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Systematics of *Syzygium* Gaertner (Myrtaceae) in Indochina (Cambodia, Laos and Vietnam)

Thesis submitted for the Degree of Doctor of Philosophy

2010

Wuu Kuang Soh

Supervisor: Professor John A.N. Parnell

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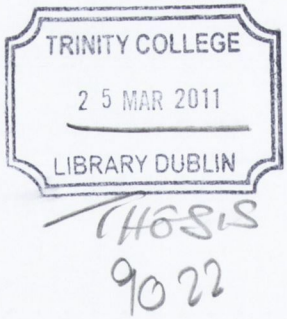

Those who know that they are profound strive for clarity.
Those who would like to seem profound strive for obscurity.
Nietzche: *The Gay Science*

Abstract

The genus *Syzygium* (Myrtaceae) is fully revised for Indochina (Cambodia, Laos and Vietnam). The species key, descriptions, typification, ecology, conservation status, phenology, vernacular names, usages, distribution maps, selected scanned herbarium images and specimens examined are given. Fifty six *Syzygium* species in Indochina are recognised within the subgenera *Acmena*, *Perikion*, *Sequestratum* and *Syzygium*. Seven species are endemic to Indochina. Three species are new to science (*S. bokorense*, *S. chantaranothaianum* and *S. cucphuongense*). Sixty two lectotypes have been designated here and 23 species names are new synonyms. Vietnam harbours the largest number of species (49), followed by Laos (30) and Cambodia (27).

A comparative study of leaf anatomy in *Syzygium* was carried out to assess its taxonomic value. General generic and subgeneric descriptions of leaf anatomy were elaborated. The differences among the subgeneric groups were critically assessed. The results showed that the stomatal types, crystals frequency and midrib vascular types were correlated to the subg. *Acmena*, *Perikion*, *Sequestratum* and *Syzygium*. The leaf anatomical characters of subg. *Perikion* are diverse and overlapped with subg. *Acmena* and *Sequestratum*. Some of the leaf anatomical characters among different *Syzygium* species exhibit some degrees of variation that are represented by intermediate types.

The significance of morphological characters in the classification of infrageneric groups based on DNA phylogenies was investigated. Leaf anatomical and macromorphological data were used to contruct the phylogeny of *Syzygium*. ETS and ITS sequences of twelve *Syzygium* species from Southeast Asia were generated here for the first time and were incorporated into the established ETS-ITS phylogeny. Morphological characters were optimised onto the ETS-ITS phylogeny. The results showed some degrees of congruence in the morphological and molecular estimates of the relationship. In the morphological majority-consensus tree, there is agreement in the monophyly of the subg. *Sequestratum*

and *Syzygium* whereas subg. *Acmena* and *Perikion* are sisters forming a clade. In the strict consensus tree from the morphological estimates, only subg. *Sequestratum* was supported. The topologies within the clade of subg. *Syzygium* derived from morphological and molecular estimates are different. Within this clade, characters reflecting size are phylogenetically uninformative whereas possible predictors for subclades may be geography and midrib vascular system. The result of the NMDS ordination is in accordance with the phylogeny in delimiting three groups: subg. *Syzygium*, subg. *Sequestratrum* and subg. *Perikion-Acmena*. In the phylogenetic and phenetic analyses, morphological characters that support the subgeneric clades are: stomata, crystal types, midrib vascular system, inflorescence type, hypanthium shape, anther locules, placentation and seed intercotyledonary intrusion. Hypotheses of characters polarity in *Syzygium* were made. The species grouping in the subgeneric rank were determined from the cladograms and ordination diagram.

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Chapter 1 General introduction

1.1 Introduction to Myrtaceae and its suprageneric classification

Myrtaceae, a moderately sized family of about 3,675 to 5,500 species in 140 genera, are mostly distributed in the southern hemisphere (Parnell et al., 2007). Since the time of De Candolle (1828), the infrafamilial classification of Myrtaceae was based upon the concept of fruit types, *i.e.* fleshy or dry fruit. Among the more popular proponents of the latter scheme was Niedenzu (1893), who divided Myrtaceae into two subfamilies: the first group, having dehiscent fruit and narrow leaf, was Leptospermoideae and the second group was Myrtoideae, which was characterised by a fleshy fruit and broad leaf: *Eugenia* L. and *Syzygium* Gaertn. were included in the latter group.

Johnson and Briggs (1984), undertook phylogenetic analysis using a morphological dataset and proposed an informal classification scheme. Although still accepting the two subfamilies of Niedenzu, they divided Myrtoideae into six informal groups (alliances and suballiances): among them were Acmena alliances (including *Syzygium*) and Myrtoideae s.s. alliances (including *Eugenia*). Subsequent molecular studies appear to confirm the separation of *Syzygium* and *Eugenia*. Gadek et al. (1996) presented the first molecular analysis of Myrtaceae. Their study of *mat*K sequence data supported the Asiatic clade of *Syzygium* and *Acmena* DC. and their separation from other fleshy-fruited Neotropical species such as *Eugenia* among others (Gadek et al., 1996).

Wilson et al. (2001, 2005) presented a hypothesis and formalised the infrafamilial classification of Myrtaceae based upon plastid *trn*K-*mat*K sequence data. This eventually laid the ground for the modern tribal classification of Myrtaceae. They proposed two subfamilies (Myrtoideae and Psiloxyloideae) and 17 tribal groups. *Syzygium* together with *Acmena*, *Acmenosperma* Kausel, *Anetholea* Peter G. Wilson and *Waterhousea* B.Hyland formed a tribe (the Syzygieae Peter G. Wilson), while *Eugenia* L. was in a separate tribe (the Myrteae DC.) along with

other genera including *Myrtus* L., *Psidium* L., *Rhodamnia* Jack and *Rhodomyrtus* (DC.) Reich. (see figure 1.1). Subsequent findings by Sytsma et al. (2004) and Biffin et al. (2010) using plastids *mat*K-*ndh*F and ITS-*mat*K-*ndh*F sequences respectively, supported Wilson et al. (2001, 2005) classification of Myrtaceae.

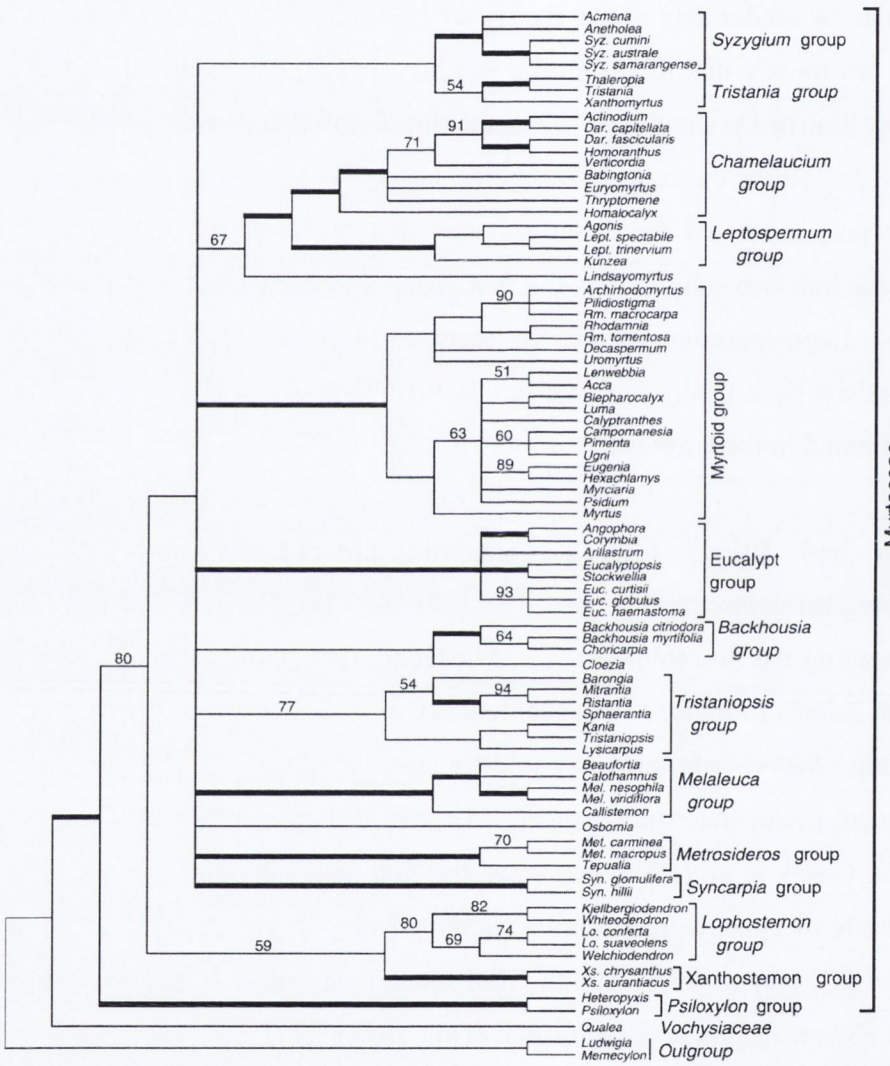

Figure 1.1. Strict consensus of 187,927 equally parsimonious trees based on matK data of Myrtaceae. Thick branches received at least 95% jacknife support, other values > 50% are shown above clades (from Wilson et al., 2005).

Evidence from phylogenetic analysis of the morphological and DNA sequences suggested Myrtaceae is of Gondwanan origin (Biffin et al., 2010). The oldest Myrtaceae fossil record was the pollen of *Myrtaceidites lisamae* from Gabon

dated 86 Ma (Muller, 1981). The tribe Myrteae was believed to have originated and diversified in Australasia between 77-56 ma, when Australia was still connected to South America via warm-temperate Antarctica land bridges. It was suggested that this was followed by at least two separate dispersal events bringing *Eugenia* from South America to Africa (van der Merwe et al., 2005), *Syzygium* and *Metrosideros* from Australasia to Africa at c. 50 ma (Sytsma et al., 2004). Biffin et al (2010) using Bayesian phylogenetic and molecular dating analyses for chloroplast and nuclear DNA sequences were able to show that the fleshy fruited lineages, Syzygieae and Myrteae diversified at higher rates than other lineages of Myrtaceae and that correlates with a shift from dry to fleshy fruit taxa. Pollination strategy and embryo specialisation were postulated as potential drivers for the rapid speciation in rainforest environment (Biffin et al., 2010).

Since Johnson and Briggs's (1984) introduction to the informal classification framework of alliances and suballiances, several of these informal groups have been subjected to detailed phylogenetic analysis using molecular and morphological characters (O'Brien et al., 2000; Brown et al., 2001; Lam et al., 2002; Harrington & Gadek, 2004). The *Acmena* alliances which include syzygioid species from the Old World is of particular interest in this study. Phenetic and phylogenetic studies pertaining to this group are further reviewed in Chapter 4 of this thesis.

1.2 Introduction to *Syzygium*: size, distribution, ecology and usages

Syzygium is the largest genus of Myrtaceae with an estimated 1,200 species in the world (Parnell et al., 2007). *Syzygium* was placed in the sixteenth in rank among 57 largest genera of flowering plants (Frodin, 2004) or possibly higher, within the top ten according to Parnell et al. (2007), on the basis that many novel species are yet to be discovered and many validly described species await transfer to *Syzygium*. This is a paleotropical genus with a wide range of occurrence mainly in Southern and Southeast Asia, Southern China, Australia, Malesia and New Caledonia. Some species occur in East Africa, Madagascar, the Mascarenes, South Western Pacific islands, Taiwan and Southern Japan. The centre of diversity is in Malesia but its basic evolutionary diversity is in the Melanesian-Australian region.

Syzygium is principally found in tropical or subtropical vegetation, ranging from lowland to montane rainforest, swamp, ultramafic forest, savannah to limestone forest. Some species occur in specialised habitat such as along river, on ultramafic or limestone soil. Van Steenis (1981) recorded 33 rheophytic species in *Syzygium* that are morphologically characterised by a narrow leaf, short petiole, and flexible twig and leaves crowded at twig-ends. In the tropical rainforest, *Syzygium* usually blooms in masses. As one of the most common tree genera in the forest ecosystem, *Syzygium* is important as a food resource for birds, insects, small and large mammals (Parnell et al., 2007).

The breeding biology of *Syzygium* has been under-studied. Several studies showed that *Syzygium* are pollinated by birds, bats and insects (bees, wasps, moths, ants and spiders) ranging from low to high self-compatibility (Nic Lughadha and Proenca, 1996; Parnell et al., 2007). Chantaranothai and Parnell (1994a) showed that in *S. formosum* (Wallich) Masam., *S. jambos* (L.) Alston, *S. megacarpum* (Craib) Rathakr. & N.C.Nair and *S. samarangense* (Blume) Merr. & L.M.Perry three breeding systems occur: apomictic, inbreeding excluding apomixes and outbreeding. Some species display inconsistent incidents of polyembrony, for example *S. cumini* (L.) Skeels (Nic Lughadha & Proenca, 1996). In short, there is no conclusive evidence indicating a general breeding trend in *Syzygium*, especially in regards to inbreeding or outbreeding.

Despite its high species diversity, only a fraction of the species are commercially cultivated or used for their fruit, timber, medicinal properties or as spices. *S. aromaticum* (L.) Merr. & L.M.Perry is widely cultivated in the tropics for cloves and essential oil. Clove oil is an important essential oil that is commonly used in the food, perfumery and pharmaceutical industry (De Guzman & Siemonsma, 1999). Other species, for instance *S. aqueum* (Burm. f.) Alston, *S. cumini* , *S. jambos* and *S. malaccense* (L.) Merr. & L.M.Perry are important and commonly cultivated as fruit trees in Southeast Asia and India. *Syzygium* is not regarded as a major source of timber but is locally used for house building and light construction (Lemmens et al., 1995). Other forest species are locally used as traditional medicine (*e.g.* leaves of *S. jambos*), fabric dye (*e.g.* bark of *S.*

antisepticum (Blume) Merr. & L.M.Perry) and cooking (*e.g.* leaves of *S. polyanthum* (Wight) Walp.).

1.3 Taxonomic history of *Syzygium*

The name *Syzygium* was adopted by Gaertner (1788) from Browne's (1756) genus *Suzygium* but with a corrected spelling. Its etymology is from the late Latin *syzygia* and from Greek *syzygos*, which means yoked together. Browne (1756) referred the new genus to the paired arrangement of the leaves and branchlets that is probably the basis of the name (Craven and Biffin, 2010). In *Species Plantarum*, Linnaeus (1753) treated five species that are currently accepted as *Syzygium* into three separate genera, namely *Caryophyllus* L., *Eugenia* L. and *Myrtus* L. Although the oldest name representing *Syzygium* is *Caryophyllus*, the former name was conserved against the latter because it was more widely used.

The works of De Candolle (1828) and Wight (1841) are influential in breeding two schools of thought about the classification of *Syzgium*. The first school favours De Candolle's concept of multiple genera, accept *Eugenia* for the New World species and recognise several genera for the Old World syzygioid species. The other, following Wight, advocated a broader concept of *Eugenia* encompassing all species of *Syzygium* s.l..

De Candolle (1828) recognised five genera, occurring in the Old World that included *Acmena*, *Caryophyllus*, *Eugenia*, *Jambosa* Adans. and *Syzygium*, while the New World species all belong to *Eugenia*. All the five genera were placed into the same subtribe *Eugeniinae*. Other botanists in the 19th and 20th centuries followed this concept but with some modification by reduction or by adding new genera to accommodate newly discovered species that exhibited novel morphological characters (for example, *Acicalyptus* A.Gray, *Aphanomyrtus* Miq., *Clavimyrtus* Blume, *Cleistocalyx* Blume, *Cupheanthus* Seem., *Paraeugenia* Turrill and *Piliocalyx* Brongn. and Gris.). Following De Candolle (1828), one of the most comprehensive reclassifications of *Syzygium*/*Eugenia* was proposed by Niedenzu (1893). He established several segregate genera, namely *Acicalyptus*, *Jambosa*, *Piliocalyx* and *Syzygium*, which were based mainly on floral characters. His system was used by many workers, but later due to the lack of distinct generic

limits (for example between *Jambosa* and *Syzygium*), many other botanists were tempted to consider *Eugenia* in a broader sense. Because of the immense number of species described in *Syzygium* s.l., the group became unmanageable. This prompted Merrill and Perry (1938a, 1938b, 1939a, 1939b) to redefine some of the earlier proposed segregates of the genera by using fruit, seed (seed coat adhesion and cotyledon fusion) and flower characters. In their new classification, they retained species from the New World in *Eugenia* and recognised *Acmena*, *Aphanomyrtus*, *Caryophyllus*, *Cleistocalyx*, *Paraeugenia*, *Syzygium*, *Tetraeugenia* Merrill and tentatively *Jambosa* for the Old World species. They also contributed significantly to taxonomic research in *Syzygium* through their reinstatement of *Acmena* and *Cleistocalyx* as separate genera, floristic treatment of *Syzygium* and its allies for Indochina, China and Borneo, and contributions on the Papuasian and the Philippine species (see table 1.1). Among the four major genera in their account, *Eugenia* and *Acmena* were separated from *Syzygium* in having undivided cotyledons, therein *Acmena* was differentiated from *Eugenia* in having the testa adhering to the pericarp and also in having divaricate anther locules, while *Cleistocalyx* stands out from the rest due to its calyptrate calyx. Table 1.1 summarises the monographic and floristic work undertaken by various botanists and the two approaches to *Syzygium* classification in the 20th and 21st centuries.

