THAI FOR. BULL. (BOT.) 31: 75–94. 2003.

Non-indigenous Rubiaceae grown in Thailand

CHRISTIAN PUFF* & VORADOL CHAMCHUMROON **

ABSTRACT. A survey of non-indigenous Rubiaceae that are either commercially important or cultivated as ornamentals is given. It covers the genera *Coffea*, *Cinchona*, *Carphalea*, *Gardenia*, *Hamelia*, *Mussaenda* and *Pseudomussaenda*, *Pentas*, *Psilanthus*, *Rondeletia* and *Serissa*.

INTRODUCTION

The Rubiaceae are an essentially tropical family, fairly evenly distributed in the Old and New World. Various Rubiaceae which originate from other parts of Asia, from Africa, Madagascar, or from Central and South America are cultivated in Thailand. These non-indigenous Rubiaceae found in Thailand fall in two categories: (a) commercially important plants, and (b) ornamentals.

The present paper presents a survey of these taxa and provides brief descriptions for them. It explicitly excludes Ixoras, probably the most commonly grown rubiaceous ornamentals, as the genus, including ornamentals, is currently being studied by one of us (VC). Also excluded are taxa native to Thailand that are cultivated; only non-indigenous species are dealt with.

COMMERCIALLY IMPORTANT PLANTS

Coffea L.

The genus *Coffea* does not occur naturally in Thailand or the rest of Asia. Only planted coffees, namely *C. arabica* and *C. canephora* (and possibly *C. liberica*; see below), are found in the country. All other taxa listed under *Coffea* in older literature on the Thai flora (e.g. Craib, 1934: 171–174) are referable to other genera, primarily *Psilanthus* (see Chamchumroon & Puff, 2003).

Coffea arabica L. (ARABICA Coffee). Fig. 2A–D.

Shrubs or small trees to ca. 4 m tall. *Leaves* opposite, with petioles to 10 mm long, elliptic to ovate-lanceolate, 6–15(–18) by 3–8 cm, acuminate at apex, narrowed to base, with 7–10 pairs of lateral veins, glabrous, glossy above. *Flowers* in axillary clusters of few to ca. 20; calyx ring-like, minute, often with very small indistinct teeth; corolla (4–)

*Institute of Botany, University of Vienna, Rennweg 14, A-1030 Vienna, Austria.
**The Forest Herbarium, National Park, Wildlife and Plant Conservation Department, Chatuchak, Bangkok 10900, Thailand.

5(–6)-merous, tube 7–11 mm long, lobes 8–18 by 3–6 mm; anthers to 10 mm long, exserted; style with bifid stigma slightly exserted; ovary 2-locular, each locule with a solitary ovule. *Fruits* drupaceous, red, oblong-ellipsoid to ± globose, greatest length ca. 10–20 mm when fresh. *Seeds* 2, ca. 9–16 mm long, enclosed in a thin endocarp.

The natural distributional range of the species is confined to Southwest Ethiopia and to a few localities in neighbouring south-eastern Sudan and northern Kenya (cf. map, Fig. 1). It grows in evergreen forest in Ethiopia at altitudes ranging from 1500–1900 m (Puff, 2003).

Coffea canephora Pierre ex Fröhner.— *C. robusta* Linden. (ROBUSTA coffee). Fig. 2E–F.

Shrubs or small trees ca. 2-4 m tall. *Leaves* with petioles to 20 mm long, oblong-elliptic to broadly elliptic, 12–35(–40) by 5–11 cm, acuminate at apex, obtuse to cuneate at base, with (8–)11–15(–17) pairs of lateral veins, glabrous, glossy above. *Flowers* in axillary clusters of ca. 10–30(–50); calyx ring-like, minute; corolla 5–6(–7)-merous, tube ca. 5–15 mm long, lobes ca. 10–20 by 2–5 mm; anthers to 10 mm long, exserted; style with bifid stigma slightly exserted; ovary 2-locular, each locule with a solitary ovule. *Fruits* drupaceous, red, oblong-ellipsoid, greatest length ca. 9–12 mm when fresh. *Seeds* 2, ca. 7–11 mm long, enclosed in a thin endocarp.

The species occurs naturally from Sudan, Uganda and Northwest Tanzania westward to Sierra Leone, and southwestwards to Angola. It is a component of the African lowland rain forest (cf. Fig. 1, which, however, only shows the core range of the species).

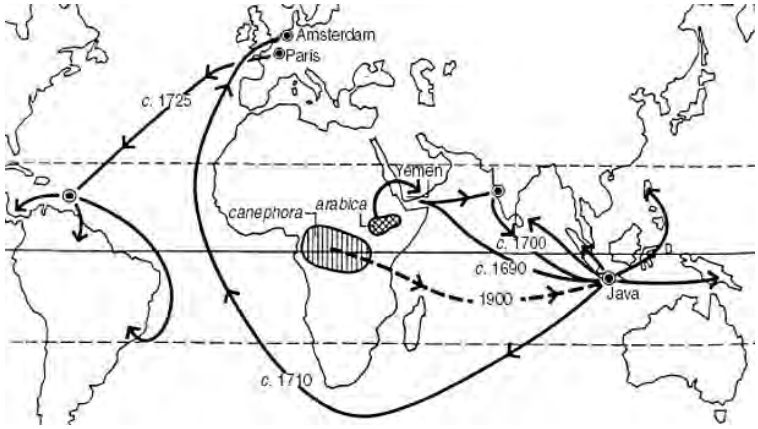

Figure 1. Distribution routes for the cultivated coffee crop in the tropics; the solid lines refer to *Coffea arabica* (ARABICA coffee), the broken lines to *C. canephora* (ROBUSTA coffee); numbers are the approximate years of introduction (Ferwerda 1976). The natural distribution range of *C. canephora* (vertically hatched) is shown incompletely; its stretches further westward as far as Sierra Leone, and southwestward to Angola.

Table 1. Differences between *Coffea arabica* and *C. canephora* compiled from various sources. See text for further comments.

