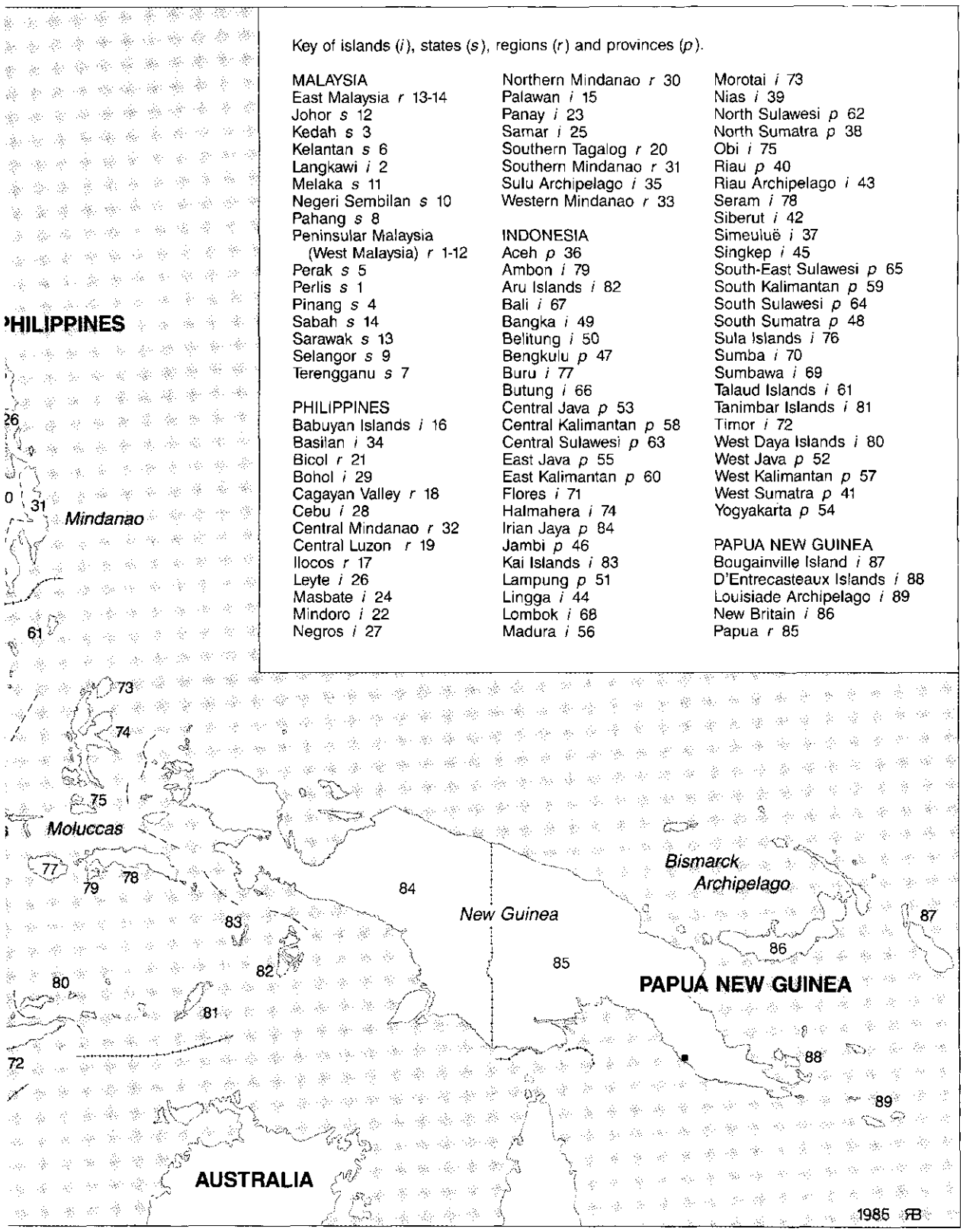


MAP OF SOUTH-EAST ASIA FOR PROSEA

Names of countries in capital letters and islands in lower case; numbers refer to the key.


Key of islands (i), states (s), regions (r) and provinces (p).
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