Table 1.1. Summary of monographs and floristic accounts of *Syzygium* from 1900 onwards in chronological order.

Author (year)	Geographic scope	Genera recognised	Species number
King (1900)	Malaya	*Eugenia* (sect. *Jambosa* & sect. *Syzygium*; incl. *Acmena* and *Cleistocalyx*), *Pseudoeugenia*	98
Robinson (1909)	The Philippines	*Eugenia* (incl. *Acmena* and *Cleistocalyx*)	98
Gagnepain (1920)	French-Indochina	*Eugenia* (sect. I, II, III, IV & V; incl. *Cleistocalyx*)	54
Craib (1931)	Thailand	*Eugenia* (incl. *Cleistocalyx*)	79
Merrill & Perry (1937)	World	*Cleistocalyx* (monograph)	21
Merrill & Perry (1938a)	World	*Acmena* (monograph)	11

Merrill & Perry (1938b)	French-Indochina	*Syzygium* (excl. *Cleistocalyx* and *Acmena*)	51
Merrill & Perry (1938c)	China	*Acmena*, *Cleistocalyx*, *Syzygium*	48
Merrill & Perry (1939a)	Borneo	*Syzygium*	156
Henderson (1949)	Malaya	*Eugenia* (sect. *Syzygium* – Group I, II, III, IV & V; sect. *Acmena*; sect. *Cleistocalyx*; sect. *Fissicalyx*; sect. *Eueugenia*)	138
Merrill (1950)	The Philippines	*Acmena*, *Cleistocalyx*, *Syzygium*	170
Perry (1950)	Fiji	*Syzygium*, *Piliocalyx*	29
Wilson (1957)	Hawaii	*Eugenia*	4
Amshoff (1964)	Java	*Acmena*, *Aphanomyrtus*, *Cleistocalyx*, *Syzygium*	55
Hartley & Perry (1973)	Papuasia	*Acmena*, *Syzygium*	138
Hartley & Craven (1977)	Papuasia	*Acmena*, *Acmenosperma*, *Syzygium*, *Piliocalyx*	15
Kochummen (1978)	Malaya	*Eugenia*, *Pseudoeugenia* *Acmena*, *Cleistocalyx*, *Stereocarpum*, *Syzygium* (incl. *Acmenosperma*)	132
Scott (1980)	Mascarenes	*Syzygium*	22
Ashton (1981)	Sri Lanka	*Syzygium*	30
Kostermans (1981)	Sri Lanka	*Cleistocalyx*, *Syzygium* (sect. *Syzygium* & sect. *Jambosa*)	32
Hyland (1983)	Australia	*Acmena*, *Acmenosperma*, *Syzygium* (incl. *Cleistocalyx*), *Waterhousea*	65
Whistler (1988)	Samoa	*Syzygium*	45
Chantaranothai & Parnell (1994b)	Thailand	*Acmena*, *Cleistocalyx*, *Syzygium* (incl. *Acmenosperma*)	89
Chen & Craven (2007)	China	*Syzygium* (incl. *Acmena*, *Cleistocalyx*)	80

Wight (1841) recommended merging the five genera recognised by De Candolle (1828) into *Eugenia* but maintaining the overall structure of the classification in having five subgeneric groups by using the same epithets. The justifications for this were that first, there were no discrete variations in the flowering and fruiting characters, and second, for stabilising the nomenclature. Bentham and Hooker (1865) adopted the same principle in their influential *Genera Plantarum*. Others, mostly if not all, British or British-associated botanists followed, this classification in their floristic work (see table 1.1). Among them is Henderson (1949), who revised *Syzygium* in Malaya and vehemently rejected Merrill and Perry's classification and advocation of the taxonomic importance of testa and cotyledon fusion. Merrill and Perry (1939a) based on their observations on herbarium specimens, suggested that the testa in *Syzygium* is adherent to the pericarp while in Eugenia it is free from it and adherent to the cotyledons. Henderson (1949) found that in live specimens, the degree of adherence of testa to the cotyledons varies greatly in *Syzygium*. Within *Eugenia*, he recognised four sections, including *Acmena*, *Cleistocalyx*, *Fissicalyx* and *Syzygium* (including *Caryophyllus* and *Jambosa*): sect. *Syzygium*, he divided into five groups, simply named group I, II, III, IV and V.

Schmid (1972a, 1972b) provided an extensive review of the status of *Eugenia* and *Syzygium* and its segregate genera including *Acmena*, *Cleistocalyx*, *Caryophyllus* and *Jambosa*. He showed that *Eugenia* and *Syzygium* s.l. are not closely related on the basis that the pathway of vascular supply to ovules in *Eugenia* is transeptal and that of *Syzygium* s.l. is axile. He further suggested that both the genera have separate lines of evolution and neither was directly ancestral to the other. His hypothesis was later supported by phylogenetic studies from DNA sequences data (Gadek et al. (1996; Wilson et al., 2001, 2005).

Although the exclusion of *Eugenia* from *Syzygium* s.l. is now widely accepted by contemporary botanists, it does not solve the conceptual problem in the classification within *Syzygium* s.l. in the Old World. Presently, there are two schools of thought as to the approach for a classification scheme for *Syzygium*. Craven and Biffin (Craven, 2001; Craven et al., 2006; Craven & Biffin, 2010), based on up-to-date DNA sequences phylogeny and morphological evidence, are

in favour of an all inclusive generic concept of *Syzygium* but with an infrageneric classification to reflect evolutionary relationship among the clades. According to them, until enough molecular evidence is gathered to erect phylogenetically robust genera, a wide-ranging concept of *Syzygium* will tentatively eliminate the needs to create more new genera to accommodate novel morphological characters. On the contrary, Parnell et al. (2007) advocated having multiple and smaller genera within *Syzygium* s.l. on the basis that an expanded concept of *Syzygium* will make it more polyphyletic and diminish any degrees of predictability. Indeed, this scenario is analogous with the *Eugenia* s.s-*Syzygium* s.l. problem faced by 19th and 20th centuries botanists but differs from the latter on scale.

1.4 Introduction to Indochina: climate, geology, biogeography and flora

The term *Indochina* is used here in a geographical sense to account for the area covering Cambodia, Laos and Vietnam, *c.* 748,230 km^2. It therefore falls within the former territory of French Indochina, which was part of the French colonial empire including Kouang-Tchéou-Wan (China) and part of eastern Thailand (Frodin, 2001).

All of the lowland areas of Indochina have a tropical monsoon type of climate, generally characterized by a dry and rainy season. There are two major distinct climatic types: that of southern Indochina, south and west of the Annam mountain range, and that of northern Indochina. The southern Indochina generally has a typical tropical climate with high temperature (28 – 29 °C) all the year round, and it has only the dry and rainy seasons, in which the rainy season occupies more than 90% of the total annual rainfalls . The northern Indochina has a tropical monsoon climate with four distinct seasons; the summer is hot (28 – 29 °C) and rainy, and the winter is cold (16 – 17 °C) and dry (Thao 1998, Lap 1999). Because of differences in latitude, altitude and the marked differences of topographical terrains, the climate tends to vary considerably from place to place (McCune, 1947).

Over half of the total area of Indochina comprises mountains and plateaus. There are four major mountain groups within Indochina. The most important mountain area is the Annam range which separates northern from southern Indochina. In

southwestern Cambodia, there is a dissected sandstone plateau called the Cardamom mountains. In the north are complex mountain ranges forming the drainage division between the upper Mekong and Red rivers. There are two main formations, at the Northwest bordering Laos and Vietnam and at the Northeast bordering Vietnam and Southern China. The areas surrounding the Red river delta, Mekong river delta and Tonle Sap are three major plains in Indochina (McCune, 1947).

Indochina is an amalgamation of three major terranes, including the largely Indochina terrane, a smaller part of the Sibumasu terrane (in Northwestern Laos) and South China terrane (in Northeastern Vietnam). A terrane in geological term is a fault-bounded area or region with a distinctive stratigraphy, structure, and geological history (The Oxford Dictionary). These together with the East Malaya terrane, were thought to have assembled between late Carboniferous and the Late Triassic (c. 359-227 Ma) with the final consolidation between the Late Triassic and Early Jurassic (c. 227-180 Ma) linking the Eurasian plate with Sundaland (Metcalfe, 2001). During this period, immigration of taxa from adjacent areas into Indochina and subsequent species radiation was facilitated as the areas lie on or near the contact zones of the terranes. Schmid (1962) and Vidal (1973) suggested that the present flora of Indochina developed after this period, mainly in the Cenozoic Era. The availability of different source floras and the occurrence of dispersal tracks make Indochinese plants geographically very interesting. The Indochinese flora includes elements from nearby geographical regions including from the Southern China Flora in the north, the Himalaya-Yunnan-Guizhou flora in the North-West, the India-Myanmar flora in the West, and the Malaysia-Indonesian flora in the South and South-East (Figure 1) (Trung, 1998; Chan et al. 1999)

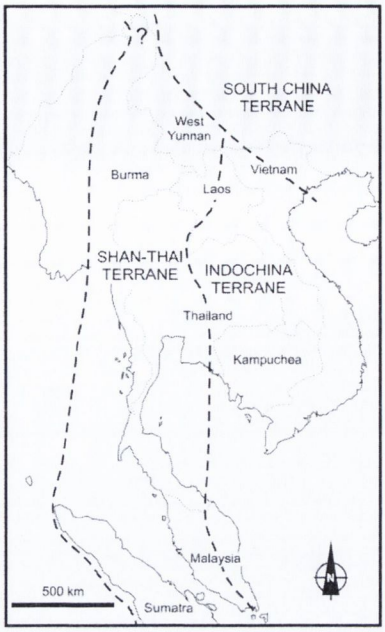

Figure 1.2. Current map showing the boundaries of the terranes in continental Southeast Asia (from Fortey & Cocks, 1998).

The investigation of the regional flora of Indochina commenced in 1907, under the direction of H. Lecomte (Stafleu & Cowan, 1979) and has led to the publication of seven volumes of the *Flore Générale de l'Indochine* (1907-1951). More than 8,000 plant species were documented and described in this work. Following this, its successor, *Flore du Cambodge, du Laos et du Viêtnam*, was initiated in 1960 and is ongoing. Between 1960 and 2007, 32 volumes have been produced, documenting 2,000 plant species from Cambodia, Laos and Vietnam. Taxonomic revisions published over the last few decades suggest that many more species will certainly be discovered in Indochina. Given the poor state of botanical exploration in Indochina at the time when the *Flore Générale de l'Indochine* (1907-1951) was in progress, the flora is very incomplete. Many of the families revised in the early volumes need revisiting.

Current estimates place the total number of plant species in Cambodia, Laos and Vietnam between 12,000 and 15,000 (Davies et al., 1997). In addition to the regional flora, there are many localised floristic publications at country and nature reserve level focusing on checklists, taxonomic revisions, plant uses, timber trees and many others (see Chapter 5 and Frodin, 2001)

Table 1.2. Estimated number of vascular plant species in Indochina.

Country	Vascular species
Cambodia	c. 2,308[1] angiosperm species (Dy Phon, 1982)
Laos	c. 4,850 vascular species (Newman et al., 2007)
Vietnam	c. 10,500 vascular species (Ho, 1991-93)

The forest in Indochina has suffered much destruction during the political unrest between 1950's and 1980's, and this was particularly apparent during the Vietnam War (1955-1975). Since the 1990's, parallel with the economic boom in the region, forest destruction has continued due to commercial logging, land conversion for agriculture, human dwellings and large scale infrastructure projects (Lang, 2001). Therefore, knowledge about the little known plant species in Indochina is imperative and urgently needed for the conservation and sustainable management of the local flora.

1.5 General aims of the thesis

The main aims of the project are to:

1. Provide an up to date taxonomic revision of *Syzygium* in Indochina (Chapter 5).
2. Assess the taxonomic value of leaf anatomy in *Syzygium* (Chapter 3).
3. Determine the significance and evolution of leaf anatomical and macromorphological characters in the delimitation of infrageneric groups in *Syzygium* (Chapter 4)

The specific aims are given in the respective chapters. The taxonomic account of *Syzygium* in this thesis will be incorporated into the floristic treatment of Myrtaceae for the Flora of Indochina (*Flore du Cambodge, du Laos et du Viêtnam*).

[1] This figure was probably underestimated by Dy Phon (1982), who extracted the Cambodian species from the *Flore Générale de l'Indochine* (1907-1951) and *Flore du Cambodge, du Laos et*

Chapter 2 General notes on the macromorphology of *Syzygium*

2.1 Introduction

A full morphological description of the genus *Syzygium* is given in Chapter 5 (section 5.6) and therefore this Chapter will not repeat this but aims to clarify some of the morphological terms and provides additional notes to complement and elaborate on selected characters used in the taxonomic account. Some of the taxonomically important and less important characters for *Syzygium* and its infrageneric classification are discussed here. Gagnepain (1917) gave a detailed morphological description of the Indochinese *Syzygium* (as *Eugenia*). However, equally, a comprehensive synopsis of *Syzygium* morphology based on Thai species, given by Chantaranothai and Parnell (1994), in my opinion, is applicable for Indochinese species but some characters like the leaf venation, inflorescence and hypanthium are reinterpreted or given further explanation in this section.

2.2 Macromorphology

Twig

Terete, subangular, angular or winged in cross-section. Angular twigs are usually 4-angled or sometimes 3-angled (*S. formosum* and *S. diospyrifolium* (Wall. ex Duthie) S.N.Mitra). The young twig is usually angular and in most species becomes terete as it gets older. The term 'subangular' is used here for conditions that fall in between terete and angular, especially when the angle is not sharp. Terete and subangular twigs usually occur together in the same species or specimen. Twig texture and colour are important for identification in some species.

Oil glands

Oil glands are present in nearly all organs close to the surface: in the leaves, petioles, young twigs and inflorescences including peduncles and flowers. This is recorded on the upper leaf surface which is usually punctilate or sometimes pustulate, rarely without pustulation; on the lower surface it is always pustulate.

The pustulation is prominent on the lower surface of dried leaves because the oil glands are positioned in the spongy mesophyll, which contracts more than the palisade layer upon drying. In the species with foliar sclereids (*e.g. S. jambos* and *S. siamense* (Craib) Chantaranothai & J.Parn.), the raised pustulation on lower leaf surface is less prominent. Some species do have relatively denser and larger oil glands, for *e.g. S. hemisphericum* (Wight) Alston and *S. malaccense*, but these charcters are not clearly disjunct from other species and furthermore their use for identification is impractical. Cork warts are present in all species on the leaf surface as random black dots and are of no taxonomic value.

Indumentum

An indumentums rarely occur in *Syzygium* and therefore is useful for species identification. In Indochina this character is found only in *S. vestitum* Merr. & L.M.Perry and *S. levinei* (Merr.) Merr. & L.M.Perry. In *S. levinei*, the hair is confine to the inflorescence and in *S. vestitum* they are found on all major organs.

Leaf

Leaves are arranged as opposite, subopposite, alternate or verticillate in whorls of three. The leaves are considered subopposite when their position is almost opposite but they do not show clear alternate arrangement. Opposite and subopposite leaves usually occur together on the same specimen. Alternate leaves do not occur by themselves but together with opposite and subopposite leaves, and are only found in *S. thorelii* (Gagnep.) Merr. & L.M.Perry. Verticillate leaves are found only in *S. attopeuense* (Gagnep.) Merr. & L.M.Perry, *S. diospyrifolium*, *S. formosum* and *S. harmandii* (Gagnep.) Merr. & L.M.Perry. Opposite or subopposite leaves can occur together with verticillate leaves.