Character	***Coffea arabica***	***Coffea canephora*** (syn. *C. robusta*)
Leaf length (mm)	60–150(–180)	120–350(–400)
Leaf width (mm)	30–80	50–110
Pairs of lateral veins	7–10	(8–)11–15(–17)
Flowers per axillary inflorescence	(2–)6–20	(8–)12–30(–50)
Flowers: corolla lobes	(4–)5(–6)	5–6(–7)
Fruit size (greatest length; mm)	10–20	9–12
Fruits at maturity	falling off	remaining on plant
Seed (“coffee bean”) length (mm)	9–16	7–11
Breeding	autogamous	allogamous
Chromosomes (2n)	44	22
Flowering time	after rainy season	irregular
Flower → mature fruit	9 months	10–11 months
"coffee beans": caffeine content	ca. 0.5–1.5%	ca. 2–4%
"coffee beans": yield (in tons per hectare)	1.5–3	2.3–4
Root system	deep	shallow
Optimal temperature (annual average)	15–24 °C	18–30 °C
Optimal annual rainfall	1500–2000 mm	2000–3000 mm
Altitudinal range	Typically 1000 to 2500 m ("mountain coffee") [800–1500 m in Thailand]	Sea level to ca. 1000 m ("lowland coffee") [usually below 1000 m in Thailand]
Diseases: coffee rust (*Hemileia vastatrix*)	susceptible	resistant
Diseases: “coffee bean disease“ (beetle)	susceptible	resistant
Diseases: nematodes	susceptible	resistant
Diseases: “spider web disease“	susceptible	+/- resistant
Diseases: tracheomycosis (*Giberella xylarioides*)	resistant	susceptible
Major production areas	primarily America	especially Old World
World production	"ca. 74%" "80–90%"	"ca. 25%" "ca. 10%"

Morphological as well as other diagnostic characters between the two species are summarized in Table 1. It should be noted that, due to the large numbers of cultivars in each of the two species, and due to the continuous development of new strains, individual data may not always fully hold. Data on world production (Table 1, last row) vary greatly from source to source. In recent years, ROBUSTA coffee production in Asia has drastically increased, so that it is likely to the world production ratio is shifting in favour of ROBUSTA (see also below). The remaining few percent of world coffee production is contributed by LIBERICA and EXCELSA coffee (*C. liberica*), and some other species such as *C. stenophylla* (West African Highland coffee or "Highland coffee of Sierra Leone") and others.

ARABICA coffee beans are generally considered to be of higher quality than ROBUSTA beans and always fetch higher prices. Coffee made from pure ARABICA beans is usually considered very palatable, while coffee made from pure ROBUSTA beans is not well liked because it is bitter. Moreover, the beans of ARABICA, being larger and more "perfectly" shaped than those of ROBUSTA, are more pleasing to the customer's eye. Consequently, "pure" roasted ARABICA beans sell better - and at a higher price.

Both in ARABICA and in ROBUSTA, there are many slight variations in flavour. The reasons for these differences are many-fold: different strains produce different flavours; growth of the same strain under different soil and climatic conditions also results in variation in flavour; roasting techniques (primarily the length of roasting and temperature) influences the taste.

Many of the coffees (either roasted, packed beans or ground roasted beans) are blends of ARABICA of different origin, or blends of ARABICA and ROBUSTA. A general guidline is that the cheaper the coffee blend the more of the less expensive ROBUSTA will be in it. Instant coffees are primarily made from the lower-priced ROBUSTA beans.

A note on coffee fruits and "coffee beans", using *Coffea arabica* as an example (Fig. 2D)

The fruits are drupes with a skin-like exocarp and a fleshy mesocarp and typically contain two 1-seeded pyrenes (Fig. 2Da) (in some cultivars, one of the two seed-containing pyrenes is always aborted, and the remaining pyrene, containing the only well-developed seed, becomes ± globose; for this reason, such coffees are called "Pearl Coffee"). The two pyrenes are flat on their ventral surface, where they face each other (see Fig. 2Da). Compared to other Rubiaceae with drupaceous fruits, *Coffea* is somewhat unusual in having very thin, horn-like endocarps (rather than the more common, thick endocarps made up of numerous layers of sclerenchymatic tissue).

In coffee processing plants, the seed-containing pyrenes (cf. Fig. 2Db) are first removed from the fruits in various ways. Then the endocarps, being thin, are easily cracked open mechanically, and the empty endocarp cases and seeds (Fig. 2Dc) are separated.

The seeds ("coffee beans" in commercial terms) show a characteristic, slightly curved fold on the ventral side which extends to the inside (compare seed section and

ventral view, Fig. 2Da and Dc), which is an unusual feature within the family. Well over 95% (by volume) of the seed is occupied by endosperm; the minute embryo (Fig. 2De) is located in the lower part of the seed, in an oblique position (Fig. 2Dd). Yet another unusual feature of a coffee seed is the structure of the exotesta (seed coat). Whereas, in the majority of Rubiaceae, the exotesta is a continuous layer of cells covering the entire seed, the seed coat of *Coffea* is discontinuous: during growth of a coffee seed the seed coat cannot "keep up" with the resultant increase in size and diameter and eventually breaks up into isolated "islands" of exotesta cell groups on the surface of the endosperm. Coffee-growers call this "silver-skin" (visible on the surface of the seeds in Fig. 2Dc–d).

This silver-skin can be easily washed off, and the green "coffee beans" commercially sold are primarily endosperm (remnants of the seed coat are normally only left in the ventral fold of a "coffee bean").

For anatomical information of both *C. arabica* and *C. canephora* seeds see Dentan (1985).

History and economic importance for Thailand

Figure 1 shows the distribution routes for cultivated ARABICA and ROBUSTA coffee (*C. arabica* and *C. canephora*). Interesting and important from an Asiatic point of view is the introduction of ROBUSTA coffee to Java in 1900. This was the starting point which has led to the current lead in ROBUSTA production in Asian countries (whereas ARABICA, although introduced to Asia earlier than to the Americas, lags behind in terms of production; primary ARABICA producers are Brazil and Colombia).

Larger scale coffee production in Thailand only started in the 1960s. However, since then, there have been dramatic increases. By 1976, Thailand officially became a coffee exporting nation. By the late 1990s, the country was ranked seventh in world coffee production (i.e. production of ARABICA, ROBUSTA, and other minor coffees put together). Amongst the Southeast Asiatic ROBUSTA coffee producers, Thailand ranks third (behind Vietnam and Indonesia). At present, Thailand produces ca. 80,000 tons of ROBUSTA coffee per year, of which about 60% (ca. 50,000 tons) is exported, whereas the rest is processed locally (see below).

ROBUSTA coffee is grown in large-scale plantations primarily in peninsular Thailand, from Chumphon southwards (Ranong, Surat Thani, Phang-Nga, Krabi and Nakhon Si Thammarat). ROBUSTA is easier to cultivate, more disease-resistant, can tolerate wider temperature and moisture extremes, produces more beans and the fruits mature more quickly than ARABICA. Although ROBUSTA beans are generally considered to be of lesser quality than ARABICA beans, Thai ROBUSTA has the reputation of being of good quality and is exported primarily to the U.S.A., Europe, Japan and Singapore. Locally used and processed ROBUSTA is mainly used for canned coffee drinks as well as instant coffee (which, too, is partly exported).

In contrast, ARABICA coffee, is primarily grown on a small scale, often by hill tribe families and villages, in Thailand's northern provinces (Chiang Mai, Chiang Rai, Lampang, Mae Hong Son, Tak). Only a few hundred tons of beans are produced annually, almost all of which are processed and consumed locally. ARABICA growing in the North started in the 1970s, as part of the opium crop replacement campaign, and

was supported by the Royal Development Projects, the United Nations and many other governmental and non-governmental organisations.

ARABICA growing in Thailand is still somewhat experimental but it is to be excepted that, due to increasing local demands, this might change quickly. Many coffee shop chains have opened in recent years, and nowadays numerous service stations and shopping centres have highly popular coffee outlets. Most of these serve ARABICAS of local production.

The Boncafé Website (self-termed "The Thai Coffee Website", http://www.boncafe.co.th/thai-coffee/thai-coffee.htm, and links) gives excellent information in a Thai context and is recommended for further reading. The website of the International Coffee Organization (ICO) (http://www.ico.org/) provides extensive general information on various aspects, ranging from botanical data, plant breeding and ecology to coffee prices, trade statistics and economic-political trends concerning coffee. Generalized statistical data are also available from the website of the Food and Agriculture Organization of the UN (FAO) (htto://www.apps.fao.org). Recommended standard references on cultivated coffee are Clarke & Macrae (1985–1988), Clifford & Willson (1985) and Wrigley (1988).

Is *Coffea liberica* Hiern in Thailand?

Craib (1934: 172) mentioned two Kerr collections of cultivated plants of this species, one from Chanthaburi province, the other from Nakhon Si Thammarat, and commented that the species is "frequent in cultivation".

As these specimens could not be traced, it remains uncertain whether their identity is correct. The situation is rather complex: Hiern's original description of *C. liberica* contained elements of two species, namely *C. liberica* [sensu stricto] and *C. canephora* (see Bridson & Vercourt, 1988: 706, 711). It is, therefore, possible that the specimens referred to by Craib are *C. canephora*. Craib's comment that it is frequently cultivated would support this proposition.

Coffea liberica Hiern.— *C. excelsa* A. Chev. (LIBERICA Coffee, EXCELSA Coffee).

This species occurs naturally in West Africa, having a range that more or less corresponds to that of *C. canephora*. It is fairly widely cultivated in tropical Africa, although not in large-scale plantations. The species is also grown elsewhere in the tropics, but is of minor importance (less than 5% of the world coffee production). Beans yield a very bitter coffee of low quality (coffee from EXCELSA strains is said to be somewhat less bitter than coffee from LIBERICA strains). It is the most "robust" *Coffea* species: plants can become trees to 20 m tall (with trunks 30 cm in diam.); leaves can be to 55 cm long and over 20 cm wide; flowers and fruits, too, are larger than in the other species.

Cinchona calisaya Wedd.— *C. ledgeriana* (Howard) Trimen. Fig. 2G.

Trees to ca. 5 m tall. *Leaves* oblong to ovate, ca. 8–15 by 2–8 cm, rounded at apex, cuneate at base, with 7–9 pairs of lateral veins. *Inflorescences* terminal, many-flowered.

Flowers heterodistylous, 5-merous; calyx with small teeth; corolla white to pinkish, tube ca. 8–12 mm long, lobes to ca 5 mm long, conspicuously villous along the margins; tips of stamens exserted in short-styled flowers (cf. Fig. 2G), included in long-styled flowers; styles and stigmas included. *Fruits* capsular, with septicidal dehiscence, to ca. 2 cm long, ellipsoidal. *Seeds* flattened, to ca. 7 by 2 mm, with strongly dentate to more or less fimbriate wing.

A neotropical species spontaneously occurring on the eastern slopes of the Andes from central Peru to central Bolivia (Andersson, 1998: map, Fig. 14D).

Cinchona trees have been grown throughout the tropics for the extraction of quinine. Northern and southwestern India and Java are major areas of production.

Within the genus (ca. 23 species confined to north-western South America) only strains from two species are of any commercial importance, i.e. *C. calisaya* (often grown as *C. ledgeriana*), and *C. pubescens* (often grown under the name *C. succirubra*). Bark from *C. calisava* was commercially known as yellow, that of *C. pubescens* as brown or (the *succirubra* strain) red (Andersson, 1998). These two species contain the highest amount of quinine alkaloids within the genus. Another species often cited as being of commercial importance, *C. officinalis*, has been redelimited by the revisor of the genus (Andersson, 1998) to a form that has no medicinal value at all.

The name *Cinchona* came from the Countess of Chinchón, the wife of the fourth Count of Chinchón and Viceroy of Peru, who, in 1638, was cured of a malarial type of fever by using a decoction made from the bark of *Cinchona*. After her return to Spain, she introduced the drug to European medicine. In 1820 two scientists, Pelletier and Caventou, isolated an alkaloid chemical in the bark which provided the highest antimalarial effect and named it *quinine*. In the middle of the 19th century, seeds of *Cinchona* were smuggled out of South America by the British and the Dutch and planted and cultivated in Java by the Dutch and in India and Sri Lanka by the British. They quickly dominated the world production of quinine, whereas Bolivia and Peru, where the trees originated from, played no commercial role as quinine producers.

The occupation of Java by the Japanese in 1942, during World War II, resulted in major shortages of natural quinine. For this reason, research to develop a synthetic quinine alkaloid was intensified, and by 1944 the goal was successfully achieved. After World War II, synthetic products largely replaced natural quinine, and the importance of *Cinchona* as a commercial crop dropped dramatically, but this may change. Because of increasing problems with malaria strains which have developed a resistance to synthesised quinine drugs, natural quinine extracted from quinine bark and the use of natural bark tea and/or bark extracts are making a comeback in the management and treatment of malaria. New strains of drug-resistant malaria can be treated effectively with natural quinine and/or quinine bark extracts (Taylor, 2002).

Some production of *Cinchona* bark is also supported by the soft-drink industry. Quinine is very bitter tasting and commercially sold tonic waters often use quinine as its bitter ingredient/component. Commercially produced tonic water usually contains around 100 to 300 ppm quinine and up to a maximum allowable concentration of 70 mg/l^{-1}(Taylor, l.c.).

In Thailand, *Cinchona* was probably never planted on a large scale. A well known locality for planted *Cinchona calisaya* (as *C. ledgeriana*) is the medicinal garden (Forestry Experimental Station) on Doi Suthep (Chiang Mai province). There are also some isolated trees near the Doi Inthanon National Park guesthouse.