In the species descriptions, the terminology for the leaf venation follows Hickey (1973, 1979) in a topological sense, and is based on the venation thickness, length and direction within lamina without regard to histology, function, ontogeny or homology. For *Syzygium* and other genera with intramarginal veins, the terminology for secondary, intramarginal and tertiary veins are not comparable (homologous) to other pinnate leaf because of the differences in venation ontologeny. Carr et al. (1986), who studied the leaf development of *Eucalyptus*,

showed that the intramarginal veins in Myrtaceae are acrodromal veins: they are distinct veins that arise from the leaf base and extend steeply towards the apex and were initiated before the formation of secondary veins and therefore they are not derived from connecting secondary veins. Ontogenetically, the intramarginal and secondary veins of *Syzygium* are comparable to the secondary and tertiary veins of pinnate leaf, respectively. Carr et al. (1986) and Klucking (1989) proposed the used different leaf venation terminology in relation to Hickey's terminology, for species with intramarginal veins. However, since Hickey's terminology is widely used in conventional floras and has become standard, it is essential to use it here to facilitate usage of the taxonomic account. The following is a classification of *Syzygium* leaf venation simplified from Klucking (1989), modified from Chantaranothai and Parnell (1994) and from my own observations (Figure 1.3). More than one type can occur in a species and intermediate types occur within type A and among types A to C.

Type A: This is a typical *Syzygium* leaf venation which is found in 84 of 123 species (70%) in a survey done by Klucking (1989). It has one to two pairs of intramarginal veins (acrodromous veins) extending from base to leaf apex either straight or scalloped, the distance of inner pair from the leaf margin is either narrow or broad, the inner pair is of secondary strength and distinct, outer pairs are of tertiary strength, faint and rarely prominent. The differences between Type A.II and A.III can be very subtle and sometimes there are intermediate types.

Type A.I: This is a *Calophyllum*-like venation in which the secondary veins (secondary-like veins) are narrowly spaced, and a pair of prominent inner intramarginal veins (acrodromal veins) extend from base to leaf apex, straight, close to the leaf margin, the inner pair is of secondary strength, the outer intramarginal veins are absent or if present faint. This pattern occurs in *e.g. S. angkae* (Craib) P.Chantaranothai & J.Parn., *S. cumini* and *S. lineatum* (DC.) Merr. & L.M.Perry. [*Equivalent to Predominant venation pattern variation 1* (Klucking, 1989); *Group 1* (Chantaranothai & Parnell, 1994b)]

Type A.II: Secondary veins (secondary-like veins) broadly spaced, 1 or 2 pairs of intramarginal veins (acrodromal veins) extending from base to leaf apex, scalloped or straight, distance from the leaf margin is large, the inner pair is prominent and of secondary strength, the outer pair is absent or faint. This

pattern occurs in *e.g. S. attopeuense, S. jambos* and *S. thorelii,*. [equivalent to *Predominant venation pattern variation 2* (Klucking, 1989); *Group 1* (Chantaranothai & Parnell ,1994b)]

Type A.III: Similar to Type A.II venation in all aspects, except the outer intramarginal veins are prominent and the distance between inner intramarginal veins and the margins in comparison to Type A.II is larger. This pattern occurs in *e.g. S. grande* Walp., *S. megacarpum* (Craib) Rathakr. & N.C.Nair and *S. vestitum* [Equivalent ot *Venation type A* (Klucking, 1989); *Group 1* (Chantaranothai & Parnell, 1994b)]

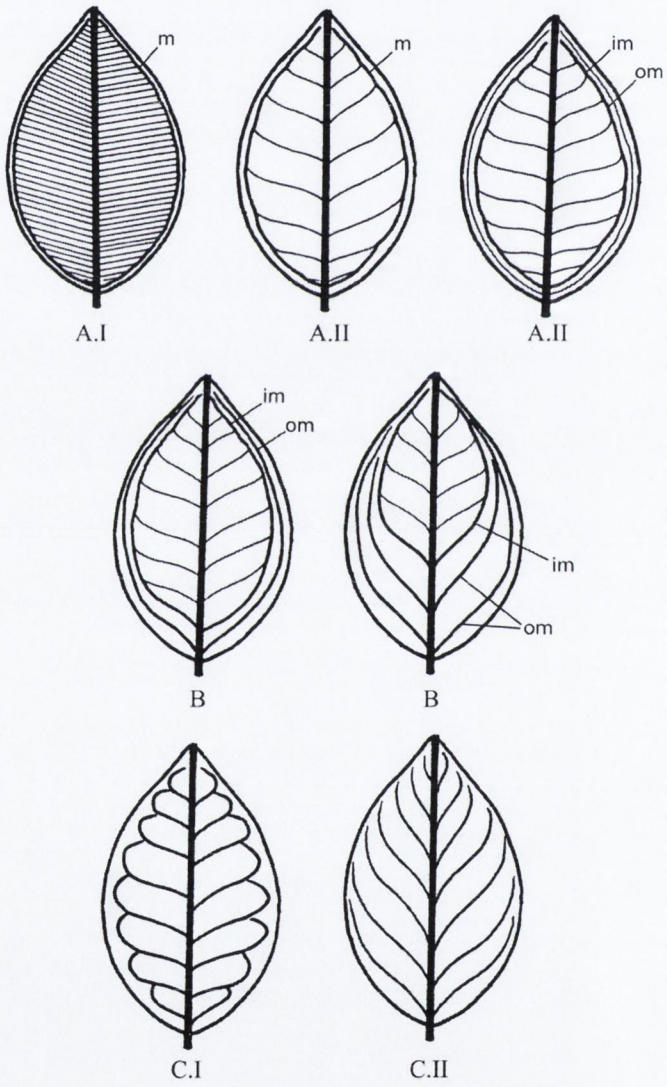

Figure 2.1. Leaf venation type in *Syzygium*. The abbreviations m = intramarginal veins, im = inner intramarginal veins, om = outer intramarginal veins. Drawing by the Author.

Type B: Secondary veins (secondary-like veins) broadly spaced, 1–3 pairs of basal secondary veins (acrodromous veins) arcuate, extend from the base to half way or near leaf apex and often forming outer intramarginal veins. The inner intramarginal veins extend from the lower half of the leaf distal to the basal secondary veins to leaf apex. Occurs in *e.g. S. balsameum* Walp., *S. polyanthum, S. hemisphericum* & *S. samarangense*. [Equivalent to *Venation type B* & *C* (Klucking, 1989); *Group 2* (Chantaranothai & Parnell (1994b)]

Note: In Chantaranothai & Parnell (1994b), the basal secondary veins that arch and extend towards apex are not interpreted as true intramarginal veins, *i.e.* they are not considered to be acrodromous veins but as intramarginal-like veins.

Type C: pinnate-like venation, the distance between secondary veins (secondary-like veins) is large, secondary veins looped or arcuate near margin but without forming distinct intramarginal veins. Occur in *e.g. S. glomerulatum* (Gagnep.) Merr. & L.M.Perry and *S. nervosum* A.Cunn. ex DC.. [Equivalent to venation type D (Klucking, 1989); Group 3 (Chantaranothai & Parnell, 1994b)]

Type C.I: The secondary veins looped.

Type C.II: The secondary veins arcuate.

Inflorescence

The inflorescence is either terminal, axillary on a leafy twig or lateral-axillary in the axil of a fallen leaf. The earlier two positions often occur together in the same specimen near the twig apex whereas the last one occurs exclusively. There are two types of inflorescence, unbranched and branched. The unbranched inflorescences can be racemose or solitary, and the branched as paniculate. In the paniculate inflorescence, the branch length varies from subsessile to long. When the length of the last order branch is very short, the flowers clump at the branch-end to form a flower head (*e.g. S. ripicola* (Craib) Merr. & L.M.Perry, *S. cumini*, *S. glomerulatum* & *S. grande*). Paniculate inflorescences vary in branch length and branch order. These characters when combined with other morphological characters, are useful for species identification.

Flower

There are two major hypanthium types, the first one is obconic/pyriform and the second type is clavate/elongate (Figure 2.2a-d). In this study, species with an elongated hypanthial cup are grouped together with those of clavate type. The clavate or elongate hypanthium differ from the obconic or pyriform in that the ovules are arranged in two longitudinal rows in each locule (Figure 2.3a). In the latter form, the ovules are arranged irregulary and radiating (Figure 2.3b). Sometimes the distinctions between the two forms are vague and there are intermediate forms, especially for species in the Subg. *Sequestratum.* The difficulty in recognising hypanthium types is illustrated in Chantaranothai and Parnell (1994), where seven types of hypanthium are recognised. In Indochina, elongate and clavate hypanthium are found in Subg. *Sequestratum* and Subg. *Perikion* respectively but rarely in Subg. *Syzygium* (only in *S. aromaticum* and *S. attenuatum* (Miq.) Merr. & L.M.Perry). The typical hypanthium types in Subg. *Syzygium* are obconic or pyriform. The flower in Subg. *Syzygium* is more diverse than in Subg. *Sequestratum* and *Perikion* in its size and shape of hypanthium, sepals and petals.

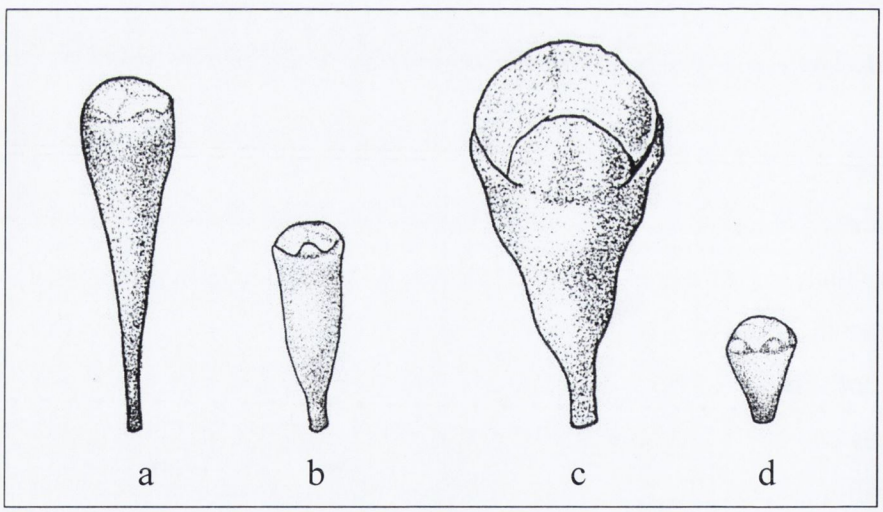

Figure 2.2a-d. Hypanthium type in *Syzygium* – a. Clavate; b. Elongate; c. Pyriform; d. Obconic. Images by the Author.

The pseudostalk is the part of the hypanthium that looks like a pedicel but that eventually develops into part of the fruit. Therefore, there is no clearcut separation of the hypanthium per se from the pseudostalk. The pseudostalk is separated from

the pedicel by an articulation and bracteoles. Ovule placentation in Indochinese species is either axile-median or axile-apical. Axile-apical placentation is only found in the Subg. *Acmena* (Figure 2.3c).

The locules in the anthers in most *Syzgium* species are elongate and parallel while only in Subg. *Acmena* are they divaricate (Figure 2.4a-b)

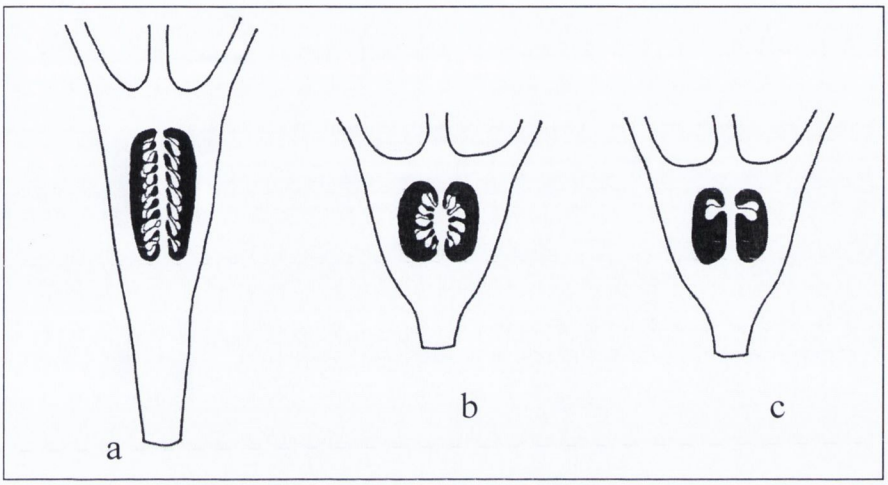

Figure 2.3a-c. Placentation type and ovules arrangement in *Syzygium* – a. Axile-median, ovules in two longitudinal rows per locule; b. Axile-median, ovules arranged irregulary and radiating; c. Axile-apical, ovules radiating horizontally. Images by the Author.

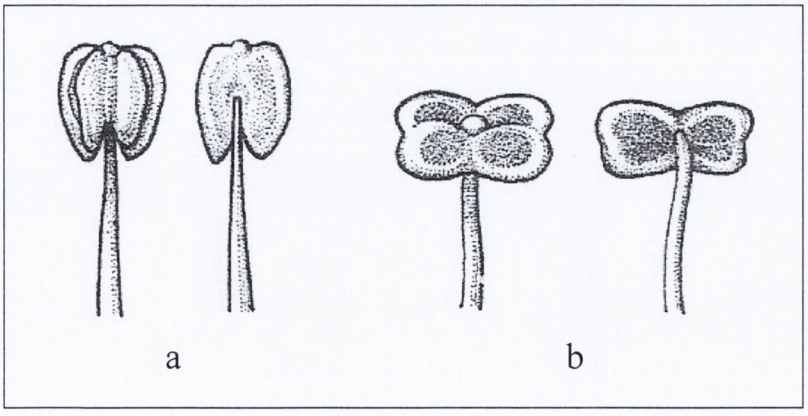

Figure 2.4a-b. Anthers in *Syzygium* – a. Anther locules elongate and parallel, dehiscence by longitudinal slits; b. Anthers locules divaricate, dehiscence by apical slits. Images extracted from Hyland (1983).

Fruits and seeds

The fruit comes in various shapes ranging from pyriform, globose, depressed globose, ellipsoid to obloid. The presence of seed intercotyledonary intrusion in Subg. *Acmena* and Subg. *Perikion* and the absence in Subg. *Syzygium* and Subg. *Sequestratum*, is an important character in segregating these two groups of Subgenera (Figure 2.5a-b). Hartley and Craven (1977) suggested that the intercotyledonary tissues are derived from the placenta (or funicle) since the direction of ramification in the seeds is correlated with the placentation type; that is apical in Subg. *Acmena* and lateral in Subg. *Perikion*.

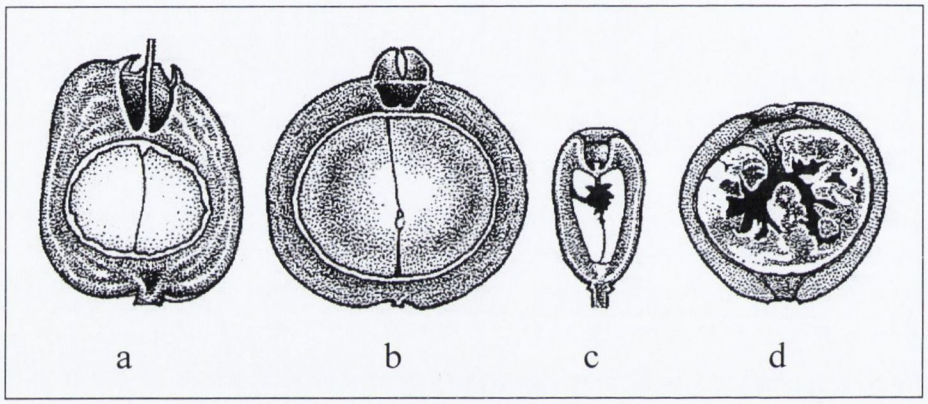

Figure 2.5a-b. Vertical section of *Syzygium* fruit – a-b. Seed without intercotyledonary intrusion; c. Seed with intercotyledonary intrusion ramifying from the side; d. Seed with intercotyledonary intrusion ramifying from the seed apex. Images extracted from Hyland (1983).

Chapter 3 Comparative leaf anatomy of *Syzygium* Gaertn.