ORNAMENTALS

Taxa are presented here in alphabetic sequence. The brief descriptions are primarily based on cultivated material. Descriptions may therefore deviate from those given for the taxa in their natural state (e.g. growth form, leaf sizes and shapes, or flower colour may differ in cultivars).

Carphalea kirondron Baillon. Fig. 3A–B.

Shrubs to 3 m tall (much taller and becoming tree-like if allowed to grow). *Leaves* mostly opposite but occasionally in whorls of 3, with petioles to 2 cm long, lanceolate to ovate-lanceolate, ca. 4–10 by 2–5 cm, acute at apex, narrowed to base, glabrous to variously hairy. *Inflorescences* terminal, very many-flowered, corymb-like, to 20 cm in diam. *Flowers* mostly 4-merous, heterodistylous; calyx lobes enlarged, unequal (1 more enlarged than the others and to ca. 2 cm long), bright red; corolla tube narrowly filiform, reddish, ca. 1.5–2.5 cm long, lobes (creamy-) white, to 5 mm long; filaments and anthers exserted and styles and stigmas included in short-styled forms, upper part of style and 2 filiform stigmas exserted in long-styled form. *Fruits* indehiscent, nut-like, obconic, to ca. 5 mm long, crowned by the enlarged calyx lobes; typically 1 fertile seed in each of the two locules, but not infrequently one or both seeds are aborted.

A species native and endemic to Madagascar (Puff, 1988: map, Fig. 14B).

The entire genus is characterised by the presence of coloured, enlarged calyces. It is a member of the tribe Hedyotideae, along with *Pentas* (see below).

The species is infrequently seen in Thailand (several localities in Chiang Mai and Kanchanaburi provinces). Outside Thailand, it has been observed by one of us (C.P.) in the Philippines and in Malaysia (in recent years, plants have been regularly seen on sale in Kuala Lumpur markets). The plant may not be easy to propagate. Seed germination rates at the Singapore Botanic Gardens was extremely low (only ca. 2%; Ng Siew Yin, 1981). Propagation by cuttings also appears to be difficult (also cf. Puff, 1988: 304).

Gardenia Ellis. Fig. 3K.

Several species, including both native and non-indigenous ones, are cultivated in Thailand. The most commonly seen cultivated native species is probably *G. carinata* (not treated here).

G. augusta (L.) Merr.— *G. jasminoides* Ellis, a name often used in horticultural literature.— *G. florida* L.

Shrubs ca. 1–2 m tall. *Leaves* opposite or occasionally in whorls of 3, shortly petiolate, elliptic-obovate or oblong-lanceolate, ca. 5–12 by 2.5–5 cm, acute to acuminate at apex, narrowed to base, ± coriaceous, glabrous, glossy; stipules sheath-like above insertion of petioles. *Flowers* solitary and terminal on abbreviated lateral shoots (thus seemingly axillary), fragrant, very often double; calyx made up of 6 linear (-lanceolate) lobes, ca. 2–3 cm long; corolla white (turning creamy-yellow with age), tube and lobes to ca. 5 cm long; double flowers: the outer (true) corolla lobes 6(–9), elliptic-ovate, the inner more numerous, smaller; stamens poorly developed or petaloid; ovary often sterile in double flowers. *Fruits* or sterile "pseudo-fruits" longitudinally ribbed, these and the persistent calyx often turning bright orange-reddish.

A species native to south-eastern China, Taiwan, Japan and nearby regions of the subtropical eastern hemisphere.

Several species, including both native and non-indigenous ones, are cultivated in Thailand. The most commonly cultivated *native* species is probably *G. carinata* (not treated here). The most prominent non-indigenous ornamental is *G. augusta* (L.) Merr. (syn. *G. jasminoides* Ellis, a name often used in horticultural literature; syn. *G. florida* L.).

The species is widely planted in all parts of Thailand. Cultivated plants are mostly of the "normal" shrubby type. Prostrate forms (cv. 'Prostrata'), used elsewhere in the tropics as ground cover in protected, partly shady areas, do not seem to be grown in Thailand. Also forms with variegated leaves (cv. 'Variegata') appear to be absent.

Hamelia patens Jacq. (syn. *H. erecta* Jacq., *H. coccinea* Swartz). Fig. 3F–G.

Shrubs or, if allowed to grow, small trees to 7 m. *Leaves* opposite or in whorls of 3 or 4, petiolate, ovate-elliptic, ca. 6–12 by 3–8 cm, (sub)acuminate at apex, narrowed to the base, membranous, glabrous to villous. *Inflorescences* terminal, many-flowered, with distinct double-helicoid cymes as partial inflorescences; inflorescence axes red. *Flowers* 5-merous; corollas rather thick and robust, yellow to yellow-orange or orange-red, tube ca. 1.5–2 cm long, lobes erect, very small; anther, styles and stigmas mostly included; ovary red, 5-locular. *Fruits* berry-like, ± globose, to ca. 1 cm in diam., yellow to red at first, dark blue-black when fully mature. *Seeds* minute, numerous.

A widespread tropical American species, naturally occurring from tropical Florida and Mexico southwards through Central America, the West Indies, and South America to Chile and Argentina (Elias, 1976: map, Fig. 5).

In its natural distribution range, the species is known to be rather aggressive, quickly occupying newly disturbed sites (Elias 1976). Seeds (both in its natural range and elsewhere) are dispersed by birds and germinate readily. The species apparently also reproduces vegetatively by sending out runners and rhizomatous branches (Elias, l.c.).

Flowers are typical bird flowers, being pollinated by hummingbirds in the New World; sun birds (and also butterflies) were observed as pollinators in Thailand. As is typical for ornithophilous flowers, they lack any scent. This fast-growing species is widely planted in all parts of Thailand. It is often grown as a living fence or hedge and soon flowers again after pruning. It is often also grown as a solitary bush and can be trimmed into various shapes without negative effects. Individuals left untouched for several years become tree-like but are less attractive in such a state.

Mussaenda L. and **Pseudomussaenda** Wernham

Mussaenda, *Pseudomussaenda* and *Schizomussaenda* are three genera characterised by enlarged, coloured ("petaloid") calyx lobes. The taxonomic position and relationship of the tropical African *Pseudomussaenda* has been much disputed, and several authors (e.g. Bakhuizen van den Brink & Koster, 1963, Baker & Bakhuizen van den Brink, 1965) suggested it should be merged with *Mussaenda*. Jayaweera (1963) suggested that *Pseudomussaenda* and *Schizomussaenda* are not sufficiently different to warrant the segregation as two genera. Based on a detailed investigation of the character states of the three genera, Puff et al. (1993), came to the conclusion that the three genera should be upheld. This was subsequently confirmed by DNA studies (Bremer & Thulin, 1998).

In the present context, *Schizomussaenda* (*S. dehiscens*; monotypic), a tree-like plant occurring in northern Thailand, is not treated herein as it is not used as an ornamental. Indigenous species of *Mussaenda* are well represented in the Thai flora, but not all taxa grown as ornamentals are native.

The most obvious character distinguishing *Mussaenda* from *Pseudomussaenda* is the fruit: it is indehiscent and berry-like in the former and a dehiscent capsule in the latter.

Mussaenda erythrophylla Schumach. & Thonn. Fig. 3I.

Shrubs to 3 m (scandent and climbing, with stems to 8 m if allowed to grow; usually not seen in cultivation). *Leaves* with petioles to 4 cm long, elliptic to broadly ovate, ca. 7–12 by 5–8 cm, acute to acuminate at apex, rounded, subcordate to cuneate at base, hairy; stipules bifid. *Inflorescences* terminal, many-flowered, inflorescence axes densely covered with red hairs. *Flowers* 5-merous, heterodistylous; calyx lobes of most flowers small, ca. 1–1.5 mm long, lanceolate, with red hairs, but 2–6 flowers per inflorescence with a single calyx lobe enlarged, foliaceous and coloured bright red (elliptic to round, to ca. 10 by 8 cm); corolla tube with red hairs outside, to ca. 3 mm long, lobes white to creamy-yellow, round, to ca. 1 cm long, a ring of dark red hairs surrounding the throat; anthers and style and stigmas included in the corolla tube both in long- and short-styled forms. *Fruits* berry-like, ellipsoid, to ca. 2 cm long, with numerous minute seeds.

A species native to Western tropical Africa.

The species is occasionally seen in gardens and parks, but is not as commonly planted as the *M. philippica* cultivars described below. It appears to be cultivated much more frequently in the peninsula than elsewhere in Thailand.

Mussaenda philippica L.C. Rich. '**Doña**' and '**Queen Sirikit**'. Fig. 3H.

Shrubs, sometimes rather tree-like, to ca. 3 m tall. *Leaves* with petioles to ca 3 cm long, variable, ovate to lanceolate, ca. 5–15 by 3–7 cm, shortly acuminate at apex, rounded to cuneate at base, glabrous to hairy; stipules bifid. *Inflorescences* terminal, many-flowered. *Flowers* 5-merous, often completely sterile; all calyx lobes of all flowers of an inflorescence enlarged, foliaceous and white or in various shades of pink, lanceolate to rounded, ca. 6–10 by 4–8 cm; corolla tube and lobes to ca. 1 cm long, corolla yellow, yellow-orange to orange, with a darker orange "eye". *Fruit* not developed.

"Normal" *M. philippica* shows the typical *Mussaenda* characteristics, i.e. it has only relatively few enlarged white calyx lobes per inflorescence. Usually, only one to four flowers of a partial inflorescence have one enlarged, coloured calyx lobe each, whereas the remaining calyx lobes remain small and inconspicuous. It is not grown as an ornamental.

The origin of cvs. 'Doña' and **'**Queen Sirikit' is partly documented in a University of the Philippines Newsletter published for the 1998 opening of a *Mussaenda* cultivar garden (http://www.up.edu.ph/newsletter/1998/01/donas.html).

An unusual mutation of *M. philippica* was discovered in the 1930s on Mt Maquilin, in the vicinity of the Los Baños Campus of the University of the Philippines (Luzon). It differed from the "normal" *M. philippica* in having all five calyx lobes of all flowers of an inflorescence enlarged and coloured pure white. The aberrant form was eventually formally described as *M. philippica* var. *aurorae* Sulit. This sport was taken into cultivation by horticulturists at Los Baños and reproduced vegetatively. It became known as *M. philippica* 'Doña Aurora', named after the wife of former President Manuel L. Quezon. This set the precedent for naming subsequently developed cultivars after First Ladies ('Doñas').

Pink 'Doñas' (cultivars with all enlarged calyx lobes in various shades of pink): all of these originated by basically crossing cv. 'Doña Aurora' (white enlarged calyx lobes) with *M. erythrophylla* (bright red enlarged calyx lobes; see above): white + red = pink. Further backcrossing of F1 hybrids with other cultivars resulted in slight colour variations, e.g. cv. 'Doña Luz' (mottled pink with whitish veins), cv. 'Doña Hilaria' (pure pink), cv. 'Doña Evangelina' (dark pinkish-red), and many others. *Mussaenda philippica* 'Queen Sirikit' also belongs to the group of 'pinks'. It was named after the Queen of Thailand during her visit to the Los Baños campus of the University of the Philippines in 1963. According to the Plant Science Department at the University of Connecticut (http://florawww.eeb.uconn.edu/acc_num/199300381.html), cv. 'Queen Sirikit' resulted from the backcross of the F1 hybrid, *M. erythrophylla* x *M. philippica* 'Doña Aurora', to *M. philippica* 'Doña Aurora'.

Both white and pink *M. philippica* cultivars are widely grown in Thailand as ornamentals, not infrequently both are planted side by side (Fig. 3H). They appear to require continuously high humidity and undoubtedly are most commonly seen in the Peninsula, but are also frequent in Bangkok and can be observed as far north as Chiang Mai province, where they are grown in the low-lying areas.

Whilst the white-calyx cultivars invariably are cv. 'Doña Aurora', it is not certain whether the pink-calyx cultivars seen in Thailand are always cv. 'Queen Sirikit'. Cultivars in various shades of pink occur which, except for the colour tone of the enlarged calyces, are indistinguishable. It is likely that many of the pink cultivars are rather cv. 'Doña Luz' (a much older cultivar than cv. 'Queen Sirikit') which has been grown in many parts of Southeast Asia for a long time.

Pseudomussaenda flava Verdc.— *Mussaenda luteola* Delile.— *Mussaenda flava* (Verdc.) Bakh. f. Fig. 3J.

Shrubs to ca. 3 m tall. *Leaves* opposite, shortly petiolate, elliptic to oblong-elliptic, ca. 4–8 by 2–4 cm, acute to acuminate at apex, narrowed to the base, softly pubescent; stipules with 2 filiform fimbriae. *Inflorescences* terminal, several-flowered. *Flowers* 5-merous, heterodistylous; calyx lobes of most flowers small, ca. 2–5 mm long, filiform, hairy, but 1–2 flowers per inflorescence with a single calyx lobe enlarged, foliaceous and coloured white to creamy-yellow (oblong, ovate or elliptic, ca. 2–5 by 1.5–4 cm); corolla tube 2–3 cm long, greenish, lobes ca. 5–8 mm long, ovate, yellow, throat often with a ring of orange-yellow hairs; anthers and style and stigmas included in the corolla tube both in long- and short-styles forms. *Fruits* dry, capsular, oblong, to ca. 5 mm long, loculicidally splitting into two valves.