3.1 Introduction

Research into the vegetative and floral anatomy of Myrtaceae gained momentum when macromorphological characters were unable to give satisfactory resolution to generic or suprageneric delimitation. For example, early workers were able to use wood and floral anatomical evidence to distinguish *Eugenia* and *Syzygium*: findings from the floral anatomy showed that both these taxa can be satisfactorily separated on the basis of ovule vascular supply system, which is transeptal in *Eugenia* and axile in *Syzygium* (Schmid 1972a, b); wood anatomy studies showed that vasicentric tracheids are absent in *Syzygium* but present in *Eugenia* and the fibres in *Syzygium* have simple or indistinctly bordered pits, whereas in *Eugenia* the pits are conspicuously bordered (Chattaway, 1959; Dadswell & Ingle, 1947; Ingle & Dadswell, 1953).

Noorma and Moore (1996) surveyed the leaf surface of *Syzygium* and *Eugenia* species, and demonstrated the potential use of micromorphological characters including leaf surface sculpturing, outer stomatal rims and stomatal types to differentiate both taxa. Khatijah et al. (1992), who surveyed leaf and petiole anatomy of selected species representative of Henderson's Groups 2 to 5, concluded that Henderson's group 4 appeared to be 'natural' in sharing characters like anisocytic stomata and a shallow arc-shaped vascular system in midrib and petiole. Henderson's group 4 is comparable to subg. *Sequestratum* Craven and Biffin. Khatijah's study (*op. cit.*) also supported *Acmena* as a distinct group but not *Cleistocalyx* and not Henderson's Groups 2 and 3. In addition to that, she identified 12 anatomical characters that were useful for species identification. In Thailand, Kantachot et al. (2007) surveyed 28 species from 12 genera of Myrtaceae in Thailand, and found 14 leaf anatomical characters that are useful for generic and species diagnosis. In accordance with Khatijah et al. (1992), they reject *Cleistocalyx* as a natural group (see Table 3.1).

The findings from other comparative studies on the taxonomic value of leaf anatomical characters in Myrtaceae are mixed. At higher taxonomic level, Keating (1984) identified at least seven leaf anatomical characters that are useful in delimitating 12 families in the Myrtales sensu Cronquist. These characters include the midrib shape, the venation, the shape and extent of extraxylary fibers, sclereids, epidermal and mesophyll features. For the New World species, Cardoso et al (2009) surveyed 44 species representative of 22 genera from the subtribe Myrtinae, Myrciinae and Eugeniinae. They examined the relative amount of palisade parenchyma, presence or absence of hypodermis, bundle sheath extension types and vascular system types, and found that these characters do not have diagnostic value in distinguishing taxa groupings at subfamilial, subtribal and generic level. Jarvie and Koerniati (1986) examined the leaf blade and petiole anatomy of wild and cultivated varieties of clove (*S. aromaticum*). They found that characters like vascular bundle shape, crystal types and abundance, oil gland size and abundance exhibit variations among the varieties but are not diagnostic enough for delimitation of varieties. Other studies are more descriptive, for example Metcalfe and Chalk (1950) gave a general review of the anatomy of Myrtaceae and Klucking (1989) made a survey of the leaf venation of 85 genera of Myrtaceae.

Considering the high diversity and size of *Syzygium*, other than the study by Khatijah et al. (1992), Noorma and Moore (1996) and Kantachot et al. (2007), little is known about the leaf anatomy of *Syzygium* and its value in taxonomy. Therefore, a comparative study of the leaf anatomy of *Syzygium* was undertaken to assess its taxonomic value at subgeneric or species level. The specific aims of this study are to:

1. Characterize the leaf anatomy of *Syzygium.*
2. Identify leaf anatomical characters that are diagnostic for infrageneric groups and species.

Table 3.1. Comparison of different studies on *Syzygium* (and its allies) and *Eugenia* that utilized morphological, anatomical and molecular characaters.Taxa that are recognized by the authors as associated with or undifferentiated from *Syzygium* are indicated by shading. For simplicity, only selected genera that are recently recognized are listed here. The dash indicate taxa not included in the study.

<table>
<tr><th rowspan="2">Taxa</th><th colspan="4">Morphology</th></tr>
<tr><th>Flower morphology</th><th>Flower , fruit and seed morphology</th><th>Flower and vegetative morphology (phenetic and phylogenetic)</th><th>Reproductive and vegetative anatomical and morphological characters (phylogenetic)</th></tr>
<tr><th></th><th>Henderson (1949)</th><th>Hyland (1983)</th><th>Parnell (1999)</th><th>Briggs & Johnson (1979); Johnson and Briggs (1984)</th></tr>
<tr><td rowspan="5">Syzygium</td><td>Sect. Syzygium: Group 1 (Jambosa)</td><td rowspan="5">14 informal groups</td><td>Monophyletic group (Sect. jambosa)</td><td rowspan="5">Acmena alliance (glabrous or hair multicellular)

- Syzygium suballiance (cotyledons free without intrusive tissue)</td></tr>
<tr><td>Sect. Syzygium: Group 2</td><td rowspan="4">Polyphyletic group,</td></tr>
<tr><td>Sect. Syzygium: Group 3</td></tr>
<tr><td>Sect. Syzygium: Group 4</td></tr>
<tr><td>Cleistocalyx/ calyptrate calyces spp.</td><td>Sect. Cleistocalyx</td></tr>
<tr><td>Acmena</td><td>Sect. Acmena</td><td>2 informal groups</td><td rowspan="4">Acmena alliance

– Acmena suballiance (cotyledons fused or interlocked by intrusive tissue)</td></tr>
<tr><td>Acmenosperma</td><td>Sect. Syzygium : group 5</td><td>1 group</td></tr>
<tr><td>Piliocalyx</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Waterhousea</td><td>-</td><td>2 informal groups</td><td>-</td></tr>
<tr><td>Other taxa</td><td>Sect. Fissicalyx</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Eugenia s.s.</td><td>Sect. Eu-Eugenia</td><td>distinct</td><td>-</td><td>Eugenia alliance – hairs unicellular</td></tr>
</table>

Table 3.1 continued

Taxa	Anatomy					
	Wood anatomy	**Flower anatomy**	**Pollen**	**Leaf surface**	**Leaf and petiole anatomy**	**Leaf and petiole anatomy**
	Dadswell & Ingle (1947); Ingle & Dadswell (1953)	**Schmid 1972a, b**	**Noorma & Moore (1994); Parnell (2003)**	**Noorma & Moore (1996)**	**Khatijah et al. (1992) Based on Henderson's (1949) classification**	**Kantachot et al. (2007)**
Syzygium	*Eugenia* B (vasicentric tracheids absent, fibres with simple to indistinctly bordered pits)	*Syzygium* s.l. (axile vascular supply to ovules)		Majority paracytic stomata, T-piece cutinisation prominent, trichome usually absent (14 spp.)	-	(petiole vasculature heart-shaped or U-shaped)
					Sect. *Syzygium* : Group 2 & 3	
					Sect. *Syzygium*: Group 4	
Cleistocalyx/ calyptrate calyces spp.				-	Sect. *Cleistocalyx*	
Acmena				-	distinct	-
Acmenosperma	-	-			distinct	
Piliocalyx		-	-	-	-	-
Waterhousea	-	-	-	-	-	-
Other taxa	-	-	-	-	Sect. Fissicalyx	-
Eugenia s.s.	*Eugenia* A (vasicentric tracheids present, firbres with conspicuously bordered pits)	*Eugenia* s.s. (transeptal vascular supply to ovules)		T- piece cutinisation not prominent, trichome usually present (7 spp.)	-	(petiole vasculature circular)

Table 3.1 continued

Taxa	DNA		
	Nuclear DNA (ETS-ITS)	**Chloroplast DNA (matK)**	**Chloroplast DNA** (*matK*, *ndhF* and *rpl*16)
	Harrington & Gadek (2004)	**Wilson et al. (2005)**	**Biffin et al. (2006) & Craven et al. (2006)**
Syzygium	Clade A (BS 77%; PP 99%) - I, II, III	Tribe Syzygieae Wilson	Group I (BS 97%; PP 100%)
	Clade B (BS 100%; PP 100%)		Group III (BS 100%; PP 100%)
Cleistocalyx/ calyptrate calyces spp.	Clade A- II(BS 100%; PP 100%) , III (BS 97%; PP 100%)	-	Group I, II, IV
Acmena	Clade A –I (BS 82%; PP 100%)		Group II (BS 96%; PP 100%)
Acmenosperma	Clade A –II	-	Group IV (BS 99%; PP 100%)
Piliocalyx	-	-	Group II
Waterhousea	Clade A- I	-	Group II
Other taxa	*Anetholea*: Clade A	*Anetholea*	*Anetholea* (BS 100%; PP 100%)
Eugenia s.s.	-	Tribe Myrteae DC	outgroup

3.2 Material and methods

The leaf anatomy of 78 *Syzygium* species was examined (see Appendix 1 for list of samples used). The species infrageneric classification follows Craven and Biffin (2010). Twenty-seven species used in this study were species included in the molecular study of Biffin et al. (2006) and on which their infrageneric classification was based. All specimens were taken from herbarium specimens in **BKF**, **L**, **P** and **TCD** herbaria. Species sampled in this study are distributed from Southeast Asia to the Southwest Pacific, ranging from narrow to broad range distributions. All plant material was mature and is believed to be at the same developmental stage. The majority of species chosen were morphologically representative of species grouping suggested by Henderson (1949) and Hyland (1983). Segregate genera of *Syzygium* s.l. included in this study are as follows: *Acmena*, *Acmenosperma*, *Cleistocalyx*, *Jambosa*, *Piliocalyx*[2], *Stereocaryum* and *Waterhousea*. Other small genera not covered here include: *Acicalyptus*, *Anetholea*, *Cupheanthus*, *Paraeugenia*, *Pseudoeugenia* and *Tetraeugenia*.

For the anatomical observations, temporary and permanent slides were prepared following standard methods (Cutler et al., 2008). To prepare temporary slides, portions of the herbarium specimens were hydrated by boiling in water for c. 10 minutes until soft. Then the median region of the leaf and petiole were mounted between two pieces of carrot and transversally sectioned with a sliding microtome (Leica SM 2000R). The sections were cleared with a commercial solution of sodium hypochlorite (20%), unstained and mounted on the slides with glycerol. To prepare permanent slides, the material was dehydrated in a graded ethanol series, embedded in paraffin, sectioned (10-15µm) with a rotary microtome (Leica RM2255), stained in Safranin and Fast Green solutions and permanently mounted with DPX (Cutler et al., 2008). Cuticular peels were prepared by soaking samples overnight in 70% nitric acid and then the epidermises were separated using forceps. The cleaned epidermises were stained in Safranin and mounted in glycerol. All slides were examined and photographed using an Olympus BX60 light microscope equipped with an Olympus Camedia C-5060 camera and Olympus DP-Soft software. 44 anatomical characters were

[2] L.A. Craven (pers. comm.) is revising the New Caledonian representatives of *Piliocalyx* in collaboration with J.W. Dawson and will be treating them under *Syzygium*.

recorded; most were qualitative (41) and a few were quantitative (3). Characters that are suspected to be under environmental control were not recorded and these are usually quantitative characters such as stomatal size, epidermal cell size and oil gland size. The percentage of palisade parenchyma, leaf thickness and midrib thickness were measured on photomicrographs. The dimensions of epidermal cell size were estimated by eyes. Polarizing filters were used in the light microscope to detect lignified tissues, crystals and sclereids.

The classification of stomata generally follows Metcalfe and Chalk (1950) and Wilkinson (1979) but with slight modification (see section 3.3.1). Therefore, stomatal classification is morphological and no ontogenetic studies were made.

3.3 Results and discussions

Table 3.2. summarises the essential anatomical characters of the 80 species plus 14 other species taken from Khatijah et al. (1992).

Table 3.2. Summary of leaf anatomical characters recorded here in this study (78 spp.) and taken from literature (14 spp.). Species are arranged in taxonomic groups and then in alphabetical order.

	Lamina (surface view)						Crystals		Midrib vascular system (transverse-section)					Lamina (transverse-section)									
Species	paracytic	anisocytic	anomocytic	Cyclo-staurocytic	Epidermal abaxial anticlinal cell wall	Cuticular surface ornamentation	Druses	Prismatic crystals	Adaxial midrib outline	Abaxial midrib outline	Partition at adaxial phloem	Midrib vascular	Sclerenchyma continuity	Lamina thickness (µm)	Lamina adaxial epidermal cells dimension	Lamina abaxial epidermis cells shape	Hypodermis	Number of palisade layers	Abaxial palisade	Palisade (%) in mesophyll	Bundle sheath extension	Lamina birefringence	Foliar sclereids
Subg. *Syzygium*																							
S. angkae	+	-	-	-	cur-und	-	+	-	cc	cv	-	A	cont	120-123	w>h	w>h	-	1	-	20-30	-	P, S	-
*S. anisosepalum**	+	?	-	-	str	?	+	-	cc	cv	?	A	disc	200-400	w>h	w>h	-	2	-	?	?	?	-
S. aqueum	+	±	-	-	und	+	+	-	cc	cv	-	A	cont	200-230	w=h-w>h	w>h	-	1	-	25	-	E,P,S	-
S. aromaticum	+	±	-	-	und	+	+	-	fl	cv	-	A	disc	245-280	w>h	w>h	-	1	-	10	-	E,P,S	-
S. attopeuense	+	±	-	-	str-cur	+	+	-	gr-fl	cv	-	AIM	cont-disc	182-254	w>h	irr	-	1	+	30	-	P, S	-
S. balsameum	+	±	-	-	str	-	+	-	gr	ag	-	CO	cont	169-193	w>h	w>h	-	1	-	20-30	-	P, S	-
S. borneense	+	±	-	-	cur-und	+	+	-	cc-gr	cv	-	AIM	cont-disc	237-266	w=h	w>h	-	1	+	30	-	P, S	-
S. bullockii	+	±	-	-	str-cur	-	+	-	cc	cv	-	A	disc	214-248	w=h	w=h	-	1	-	20	-	E, S	-
*S. chloranthum**	+	?	-	-	und	?	+	-	cc	cv	-	A	cont	300	w=h-w>h	w>h	-	2	-	?	?	?	-
S. cumini	+	±	-	-	str-cur	-	+	-	cc-fl	cv	-	A	cont	161-190	w>h	w>h	-\+	1	-	15-30	-	-	-
*S. curtisii**	+	?	-	-	str	?	+	-	cc	ag	?	A	cont	200-400	w<h-w>h	w>h	-	1		?	?	?	-
S. diospyrifolium	+	-	-	-	und	-	+	±	cc	cv	-	C	cont	228-279	w=h	w>h	-\+	3	-	30	-	P,S	-
*S. duthieanum**	+	?	-	-	str	?	+	-	gr	cv	-	A	cont	300-500	w<h	w>h	-	1	-	?	?	?	-
*S. dyerianum**	+	?	-	-	str	?	+	-	gr	cv	-	AIB	cont	200-500	w=h-w<h	w>h	-	2-3	-	?	?	?	-
S. fastigiatum	+	-	-	-	cur-und	-	+	-	cv	ag	-	C	cont	227-228	w>h	w>h	-	3	-	30-40	-	E, S	-
S. formosum	+	-	-	-	und	+	+	-	cc-fl	cv-ag	-	C	cont	331-344	w=h	w>h	-	1	-	20	-	P,S	-
S. grande	+	-	-	-	str	-	+	-	cc	cv	-	A	cont	340-434	w=h	w=h	-	2-3	+	35-45	-	E, S	-
*S. griffithii**	+	?	-	-	cur	?	+	-	cc	cv	-	CO	cont	200-400	w=h-w<h	w>h	-	3	-	?	?	?	-
S. hancei	+	±	-	-	str-cur, cur-und	-	+	±	cc	cv-ag	-	A	cont-disc	315-412	w=h	w>h	-	2-3	-	30-40	-	E,P,S	-
S. harmandii	+	-	-	-	str-cur	+	+	-	fl	cv	-	C	cont	242	w=h	w=h	-	1	-	30	-	S	-
*S. helferi**	+	?	-	-	und	?	+	-	fl	cv	-	A	cont	150-200	w=h-w>h	w>h	-	1	-	?	?	?	+
S. hemisphericum	+	±	-	-	und	-	+	-	cc	cv	-	A	disc	119-122	w>h	w>h	-	1	-	30	-	-	+