The species seems to be cultivated primarily in peninsular Thailand. It usually is planted in groups and is sometimes seen as a living fence.

Pentas lanceolata (Forssk.) Defl. Fig. 3C.

Perennial herbs, sometimes a little woody at base, to ca. 0.5 m tall, or, in some cultivars, low and cushion-like. *Leaves* with petioles to ca. 1 cm long, ovate to lanceolate, 4–6 by 2.5–3 cm, acute to acuminate at apex, narrowed to the base, thinnish, pubescent to puberulous. *Inflorescences* terminal, many-flowered, of umbel-like appearance. *Flowers* 5-merous, mostly heterodistylous; corolla, depending on cultivar, white, in shades of pink, reddish-purplish or lilac or mauve, sometimes 2-toned (dark pink with white stripes, etc.), tube narrowly cylindrical, to ca. 2 cm long, lobes ovate to elliptic, ca. 0.5–1 cm long; filaments and anthers exserted and styles and stigmas included in short-styled forms, upper part of style and 2 filiform stigmas exserted in long-styled form. *Fruits* capsular, dehiscing into 2 valves, to ca. 5 mm long; seeds numerous, minute.

A variable species, divided into several infraspecific taxa, occurring from Tropical East Africa to Ethiopia to Sudan and also extending into south-western Arabia (Verdcourt, 1976; Puff, 2003).

A species sporadically seen cultivated (Bangkok, Chiang Mai and Chiang Rai provinces) and presumably a relatively recent addition to Thailand's horticultural scene. Low, cushion-like forms make attractive flowering borders. More erect growing forms are occasionally seen as pot plants.

Psilanthus bengalensis (Heyne ex Schult.) Le Roy.— *Coffea bengalensis* Heyne ex Schult. Illustrations: Sivarajan et al. (1992: Fig. 2A–E); Pinratana (1980: 37).

Shrubs to 2–3 m tall (if allowed to grow; plants usually pruned and kept low, and often less than 0.5 m). *Leaves* elliptic-oblong to broadly ovate, ca. 5–9 by 4–5 cm, shortly acuminate at apex, narrowed to the base, subcoriaceous, glabrous (except for veins below); stipules small, triangular-aristate. *Flowers* 1–5 together, terminal (on main shoots or on abbreviated axillary shoots), fragrant, 5-merous; calyx rim-like, with minute teeth; corolla white, tube to 2 cm long, lobes ovate to elliptic, ca. 1 cm long; tips of anthers exserted, style and stigmas included. *Fruits* subsessile, drupaceous, ellipsoidal, crowned by persistent calyx, ca. 1 cm long, blue-black when ripe, with 2 seeds.

A species naturally occurring from Bangladesh to India and Nepal (Sivarajan et al., 1992).

An occasionally seen ornamental (Bangkok; northern provinces), probably grown for its sweetly scented flowers. Pinratana (1980) notes that the species is propagated by seed.

Rondeletia odorata Jacq. Fig. 3E.

Shrubs ca. 1–2 m tall. *Leaves* oblong (-obovate), 4–10 by 2–4 cm, rounded to acute at apex, obtuse or subcordate at the base, thick, leathery. *Inflorescences* terminal, several- to many-flowered. *Flowers* 5-merous; corollas red or red-orange, mostly with a distinct yellow-orange "eye", tube ca. 1 cm long, lobes rounded, to ca. 5 mm long; anthers included; stigmas barely exserted from throat; ovary 2-locular. *Fruits* globose, ca. 4 mm in diam., capsular, splitting into 2 valves, releasing numerous very small, wingless seeds.

A species naturally occurring from northern Central America (southern Mexico) southward to north-western South America, and also in the Caribbean.

Only seen cultivated in a few places in peninsular Thailand, and in Bangkok.

Serissa japonica (Thunb.) Thunb.— *S. foetida* (L.f.) Willd. Fig. 3D.

Shrubs to ca. 0.5 m tall. *Leaves* shortly petiolate, oblong, ca. 1.5–2.5 by 0.5 cm, acute at apex, narrowed to base, thin-coriaceous, glabrous. Leaves and young shoots foetid when bruised. *Flowers* solitary or few together terminal on abbreviated short shoots, (4–)5–6-merous, heterodistylous; corolla white to pale pink, tube ca. 5 mm long, lobes ca. 2 mm, with acuminate tips; anthers exserted and filiform stigmas included in short-styled form, reversed in long-style flowers; ovary 2-locular. *Fruits* small, less than 5 mm long, opening by means of an operculum, with 2 pyrenes.

A species native to south-eastern China and possibly an early introduction to Japan (see note in Puff, 1990).

In Craib (1934: 230), and often also in horticultural literature, the species is wrongly called *Serissa foetida*. The species was originally associated with the genus *Lycium* and was described as *L. japonicum* in 1780 and as *L. foetidum* in 1781; hence "*japonicum*" is the oldest name.

The characteristic foetid odour that is emitted when *Serissa foetida* plant tissue is damaged is due to paederoside, an iridoid glycoside (Inouye et al., 1988). Tissue damage leads to the release of an enzyme which splits the bad-smelling sulphur component off the iridoid glycoside. The same chemical compound is known from other rubiaceous genera and taxa occurring in Thailand, e.g. *Paederia* and *Leptodermis* (in the same tribe, Paederieae, as *Serissa*), *Saprosma* and species of *Lasianthus*.

The species is fairly frequently planted in all parts of Thailand but is easily overlooked because it is not particularly showy. It is often used as in the borders of flower

beds or as a low hedge. Cultivars with variegated leaves (yellowish-white leaf aged; cv. 'Variegata') are common (cf. Fig. 3D). Cultivars with double flowers are less often seen (formally described as 'forma duplex' and 'forma pleniflora', cf. Hara, 1952). Propagation by cuttings is easy.

Serissa japonica is much used in Bonsai, although not particularly so in Thailand. The plants are fast-growing so that attractive Bonsai trees can be formed by pruning and wiring in a relatively short time.

ORNAMENTALS EXPECTED TO BE GROWN IN THAILAND

At least two spectacular rubiaceous ornamentals of extra-Asiatic origin, observed in Malayan and Indonesian gardens, have not yet been recorded for Thailand although they should do well, at least in the peninsula. They are only briefly mentioned below:

Warszewiczia coccinea (Vahl) Klotzsch

Shrubs with striking terminal, spike-like inflorescences to over 50 cm long, composed of numerous congested partial inflorescence arranged along the elongated inflorescence axis. Each several-flowered partial inflorescence has two flowers with a single much enlarged calyx lobe, which is leaf-like in shape and coloured bright red (to ca. 10 by 5 cm; compare with *Mussaenda* and *Pseudomussaenda*, above).