Table 3.2 continued

S. imitans	+	-	-	-	cur-und	-	+	-	cc	cv	-	A	cont	157-170	w>h	w>h	-	1	-	20	-	S	-
S. inophyllum var. bernardi *	+	?	-	-	und	?	+	-	fl	cv	-	A	cont	200-250	w>h	w>h	-	1	-	?	?	?	-
S. jambos	+	±	-	-	und	-	+	±	cc-fl	cv	-	A	disc	223-250	w>h	w>h	-	1	-	15-20	-	E, S	+
S. khaoyensis	+	-	-	-	str-cur	-	+	-	cc	cv	-	A	cont	224-300	w>h	w>h	-	1	-	30	-	E,P,S	-
*S. leptostemon**	+	?	-	-	cur-und	?	+	-	cc-fl	ag	-	C	disc	200-300	w=h-w>h	w>h	-	1	-	?	?	?	-
S. levinei	+	±	-	-	cur-und	-	+	-	gr	cv	-	A	cont	238-247	w=h	w>h	-	1	-	25-30	-	E,P,S	-
S. lineatum	+	-	-	-	cur-und	-	+	-	cc	cv	-	A	cont	212-277	w=h	w>h	-	1	-	30-33	-	E,P,S	-
S. malaccense	+	±	-	-	str	-	+	-	gr	cv	-	A	cont	150-160	w>h	w>h	-\+	2		30	-	S	+
S. megacarpum	+	-	-	-	und	-	+	-	gr	cv	-	A	disc	322-412	w=h	w>h	-	1	-	25	-	P, S	-
S. nervosum	+	-	-	-	cur-und	-	+	-	cc	cv	-	AIB	cont-disc	213-235	w>h	w>h	-	1	-	20	-	E,P,S	-
S. nigrans	+	-	-	-	str-cur	-	+	-	cc	cv	-	A	cont	191-193	w>h	w>h	-	2	-	25-30	+	E, S	+
S. oblatum	+	±	-	-	cur-und	-	+	-	cc	cv	-	A-AIM	cont	203-239	w>h - w=h	w>h	-	1-2	-	25-30	-	E, S	-
S. pachysarcum	+	±	-	-	cur-und	-	+	-	cc	cv	-	A	cont	270-307	w<h	w>h	-	1	-	25	-	E,P,S	-
*S. papillosum**	+	?	-	-	str-und	?	+	-	cc	cv	-	A	cont	300-400	w=h-w>h	w>h	+	1	-	?	?	?	-
S. phengklaii	+	-	-	-	str-cur	-	+	-	cc	cv	-	A	cont	204-300	w=h	w>h	-	1	-	30	-	E, S	+
S. pierrei	+	±	-	-	str	-	+	-	cv	cv	-	A	cont	138	w>h	w>h	-	1	-	30	-	E, S	+
S. polyanthum	+	-	-	-	und	-	+	-	cc-fl	cv		C	cont	253-258	w>h	w>h	-	3	-	30	-	E, S	-
S. praecox	+	±	-	-	und-cur	-	+	-	gr	cv	-	A	cont	144-221	w=h	w>h	-	2	-	50	-	E, S	-
*S. pseudosubtilis**	+	?	-	-	cur-und	?	+	-	cc	cv	-	AIM	disc	200-300	w=h-w<h	w>h	-	1	-	?	?	?	-
*S. pycnanthum** (as *E.. densiflorum)*	+	?	-	-	str	?	+	-	cc	ag	?	A	disc	200-300	w<h-w>h	w>h	-	1	-	?	?	?	-
S. ripicola	+	±	-	-	cur-und	-	+	-	cc	cv-ag	-	A	cont	195-202	w>h	w>h	+	2	+	40	+	P, S	-
S. sclerophyllum	+	±	-	-	str-cur	-	+	-	cc	cv	-	A	cont	360-453	w=h-w<h	w>h	-	3	-	45	-	E,P,S	-
S. siamense	+	±	-	-	und	-	+	-	cc	cv	-	A	cont	176-185	w>h	w>h	-	1	-	20-25	-	E, S	+
S. sterrophyllum	+	-	-	-	str-cur	-	+	-	cc	ag	+	A	disc	286-292	w=h	w=h-w>h	-	1-2	-	25-30	-	E,P,S	-
*S. subdecussatum**	+	?	-	-	str	?	+	-	cc	ag	+	A	cont	300-500	w<h	w>h	-	1	-	?	?	?	-
*S. symingtonianum**	+	?	-	-	und	?	+	-	gr	cv	-	CO	cont	200-400	w>h	w>h	-	2	-	?	?	?	-
S. syzygioides	+	-	-	-	cur-und	-	+	-	cc	cv	-	A	cont	191-207	w=h	w>h	-	3	-	30	-	E,P,S	-
S. tetragonum	+	-	-	-	str-cur	-	+	-	gr	ag	-	CO	cont-disc	167-263	w>h	w>h	-	1	-	15-30	-	E,P,S	-
S. thorelii	+	±	-	-	und	-	+	-	cc -fl	cv	-	A	cont-disc	202-247	w>h	w>h	-	2	-	40	-	E, S	-
S. tonkinense	+	-	-	-	und	-	+	-	cc	ag	-	A	disc	235	w>h	w>h	-	1	-	30	-	E, S	-
S. vestitum	+	-	-	-	cur-und	-	+	-	cc-gr	cv	-	A	cont-disc	152-160	w>h	w>h	-	2	-	20-25	-	E, S	-
S. zimmermanni	+	±	-	-	cur-und	-	+	-	cv	ag	-	A	disc	157-160	w>h	w>h		1	-	40	-	E, S	-

Table 3.2 continued.

Subg. *Acmena*																								
Piliocalyx francii	-	-	-	+	str-cur	-	±	+	cc-fl	cv-ag	+	AIM	cont	230-250	w=h	w>h	+	2	-	25	-	E,P,S	-
S. acuminatissimum	-	-	-	+	und	-	±	+	cc	cv	+	AIM	cont	228-274	w>h	w=h	-	1	-	30-40	-	E,P,S	-
S. divaricatum	-	-	-	+	und	+	-	+	cc	cv	+	AIM	disc	180-230	w=h	w=h	-	1	-	15-20	-	E,P,S	-
S. graveolens	-	-	-	+	cur	-	-	+	cc	cv	±	AIM	cont	222-240	w=h	w=h	-	1	-	25	-	E,P,S	
S. gustavioides	-	-	-	+	str	+	±	+	gr	cv	±	AIM	cont	260-280	w=h	w>h	+	3	-	45-50	-	E,P,S	-
S. hedraiophyllum	-	-	-	+	str-cur	-	-	+	cc	cv	±	AIM	disc	114-200	w=h	w>h	-	1	+	40	-	E,P,S	-
S. mackinnonianum	-	-	-	+	und	-	-	+	cc	cv	+	A	disc	150-160	w=h	w=h	-	1	-	25-30	-	E,P,S	-
S. mulgraveanum	-	-	-	+	cur-und	-	-	+	cc	cv	-	A	cont	150-175	w=h	w>h	-	2	-	25	-	E,P,S	-
S. smithii	-	-	-	+	cur-und	-	±	+	cc	cv	±	A	disc	200-260	w=h	w=h	-	1	+	15-20	-	E,P,S	-
S. unipunctatum	-	-	-	+	cur	-	-	+	cc	cv	+	A	cont	200-240	w=h	w>h	-	1	-	30	+	E,P,S	-
Subg. *Sequestratum*																								
S. aksornae	-	+	±	-	und	-	-	+	cc-gr	cv	+	A	cont	160-230	w>h	w>h	-	2	-	30	-	E,P,S	-
S. araiocladum	-	+	±	-	und	-	-	+	cc	cv-fl	+	A	cont	190	w>h	w>h	-	2	-	25	-	E,P,S	-
S. bankense	-	+	±	-	und	-	±	+	cc-gr	cv-fl	+	A	cont	300-380	w>h	w>h	-	2-3	-	30	-	E,P,S	-
S. bicolor	-	+	±	-	und	-	-	+	cc-gr	cv	+	A	cont	230-250	w<h	w>h	-	2-3	+	40	-	E,P,S	-
S. cryptophlebium	-	+	±	-	und	-	-	+	cv	cv-fl	- \±	A	cont	300-350	w>h	w>h	-	2	-	15-20	-	E,P,S	-
S. francisii	-	+	±	-	und	-	+	+	cc-fl	cv	+	A	cont	310-367	w>h	w>h		2	-	30	-	E,P,S	-
S. antisepticum/ S. zeylanicum	-	+	±	-	und	-	±	+	cc	cv	+	A	cont	286-302	w>h	w>h	-	2	-	30-40	-	E,P,S	-
S. jasminifolium	-	+	±	-	und	-	-	+	cc	cv	+	A	cont	150-180	w>h	w>h	-	2	-	20	-	E,P,S	-
S. kinabaluense	-	+	±	-	und	-	±	+	cc-gr	cv	±	A	cont	400-470	w=h-w<h	w>h	-	2-3	+	45-50	-	E,P,S	-
S. luehmannii	-	+	±	-	und	-	±	+	fl	cv-fl	+	A	cont	190-245	w>h	w>h	-	2	-	30-35	-	E,P,S	
S. multibracteolatum	-	+	±	-	und	-	-	+	cc	cv-fl	+	A	cont	350-400	w>h	w>h	-	2	-	30	-	E,P,S	-
S. nummularium	-	+	±	-	und	-	-	+	cc	cv-fl	+	A	cont	380-420	w>h	w>h	-	2	-	25-30	-	E,P,S	-
S. odoratum	-	+	±	-	und	-	±	+	fl	cv	-	A	cont	370-420	w>h	w>h	-	2	-	30	-	E,P,S	-
S. polycladum	-	+	±	-	und	-	-	+	cc	fl	+	A	cont	390-415	w>h	w>h	-	3	-	30	-	E,P,S	-
S. pterophorum	-	+	±	-	und	-	-	+	cc	cv	+	A	cont	397-418	w>h	w>h	-	2-3	-	40-50	-	E,P,S	-
S. staphianum	-	+	±	-	und	-	-	+	gr	fl	-	A	cont	398-422	w>h	w>h	-	3	-	45-50	-	E,P,S	-
S. tenuirame	-	+	±	-	und	-	-	+	cc	fl	+	A	cont	187-190	w>h	w>h	-	3	-	45	-	E,P,S	-
S. tephrodes	-	+	±	-	und	-	-	+	cc	cv	+	A	cont	297-310	w>h	w>h	-	2	-	30		E,P,S	-
S. tetrapterum	-	+	±	-	und	-	-	+	cc	cv	+	A	cont	340-400	w>h	w>h	-	2-3	-	10-30	-	E,P,S	-
S. tsoongii	-	+	±	-	und	-	-	+	cc-gr	cv-fl	+	A	cont	320-332	w=h	w>h	-	2-3	-	30	-	E,P,S	-
S. wilsonii	-	+	±	-	und	-	±	+	cv	cv-fl	-	A	cont	230-255	w>h	w>h	-	2	-	30	-	E,P,S	-

Table 3.2 continued.

Subg. *Perikion*																							
S. abortivum	-	±	-	+	str-cur	-	-	+	cc	cv	+	AIM	cont	156-205	w=h	w>h	-	2-3	-	35	-	*S*	-
S. apodophyllum	+	+	-	-	und	-	-	+	gr	cv	+	A	cont	210-223	w>h	w>h	-	1-2	-	30	-	E,P,S	-
S. attenuatum	-	+	-	+	str	-	-	+	fl	cv-fl	-	AIM	cont	240-279	w>h	w>h	-\+	2-3	-	45-50	-	E,P,S	-
S. boisianum	-	+	-	±	str-cur	-	±	+	cc	cv	+	A	cont	213-240	w>h	w>h	-	1	-	17-20	-	E,P,S	-
S. canicortex	-	-	-	+	und	+	-	+	fl	fl	+	A	cont	265-278	w=h	w>h	-	1	-	25-30	-	E,P,S	-
S. championii	-	+	-	+	str-cur	-	-	+	cc	cv	+	AIM	cont	164-167	w>h	w>h	-	1	-	20	-	E, S	-
S. claviflorum	-	+	-	+	str-cur	-	±	+	cc	cv	±	AIM	cont	171-213	w>h	w>h	-	3	-	30	-	E,P,S	-
S. coryanthum	+	+	-	-	str-cur	-	-	+	gr	cv	+	A	cont	325-400	w=h	w=h	-	2-3	-	35-40	-	E,P,S	-
S. multipetalum	-	-	-	+	str	-	±	+	cv	cv	+	AIM	cont	550-570	w<h	w>h	-	3	-	40	-	E,P,S	-

- Species names in bold are the species used by Biffin et al., 2006 in molecular phylogenetic studies.
- * data taken from literature (Khatijah et al., 1992), information that is not available is marked with question mark.
- '+' = present (with the exception for stomata and crystals this means present and predominant); ' –' = absent; ± = present but infrequent (stomata and crystals) or poorly developed (adaxial phloem partition).
- Lamina: E = epidermis; P = palisade; S = spongy mesophyll. Epidermal anticlinal cell wall: str = straight; cur = curved; und = undulate; irr = irregular. Epidermal cells dimension: w = width; h = height. Midrib outline: ag = angled; cc = concave; gr = grooved; cv = convex; fl = flattish. Sclerenchyma: cont=continuous; disc = discontinuous. Midrib vascular system: A = arc with straight margins; AIM = arc with incurved margins; AIB = arc with interrupted bundles at margins; C = cylindrical; CO = complex open system.

3.3.1 General generic description

Lamina (surface view)

Indumentum absent except in *S. vestitum*, which has multicellular and multiseriate hairs (Plate 3.8-E, F). The cuticle in most species has a smooth surface, but in some it is striated on both surfaces or only on abaxial surface.

All leaves are hypostomatic[3]. Stomata appear either slightly raised or level with the epidermis. At the stomatal poles, most species are with polar cutinised T-pieces (Plate 3.1). The outer ledge is well-developed, whereas the inner ledge is absent. The average stomatal length for each species studied here varies from 15-28 μm and the average width from 15-22 μm. The average stomatal density ranges from 222 to 918 stomata per mm^2.

There are four stomatal types: anisocytic, anomocytic, cyclo-staurocytic and paracytic. These stomata either occur exclusively or in combination side by side with other stomatal types. Species in subg. *Syzygium* have either paracytic or predominantly paracytic mixed with some anisocytic stomata. In subg. *Acmena*, the stomata are exclusively cyclocytic. In subg. *Sequestratum*, the stomatal types are predominantly anisocytic mixed with some anomocytic. The stomatal types for subg. *Perikion* species vary, there are species with exclusively cyclo-staurocytic or species with a mixture of paracytic and anisocytic at more or less equal frequency and another group of species with a mixture of anisocytic and staurocytic stomata in various frequency. The following are the descriptions and interpretations of stomatal types found in *Syzygium*:

1. Anisocytic (Plate 3.1-B, D, E): the guard cells are surrounded by three cells that are not radially arranged. The subsidiary cells are mostly unequal in size, and one of the three is smaller than the other two cells. The subsidiary cells usually have the same staining properties as the surrounding epidermal cells

[3] Although this is uncommon in Myrtaceae, in *Syzygium*, the stomata of species with isobilateral leaves are present only on the abaxial leaf surface.

2. Anomocytic (Plate 3.1-D,H): the cells surrounding the guard cells do not form any recognizable and consistent pattern and they are not differentiated from other epidermal cells.
3. Cyclo- staurocytic[4]- (Plate 3.1-E, F,G): four or more subsidiary cells surrounding the guard cells in single or double layers, more or less radially arranged and ring-like. The radial diameter of the subsidiary cells can be larger than their tangential width or smaller giving rise to narrow or thick ring-like formations respectively. The size of subsidiary cells varies from equal to more or less unequal. The subsidiary cells have different staining properties from the surrounding epidermal cells.
4. Paracytic (Plate 3.1-A,B,C): the guard cells are flanked by two subsidiary cells, either extending over the poles of guard cells or not, and of equal or unequal size. The subsidiary cells can have similar or different staining properties as epidermal cells.

Anticlinal cell walls varies among species, ranging from straight (Plate 3.1-C), curved (Plate 3.1-F) to undulate (Plate 3.1-D). Intermediate cell wall curvatures are often present such as straight-curved (Plate 3.1-G) and curved-undulate (Plate 3.1-H). Usually the adaxial and abaxial anticlinal cell walls are of the same pattern. In some species the anticlinal wall patterns are different on both surfaces (*e.g.* S. *megacarpum* and *S. nigrans* (Gagnep.) Craven & Biffin).

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[4] Wilkinson (1979) extended Metcalfe and Chalk's (1950) stomata classification by differentiating actinocytic from cyclocytic types. The term cyclocytic proposed by Stace (1965), is actually an extension of actinocytic stomata types that was originally proposed by Metcalfe and Chalk (1950). Wilkinson (op. cit.) added that the subsidiary cells of actinocytic stomata are radially elongated, this implies that the radial diameters or the cells is bigger than their tangential width, and that the subsidiary cells of cyclocytic are the opposite (therefore, the tendency to form narrow rings). In this study, I consider actinocytic and cyclocytic to be the same stomatotype and that they are probably variants of one another. The term cyclocytic was used here in *Syzygium* because of the tendency of these stomata towards cyclocytic form, in having subsidiary cells that varies from equal width and height to wider than high.

van Cotthem (1970) introduced the term staurocytic and defined it as 'stoma surrounded by four (sometimes three or five) similar subsidiary cells with anticlinal walls arranged crosswise to the guard cells; subsidiary cells more or less radially elongated; the 'cross' randomly orientated to the long axis of the pore'. Later, Wilkinson (1979) broadened the term by adding 'the cell walls at the right angles to the long axis of the pore are variously oriented' after she considered anomotetracytic stomata of Dilcher (1974) as a variant form of staurocytic stomata. Dilcher (1974) differentiate anomotetracytic from staurocytic in having subsidiary cells that are not arranged strictly crosswise but irregular and variable in pattern.

In this study, there is an intergrading characters of cyclocytic and staurocytic stomatal types, and hence the term cyclo-staurocytic is used.

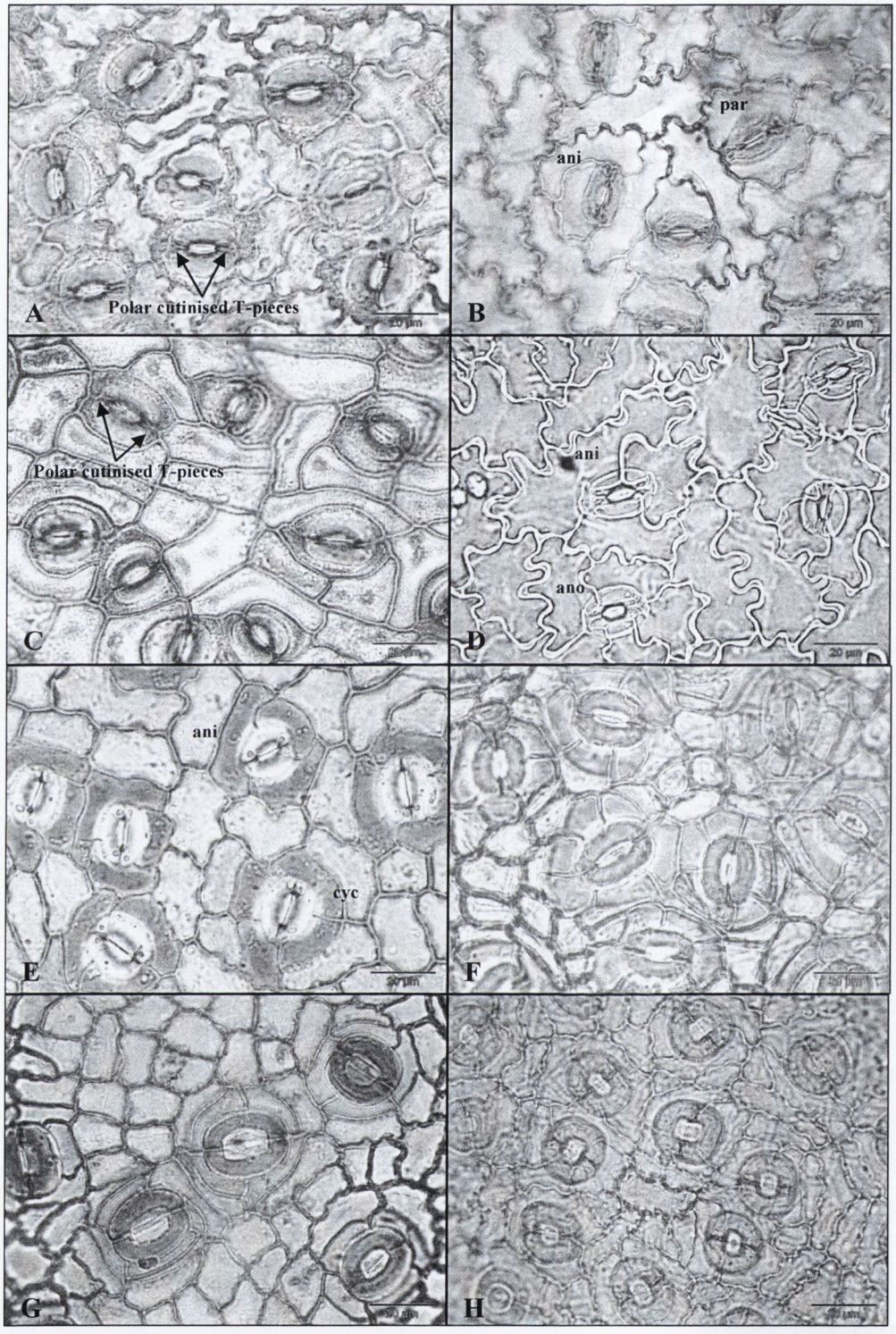

Plate 3.1. Stomata × 400. (A) *S. angkae*, paracytic stomata. (B) *S. apodophyllum* (F.Muell.) B.Hyland, paracytic and anisocytic stomata. (C) *S. malaccense*, paracytic stomata and anisocytic stomata. (D) *S. aksornae* P.Chantaranothai & J.Parn., anisocytic and anomocytic stomata. (E) *S. claviflorum* (Roxb.) Wall ex Steudel, anisocytic and cyclo-staurocytic stomata. (F) *S. graveolens* (F.M.Bailey)

Craven & Biffin, cyclocytic stomata. (G) *S. hedraiophyllum* (F.Muell.) Craven & Biffin, cyclocytic stomata. (H) *S. mulgraveanum* (B.Hyland) Craven & Biffin, anomocytic stomata. ani: anisocytic, ano: anocytic, cyc: cyclo-staurocytic, par: paracytic.

Lamina (tranverse-section)

The leaves of most species are bifacial, rarely isobilateral, with a range of thickness between 119 and 570 μm. The cuticle is between the range of 1.4 and 6.7 μm in thickenss. In transverse-section, adaxial and abaxial epidermal cells in most species are wider than high, in some species they are of equal width and height or higher than wide. The shapes of these cells are mostly regular, ranging from square to rectangular. In *Syzygium attopeuense*, the abaxial epidermal cells are papillate (Plate 3.6-A). The dimensions of the cells on adaxial and abaxial surface are not always the same and can exist in any combination. A hypodermis is absent in most species, occurring only in a few species within each group, but never in subg. *Sequestratum*. The hypodermis can be locally differentiated or continuous in 1-2 layers (Plate 3.6-E). The occurrence of a hypodermis can be inconsistent: it can be present or absent within the same species or consistently present. Therefore, this character does not have much taxonomic value.

The number of adaxial palisade cell layers varies among different species but is consistent within the same species, occurring in one-layer, two-layers to three-layers. The layer closest to the spongy mesophyll is usually poorly differentiated and shorter than the next outermost layer. The percentage of adaxial palisade parenchyma that occupies the mesophyll varies to the range of 10% to 50%. In species with isobilateral leaves, the abaxial palisade parenchyma is one-layered, poorly differentiated and shorter than the adaxial palisade parencyhyma. Abaxial palisade parenchyma (Plate 3.6-C, E) occurs infrequently in species throughout all subgenera. The spongy parenchyma for the species studied is loose and in 8-16 layers. Birefringence of mesophyll cells, indicating secondary lignified cell walls, is present in most species but absent in a few species in subg. *Syzygium* (*e.g. S. cumini* and *S. hemisphericum*). The birefringence is weak to strong and may be present in epidermis, palisade and spongy tissue (Plate 3.5-B, C, D). However most birefringence occurs in the epidermis and palisade parenchyma. Subgenera

Acmena, *Perikion* and *Sequestratum* usually have stronger birefringence than subg. *Syzygium*.

Midrib

Midrib thickness varies from 233 to 1935 μm. The adaxial surface of the midrib is usually concave in most species, but in some species it may vary from grooved, flattish to convex. The abaxial surface in most species is convex, occasionally flat, or angular.

The vascular system is bicollateral. The adaxial and abaxial phloem are either completely surrounding the xylem, or they are discontinuous at the margins, both types can occur in the same species or even the same samples: this is because the phloem becomes discontinuous when the margins branch off into lateral veins. The adaxial phloem is either continuous (*e.g.* Plate 3.2-E) or is partitioned by lignified tissues in the middle (*e.g.* Plate 3.3-E). This character is predominant in subgenera *Acmena*, *Perikion* and *Sequestratum*, and is rarely found in subg. *Syzygium* (only in *S. sterrophyllum* Merr. & L.M.Perry) and is consistent within the same species and samples. This partition can be well to poorly developed and is often associated with incurved margins of the vascular system (see section 3.4.1 for discussion). The sclerenchyma sheath, which is present in all species, is composed of two zones: the inner one consists of thin walled fibre-sclereids, and cells with an unilaterally thickened wall; the outer zone is made of thick-walled fibres (Plate 3.7-A). The sheath may be continuous or discontinuous and thick to thin. In lateral vein bundles, vertical sheath extensions are usually absent and were only found in subg. *Syzygium* in *S. nigrans*, *S. ripicola* and subg. *Acmena* in *S. unipunctatum* (B.Hyland) Craven & Biffin .

The following are the three major midrib vascular systems, the first type contains five subtypes:

1. Arc-shaped: This is the most common vascular system, while there are variations which are determined by the combination of characters such as the margins orientation, the continuity and curvature of the arc. The curvature varies from a nearly flat or shallow arc (Plate 3.2-E), a normal arc (Plate 3.2-C) to a deep

arc (Plate 3.2-D). The margins are usually straight and aligned with the axis of the bundle (Plate 3.2-E), or breaking away into smaller free bundles (Plate 3.2-G) or each end is incurved to 180° (Plate 3.3-A). The species with straight margins are found predominantly in subg. *Syzygium* and subg. *Sequestratum*, and only in one or two species in subg. *Acmena* and subg. *Perikion*. The incurved margins can be continuous (Plate 3.3-A, B) or fragmented (Plate 3.3-C, D, E) or absent (Plate 3.3-F, G, H). This type of vascular system is predominant in subg. *Acmena* and subg. *Perikion* and is often associated with adaxial phloem partition, but in subg. *Syzygium* where it occurs infrequently there is no such partition (Plate 3.2-F). For *S. graveolens* (Plate 3.3-D) in subg. *Acmena* and *S. multibracteolatum* (Merr.) Merr. & L.M.Perry, *S. tenuirame* (Miq.) Merr.and *S. wilsonii* (F.Muell.) B.Hyland (Plate 3.4-C, D) in subg. *Sequestratum*, the margins may look straight but are actually incurved, in these cases the margins have merged with the main xylem, resulting in flattish vascular bundle with protoxylem at the adaxial side separated from abaxial protoxylem by lignified tissue in the middle. This is possibly an intermediate form between straight and incurved margins. Sometimes margins are interrupted into smaller free bundles that are surrounded by sclerenchyma (Plate 3.3-G). This type of vascular bundle which is restricted to *S. dyerianum* (King) P.Chantaranothai & J.Parn. and *S. nervosum*, is closely related to or perhaps a variant of the complex open system (below).

2. Complex open system (Plate 3.2-H): the vascular system consists of several (6-9) open bundles, usually with a main bundle in the centre, and with lateral bundles that are sometimes concentric. This vascular system is found only in subg. *Syzygium* in *S. balsameum*, *S. griffithii* (Duthie) Merr. & L.M.Perry, *S. symingtonianum* (M.R.Hend.) I.M.Turner and *S. tetragonum*.

3. Cylindrical system (Plate 3.2-A, B): the vascular bundle is closed or almost closed with lignified or non-lignified pith in the centre. The phloem is present on the inner and outer side of the xylem. In transverse-section, the shape ranges from a circle to a slightly compressed circle or is heart-shaped. This vascular system is confined to subg. *Syzygium* in *S. diosyprifolium*, *S. fastigiatum* (Blume) Merr. & L.M.Perry, *S. formosum*, *S. harmandii* and *S. polyanthum*.

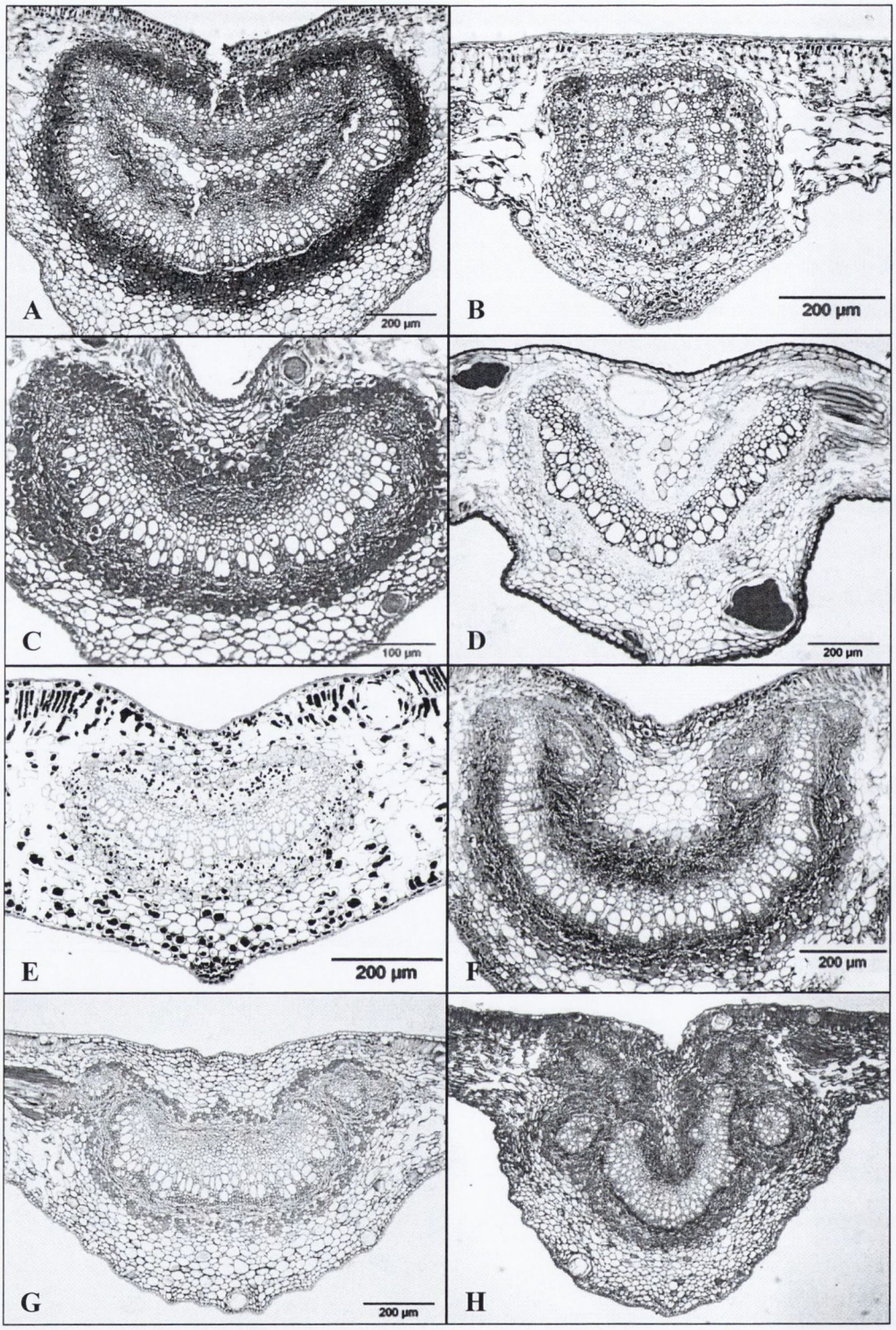

Plate 3.2. T.S. midrib vascular system, subg. *Syzygium*. (A) *S. diospyrifolium*, cylindrical. (B) *S. polyanthum*, cylindrical system. (C) *S. levinei*, arc-shaped system, normal curvature. (D) *S. hemisphricum*, arc-shaped system, deep curvature. (E) *S. hancei* Merr. & L.M.Perry, arc-shaped system, shallow curvature. (F) *S. attopeuense*, arc-shaped with incurved margins. (G) *S. nervosum*, arc-shaped with interrupted margins. (H) *S. tetragonum*, complex open system.