A species naturally occurring from southern Central America to Brazil.

The plant is often called 'Wild Poinsettia' because the enlarged, foliaceous, red-coloured calyx lobes are, at least in colour, superficially similar to the bracts subtending the inflorescences of 'Poinsettia' (*Euphorbia pulcherrima*).

Euclinia longiflora Salisb.— *Randia macrantha* (Schultes) DC.— *Gardenia macrantha* Schultes. Illustrations: Bridson & Verdcourt (1988: Fig. 79), Chin (1977).

Bushy shrubs to ca. 4 m tall with spectacular, fragrant, white 5-merous flowers mostly solitary at the end of branches. *Corolla tube* to over 20 cm long, lobes to 5 cm long, recurved; flowers turn creamy-white with age.

An African rain forest species occurring from Uganda westwards to Guinea, and south-west to Angola.

Corner (1988: 647) mentions that the species [as *Randia macrantha*] is frequently cultivated in Malay gardens and known as 'Angel's Trumpets'.

This is not to be confused with *Rothmannia longiflora* Salisb. (syn. *Randia maculata* DC.), a species that has been seen cultivated in Indonesia. It is also a tropical African plant, with a natural distribution range similar to *Euclinia longiflora*. The bushes, too, produce very large flowers (corolla tubes to ca. 20 cm long) which are erect and solitary, but the corolla tubes are greenish or reddish outside, and the inside of the lobes is white with purplish or reddish markings. Illustration: Hallé (1970: Fig. 56, 110).

ACKNOWLEDGEMENTS

Voradol Chamchumroon wishes to thank the ÖAD (Austrian Academic Exchange) for a scholarship which made it possible to carry out part of the present studies at the Institute of Botany, University of Vienna, Austria.

REFERENCES

Andersson, L. 1998. A revision of the genus *Cinchona* (Rubiaceae-Cinchoneae). Mem. New York Bot. Gard. 80: 1–75.

Backer, C. A. & Bakhuizen van den Brink, R. C., Jr. 1965. Flora of Java (Spermatophytes only), vol. 2.-N.V.P. Noordhoff, Groningen.

Bakhuizen van den Brink, R. C., Jr. & Koster, J. T. 1963. Notes on the Flora of Java VIII. Blumea 12: 61–69.

Bremer, B. & Thulin, M. 1998. Collapse of Isertieae, re-establishment of Mussaendeae, and a new genus of Sabiceeae (Rubiaceae); phylogenetic relationships based on rbcL data. Pl. Syst. Evol. 211: 71–92.

Bridson, D. & Verdcourt, B. 1988. Rubiaceae (part 2). In: Polhill, R.M. (ed.), Flora of Tropical East Africa: 415–747. Brookfield, A.A. Balkema, Rotterdam.

Chamchumroon, V. & Puff, C. 2003. The Rubiaceae of Koh Chang, south-eastern Thailand. Thai For. Bull. (Bot.) 31: 13–26.

Chin, H.F. 1977. Malaysian flowers in colour. Tropical Press, Kuala Lumpur.

Clarke, R.J. & Macrae, R. (ed.). 1985. Coffee. Vol. 1: Chemistry. Elsevier Applied Science Publ., London, New York.

_____. 1987. Coffee. Vol. 2: Technology. Elsevier Applied Science Publ., London, New York.

_____. 1988. Coffee. Vol. 3: Physiology. Elsevier Applied Science Publ., London, New York.

_____. 1988. Coffee. Vol. 4: Agronomy. Elsevier Applied Science Publ., London, New York.

_____. 1988. Coffee. Vol.5: Related beverages. Elsevier Applied Science Publ., London, New York.

_____. 1988. Coffee. Vol. 6: Commercial and technico-legal aspects. Elsevier Applied Science Publ., London, New York.

Clifford, M. N. & Willson, K. C. (eds). 1985. Coffee. Botany, biochemistry and production of beans and beverage. Croom Helm, London, New York, Sydney.

Corner, E. J. H. 1988. Wayside Trees of Malaya, 3rd. ed. vol. 2. Malayan Nature Soc., Kuala Lumpur.

Craib, W. G. 1934. Florae Siamensis enumeratio. A List of the plants known from Siam with notes of their occurrence. Vol. 2, part 2: Rubiaceae (concluded) to Dipsacaceae. 147–233. Siam Society, Bangkok.

Dentan, E. 1985. The microscopic structure of the coffee bean. In: Clifford, M. N. & Willson, K. C. (eds), Coffee. Botany, biochemistry and production of beans and beverage, pp. 284–304. Croom Helm, London, New York, Sydney.

Elias, T.S. 1976. A monograph of the genus *Hamelia* (Rubiaceae). Mem. New York Bot. Gard. 26: 81–144.

Ferwerda, F.P. 1976. Coffees. *Coffea* spp. (Rubiaceae). In: Simmonds, N.W. (ed.), Evolution of crop plants, pp. 257–260. Longman, London.

Hallé, N. 1970. Flore du Gabon 17. Famille des Rubiacées (2e partie). Musée Nationale d'Histoire Naturelle, Paris.

Hara, H. 1952. Enumeratio Spermatophytarum Japonicarum ... Pars secunda. Iwanami Shoten, Tokyo.

Inouye, H., Takeda, Y., Nishimura, H., Kanomi, A., Okuda, T. & Puff, C. 1988. Chemotaxonomic studies of rubiaceous plants containing iridoid glycosides. Phytochemistry 27: 2591–2598.

Jayaweera, D.M.A. 1963. The rubiaceous genus *Mussaenda:* the morphology of the Asiatic species. J. Arnold Arb. 63: 111–126.

Ng Siew Yin. 1981. *Carphalea kirondron* Baill. (Rubiaceae). A newcomer to the horticultural scene. IPR News (Parks & Recreation Dept., Singapore) Jan. 1981: 5.

Pinratana, Brother Amnuay. 1980. Flowers in Thailand. Nature Series no. 02G. Viratham Press, Bangkok.

Puff, C. 1988. Observations on *Carphalea* Juss. (Rubiaceae-Hedyotideae), with particular reference to the Madagascan taxa and its taxonomic position. Bull. Jard. Bot. Belg. 58: 271–323.

_____. 1990 ["1989"]. The affinities and relationships of the Japanese endemic *Pseudopyxis* (Rubiaceae-Paederieae). Pl. Spec. Biol. 4: 145–155.