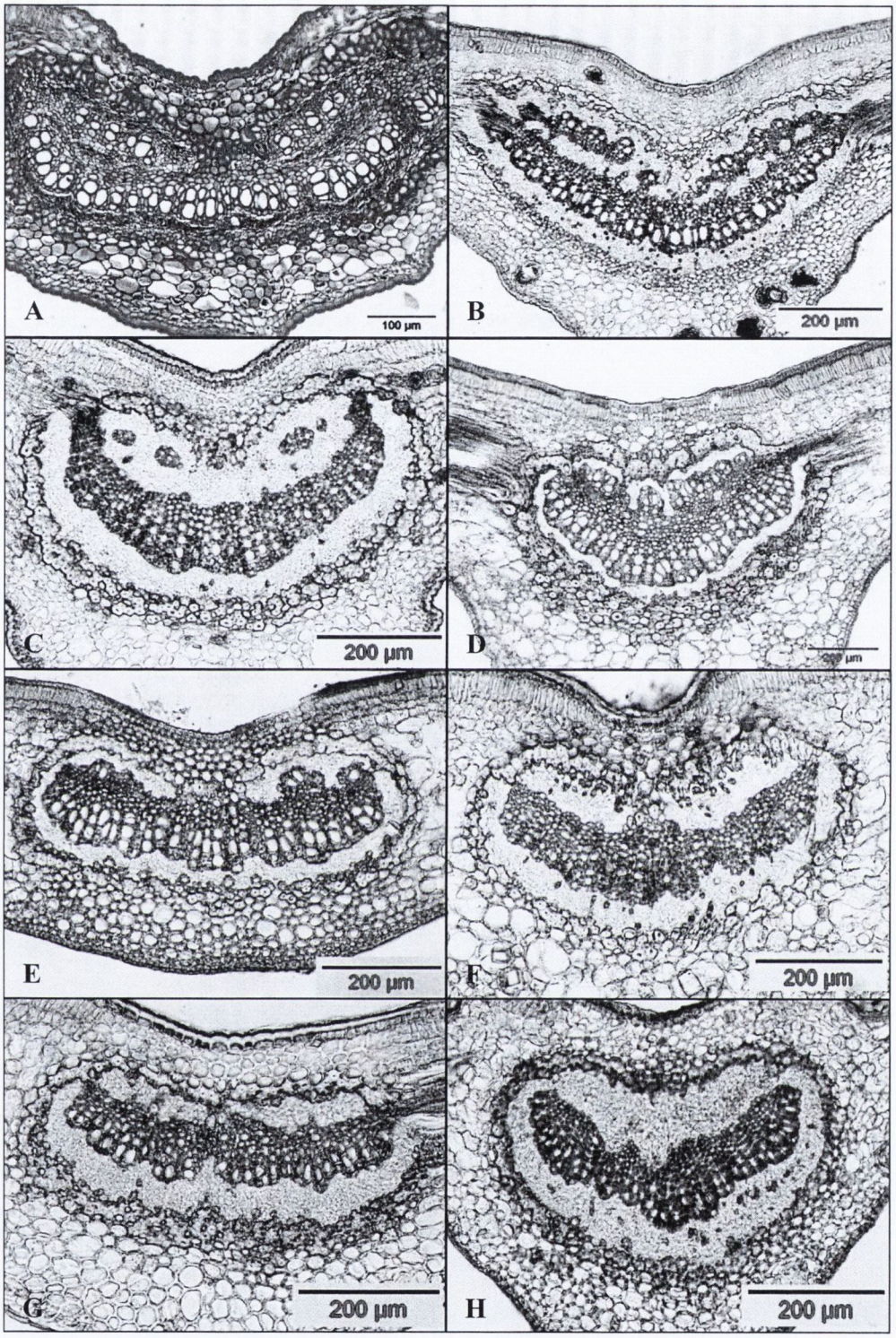

Plate 3.3. T.S. midrib vascular system in subg. *Acmena*. (A) *S. acuminatissimum* DC.. (B) *S. hedraiophyllum*. (C) *S. gustavioides* (F.M.Bail.) B.Hyland. (D) *S. graveolens*. (E) *S. divaricatum* (Merr. & L.M.Perry) Craven & Biffin. (F) *S. smithii* Nied.. (G) *S. unipunctatum* . (H) *S. mulgraveanum*. The incurved margins of the arc-shaped vascular system are well developed in (A, B), poorly developed

in (C, D, E) and absent in (F, G, H). The adaxial phloem partion is well developed in (A, E, F), poorly developed in (B, C, D, G) and absent in (H).

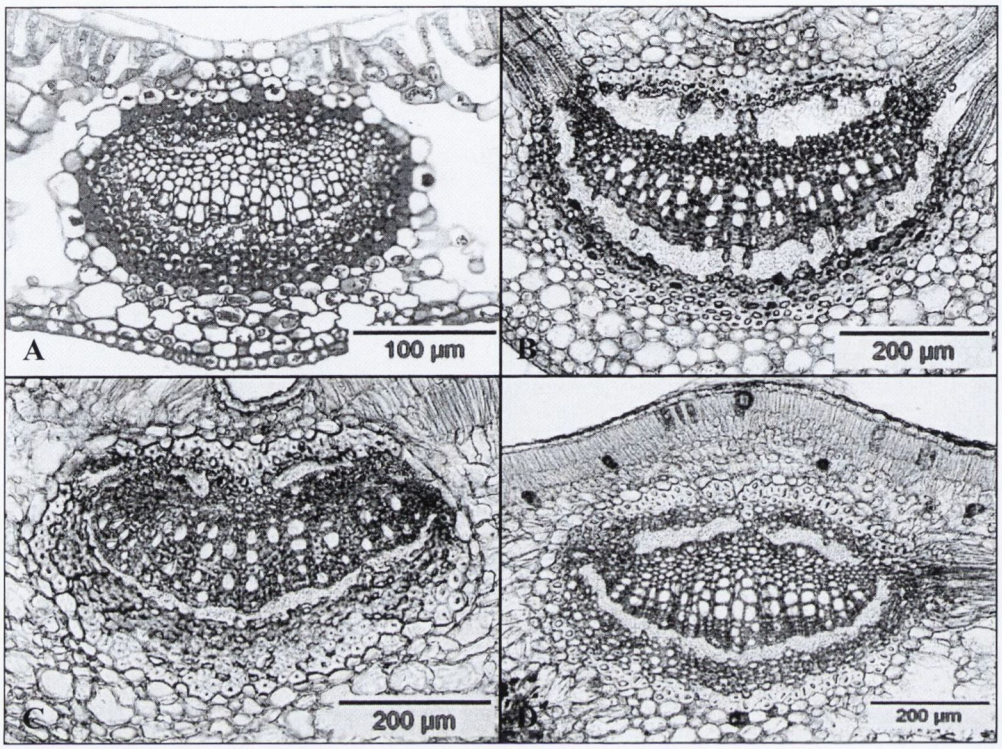

Plate 3.4. T.S. midrib vascular system in subg. *Sequestratum*. (A) *S. tsoongii* (Merr.) Merr. & L.M.Perry. (B) *S. tetrapterum* (Miq.) P. Chantaranothai & J.Parn.. (C) *S. multibracteolatum* (Merr.) Merr. & L.M.Perry . (D) *S. wilsonii* (F.Muell.) B.Hyland. (A, B) - arc with straight margins; (C, D) - arc with straight margin but representing a modified form of incurved margins in that the xylem of the incurved margins is fully (D) or partly (C) fused with main xylem.

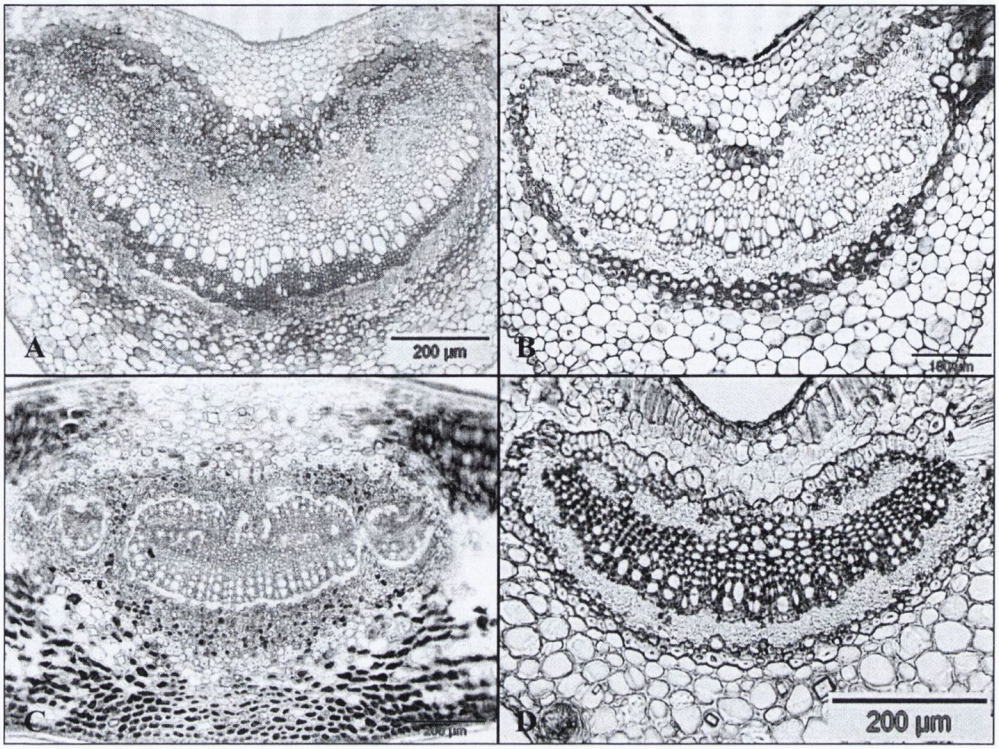

Plate 3.5. T.S. Midrib vascular system in subg. *Perikion*. (A) *S. claviflorum*. (B) *S. championii* (Benth.) Merr. & L.M.Perry. (C) *S. multipetalum* Pancher ex Brongn. & Gris. (D) *S. apodophyllum*. (A, B, C) - arc with incurved margins; (D) - arc with straight margins.

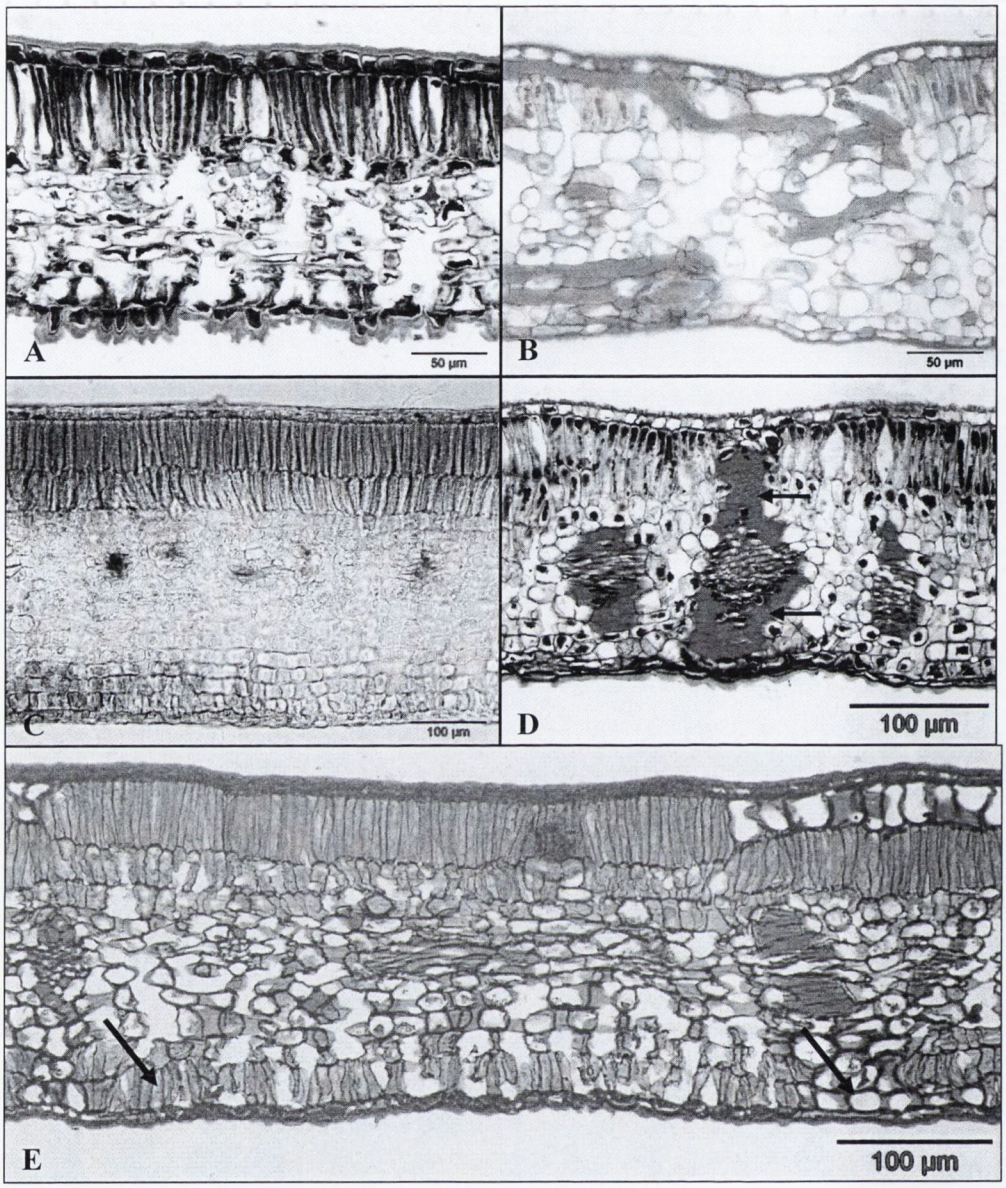

Plate 3.6. T.S. Lamina. (A) *S. attopeuense* with abaxial cuticular ornamentation and papillate epidermal cells. (B) *S. siamense* with foliar sclereids. (C) *S. grande* with poorly developed abaxial palisade tissue. (D). *S. nigrans* with lateral veins with bundle sheath extension (black arrow). (E) *S. ripicola* showing hypodermis (right black arrow) and abaxial palisade cells (left black arrow).