_____. 2003, in press. Rubiaceae. In: Hedberg, I., Sileshi Nemomissa & Edwards, S. (eds), Flora of Ethiopia and Eritrea, vol. 4,1 Nat. Herbarium, Addis Ababa Univ. & Dept. Syst. Botany, Uppsala Univ., Addis Ababa & Uppsala.

Puff, C., Igersheim, A. & Rohrhofer, U. 1993. *Pseudomussaenda* and *Schizomussaenda* (Rubiaceae): close allies of *Mussaenda*. Bull. Jard. Bot. Belg. 62: 35–68.

Sivarajan, V. V., Biju, S.D. & Mathew, P. 1992. Revision of the genus *Psilanthus* Hook.f. (Rubiaceae tribe Coffeeae) in India. Bot. Bull. Acad. Sinica 33: 209–224.

Stoffelen, P., & Robbrecht, E. 1995. De plantekunde – bril opgezet. Een botanische kijk op koffie. In: Robbrecht, E. (ed.), Kawa, koffie ontsluierd: von koffiestruk tot kopje koffie. Nat. Bot. Gard. Belgium, Meise.

Taylor, L. 2002. Herbal Secrets of the Rainforest, 2nd ed. Prima Publishing, Roseville, Califonia.

Verdcourt, B. 1976. Rubiaceae (part 1). In: Polhill, R. M. (ed.), Flora of Tropical East Africa. Agents for Overseas Governments and Administration, London.

Wrigley, G. (1988). Coffee. Tropical Agriculture Series, Longman, London.

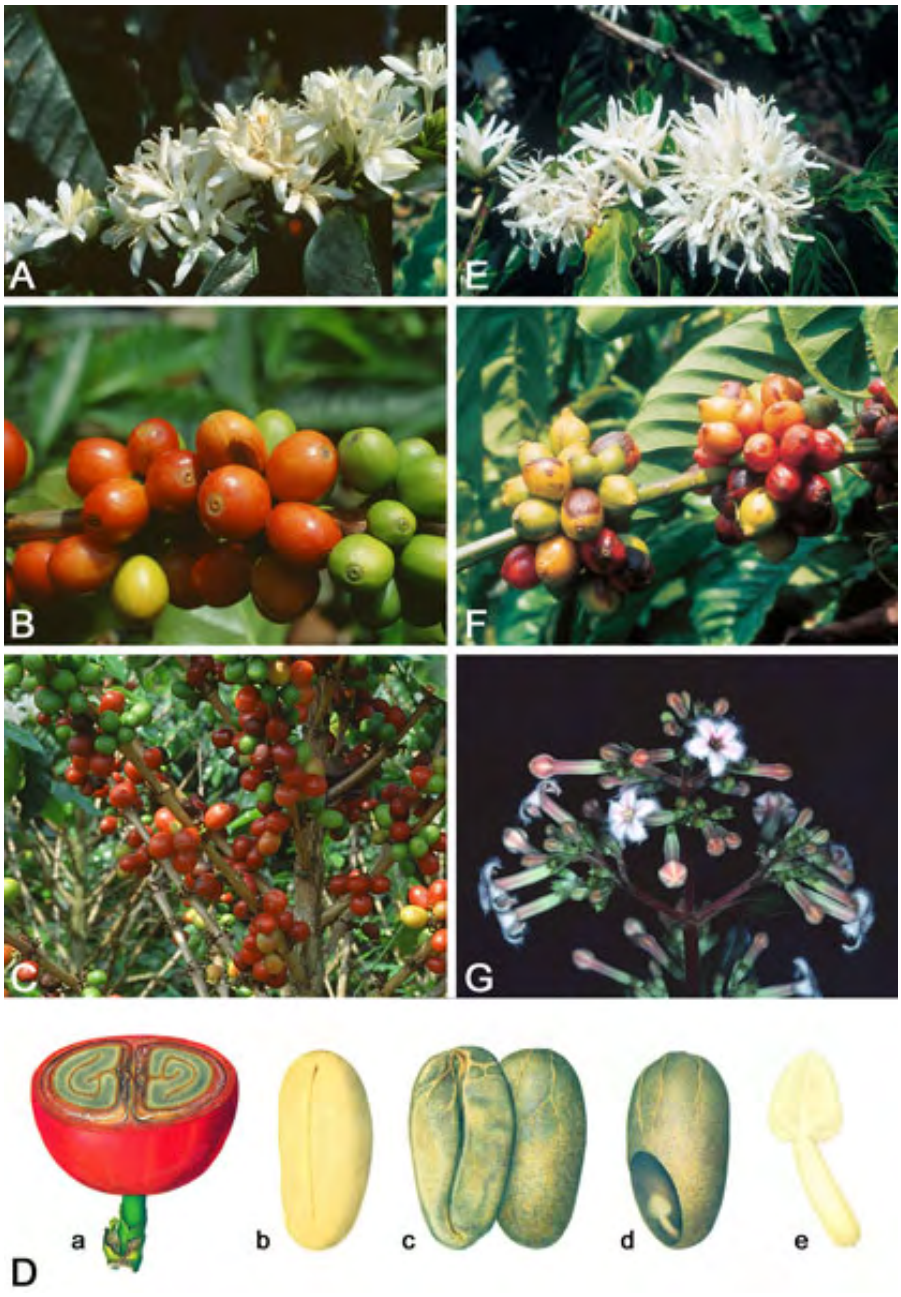

Figure 2. A–D *Coffea arabica*; E–F *C. canephora*: A, E. flowers; B–C, F. fruits; D. a, sectioned fruit showing two seeds, b, seed enclosed in endocarp, c, two seeds (endosperm covered by "silver skin"), d, seed, portion cut off to show position of embryo, e, embryo; G. *Cinchona calisaya*. A–C, E–F photographed by C. Puff; D. paintings by O. Van de Kerckhove, from Robbrecht & Stoffelen (1995: Fig. 20), modified, reproduced with permission of the National Botanic Garden of Belgium.

Figure 3. A. *Carphalea kirondron*; B. *Carphalea kirondron* inflorescence showing red enlarged calyx lobes and some corollas; C. *Pentas lanceolata*; D. *Serissa japonica*; E. *Rondeletia odorata*; F. *Hamelia patens*; G. *Hamelia patens* inflorescence, note coloured inflorescence axes; H. *Mussaenda philippica* cultivars (white: cv. 'Dona Auror'; pink: cv. 'Queen Sirikit' or possibly 'Dona Luz'); I. *M. erythrophylla*; J. *Pseudomussaenda flava*; K. *Gardenia augusta*, double flower. All photographed by C. Puff.