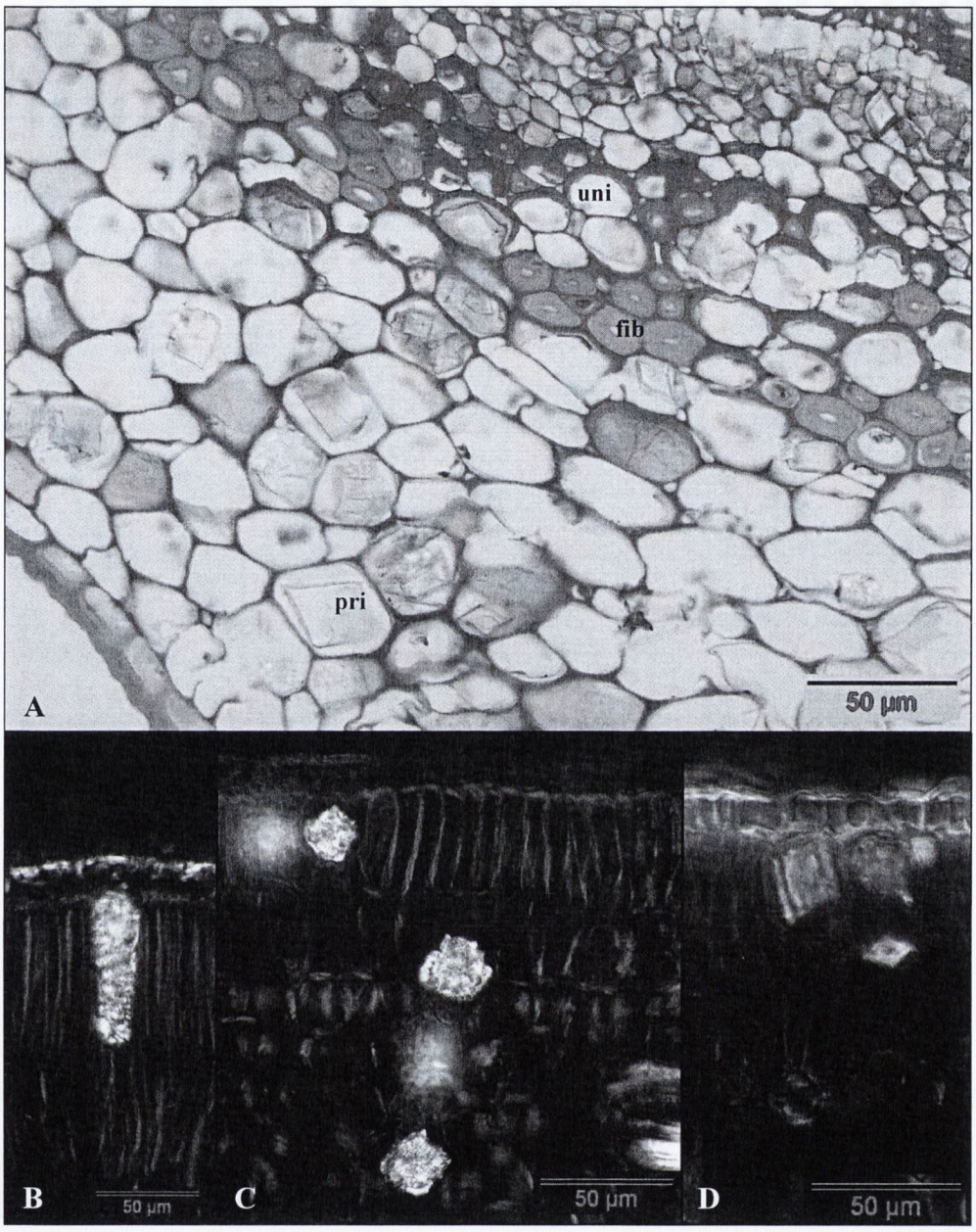

Plate 3.7. (A) Sclerenchyma and crystals in T.S. midrib (*S. claviflorum*). (B) Crystal sand (*S. araiocladum* Merr. & L.M.Perry). (C) Druses (*S. grande*). (D). Prismatic crystals (*S. claviflorum*). B-D showing birefringence in epidermal and mesophyll cell walls. uni: cells with unilaterally thickened wall, fib: fibre, pri: prismatic crytal.

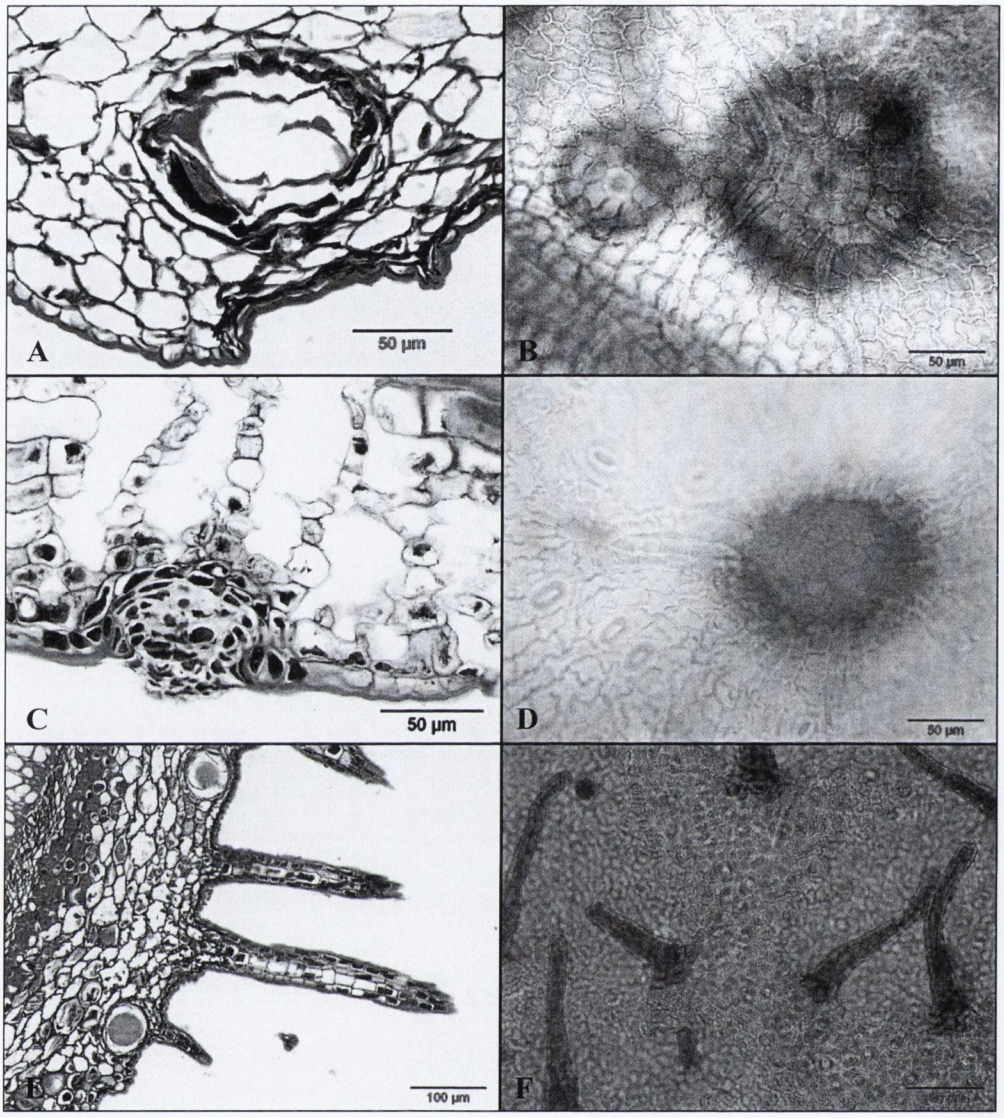

Plate 3.8. (A, B) Oil gland (*S. hemisphericum*). (C, D) Cork wart (*S. acuminatissimum*). (E, F) Multiseriate hairs (*S. vestitum*). Images on the left are T.S and on the right are surface view.

Crystals, foliar sclereids, oil glands and cork warts

Crystals are present in all the species usually in the form of druses and prismatic crystals but rarely as crystal sand (Plate 3.7-B, C, D). Species whose crystals are exclusively or predominantly druses with infrequent prismatic crystals belong to subg. *Syzygium*. The crystals in species in subgenera *Acmena*, *Perikion* and *Sequestratum* are either exclusively or predominantly prismatic with infrequent druses. Crystals sand is sometimes present in a few species in subg. *Sequestratum*. The crystals vary in frequency from few to many and are scattered in phloem, sclerenchyma (in cells with unilaterally thickened walls: cristarque cells), midrib ground tissue, spongy mesophyll and palisade (in enlarged idioblasts); they are usually concentrated near the vascular bundles.

Filiform foliar sclereids are found in only in a few species in subg. *Syzygium*, and they can be infrequent (*S. phengklaii* (P.Chantaranothai & J.Parn.) Craven & Biffin) or abundant (*S. hemisphericum*, *S. jambos*, *S. malaccense, S. nigrans*, *S. phengklaii* and *S. siamense*), scattered in the subepidermal layer in the palisade and spongy mesophyll (Plate 3.6-B).

Oil glands are abundant and present in the mesophyll of all species, usually located near the adaxial and abaxial epidermis in the palisade and spongy mesophyll layers. They are globose to subglobose and their size varies from 40 to 100 μm in diameter with one to three layers of epithelial cells (Plate 3.8-A, B).

Cork warts are regularly present on the adaxial and abaxial leaf surfaces. They vary in shape and frequency from circular to irregular in outline and infrequent to frequent (Plate 3.8-C, D).

Petiole

Petiole length ranges from 0.05 to 2 cm. On the adaxial side the petiole is grooved, concave to convex, and on the abaxial side it is usually convex. Sometimes, the petiole is circular in transverse-section. The epidermis always has a thick cuticle (3-7 μm). The vascular system is arc-shaped to almost circular. The sclerenchyma sheath is not prominent, often interrupted and sometimes absent.

Sometimes large brachysclereids are present in the ground tissue (*S. diospyrifolium*, *S. praecox* and *S. rugosum*). Oil glands are always present in the peripheral ground tissue. Crystals consisting of druses, prismatic crystals or both are present in the phloem and ground tissue.

3.3.2 Summary of subgeneric group descriptions

All characters mentioned in the family description are included here again in the subgeneric group descriptions.

Subgenus *Syzygium* (54 spp., Plate 3.2)

In surface view - indumentum absent or consisting of multiseriate hairs (only in *S. vestitum*). Cuticle usually smooth, sometimes striate. *Epidermal cells*: adaxial and abaxial anticlinal walls vary from straight, to curved to undulate, sometimes papillate. *Stomata*: exclusively paracytic or mixture of predominantly paracytic stomata and some anisocytic stomata. *Cork warts*: always present.

In transverse section - **Lamina** 120-500 μm thick (range). *Epidermis*: adaxial cells vary from wider than high to equal in width and height to higher than wide. *Hypodermis*: usually absent, rarely present, continuous or localised. *Mesophyll*: bifacial or isobilateral, adaxial palisade cells in 1-3 layers, (15)-30-(40)% of mesophyll; spongy mesophyll cells 6-16 layers. *Lateral veins*: bundle sheath extensions present or absent. *Lamina birefringence*: absent or present in epidermis, palisade and spongy mesophyll cells, intensity varies from low to strong. **Midrib** 420-1935 μm thick (range). *Outline*: adaxial varies from concave, grooved, flattish to convex, abaxial varies from convex, angular to flat. *Vascular bundle*: bicollateral, cylindrical, complex open system or arc with the margins straight, incurved or interrupted into free bundles, curvature varies from a flattish, to a shallow arc, to a normal arc to a deep arc; adaxial phloem usually continuous, rarely partitioned by lignified cells; sclerenchyma sheath continuous or discontinuous. *Crystals*: druses always present and predominant, prismatic crystals infrequent, occurring in phloem, midrib ground tissue, palisade and spongy mesophyll. *Foliar sclereids*: present or absent. *Oil glands*: always present.

Subg. *Acmena* (10 spp., Plate 3.3)

In surface view – indumentum absent. Cuticle usually smooth, rarely striate (*S. divaricatum* (Merr. & L.M.Perry) Craven & Biffin, *S. gustavioides* (F.M.Bail.) B.Hyland). *Epidermal cells*: adaxial and abaxial anticlinal wall varies from straight, to curved to undulate, sometimes papillate. *Stomata*: exclusively cyclo-staurocytic. *Cork warts*: always present.

In transverse section - **Lamina** 150-280 μm thick (range). *Epidermis*: cuticle in lamina smooth; adaxial cells usually of equal width and height, rarely wider than high, abaxial cells ranging from equal in width and height to wider than high. *Hypodermis*: usually absent, rarely present. *Mesophyll*: bifacial or isobilateral, abaxial palisade cells in a single layer, adaxial palisade cells in usually one layer, sometimes 2-3 layers, 15-50% of mesophyll; spongy mesophyll cells 8-15 layers. *Lateral veins*: bundle sheath extensions absent or present. *Lamina birefringence*: present in all epidermis, palisade and spongy mesophyll cells, intensity varies from medium to strong. **Midrib** 388-550 μm thick (range). *Outline*: adaxial usually concave, sometimes grooved or flattish, abaxial convex to angular. *Vascular bundle*: bicollateral arc, usually shallow arc, rarely normal arc, with straight or incurved margins, the xylem in the incurved margins can be continuous or interrupted, adaxial phloem partitioning well to poorly developed, rarely absent; sclerenchyma sheath continuous or discontinuous. *Crystals:* prismatic crystals always present and predominant, druses infrequent, occurring in phloem, midrib ground tissue, palisade and spongy mesophyll. *Foliar sclereids*: absent. *Oil glands*: always present.

Subg. *Sequestratum* (21 spp., Plate 3.4)

In surface view - indumentum absent. Cuticle smooth. *Epidermal cells*: adaxial and abaxial anticlinal walls undulate. *Stomata*: mixture of predominantly anisocytic and some anomocytic stomata. *Cork warts*: always present.

In transverse section - **Lamina** 150-420 μm thick (range). *Epidermis*: cuticle in lamina smooth and thick; adaxial cells usually wider than high, sometimes equal in width and height to higher than wide, abaxial cells wider than high. *Hypodermis*: absent. *Mesophyll*: bifacial or isobilateral, abaxial palisade cells if present in single layer, adaxial palisade cells in 2-3 layers, (10)-30-(50)% of mesophyll; spongy mesophyll cells in 5-10 layers. *Lateral veins*: without bundle sheath extensions. *Lamina birefringence*: present in all epidermises, palisade and

spongy mesophyll cells, intensity strong. **Midrib** 300-550 μm thick (range). *Outline*: adaxial concave, grooved to flattish, abaxial convex to flattish. *Vascular bundle*: bicollateral, flattish to shallow arc with straight margins, adaxial phloem partition well to poorly developed, rarely absent; sclerenchyma sheath continuous. *Crystals*: prismatic crystals always present and predominant, druses infrequent, occurring in phloem, midrib ground tissue, palisade and spongy mesophyll, sometimes crystal sand present (*S. araiocladum*) in palisade mesophyll. Foliar sclereids: absent. Oil glands: always present.

Subg. *Perikion* (9 spp., Plate 3.5)

In surface view - indumentum absent. Cuticle mostly smooth, rarely striated (*S. carnicortex*). *Epidermal cells*: adaxial and abaxial anticlinal wall vary from straight, to curved to undulate. *Stomata*: either exclusively cyclo-staurocytic (*S. canicortex* and *S. multipetalum*), a mixture of paracytic and anisocytic at more or less equal frequency (*S. apodophyllum* and *S. coryanthum*) or a mixture of anisocytic and cyclo-staurocytic stomata in various frequencies (*S. abortivum*, *S.* attenuatum, *S. boisianum*, *S. championii* and *S. claviflorum*).

In transverse section - **Lamina** 156-570 μm thick (range). *Epidermis*: cuticle in lamina smooth; adaxial and abaxial cells usually vary from equal width and height to wider than high. *Hypodermis*: usually absent, rarely present, continuous. *Mesophyll*: bifacial, adaxial palisade cells in 1-3 layers, 30-50% of mesophyll; spongy mesophyll cells 8-13 layers. *Lateral veins*: without bundle sheath extensions. *Lamina birefringence*: present in epidermis, palisade and spongy mesophyll cells, intensity varies from low to strong. **Midrib** 280-1000 μm thick (range). *Outline*: adaxial concave, grooved to flattish, abaxial convex to flattish. *Vascular bundle*: bicollateral, arc, usually with incurved margins, sometimes straight margins, curvature varies from flattish, shallow arc to normal arc, adaxial phloem partition well to poorly developed, rarely absent; sclerenchyma sheath continuous. *Crystals:* prismatic crystals always present and predominant, druses infrequent, occurring in phloem, midrib ground tissue, palisade and spongy mesophyll. *Foliar sclereids*: absent. *Oil glands*: always present.

3.4 Discussion

3.4.1 Anatomical characters

Three important anatomical characters, namely the stomatal types, crystal and midrib vascular system (adaxial phloem partition included), are discussed in detail below in addition to other characters.

Stomata

In the previous studies of *Syzygium* leaf anatomy, anisocytic, anomocytic and paracytic stomata were recognized (Khatijah et al., 1992; Noorma & Moore, 1996; Kantachot et al., 2002). In this study, in addition to the three stomatal types mentioned, I recognized cyclo-staurocytic stomata. The stomatal types within any *Syzygium* species are consistent, differences are due to the interpretation of stomatal types in the current and previous studies, herein summarized in Table 3.3. The different stomatal types in most species occur in combination and are less exclusive than previous studies reported (Table 3.3). The occurrence of multiple stomatal types within a single species leaf, is common and well documented (Baranova, 1992) and could be of taxonomic value. Wilkinson (1979) suggested that stomatal characters be used for diagnostic purpose or for use within restricted taxonomic groups since stomatal distribution among plant families do not reflect phylogenetic topology. Baranova (1992), in her extensive review of stomatal studies, stressed the importance of knowing the extent of variability and proportion of stomatal types for use in taxonomy in conjunction with other characters. Den Hartog and Baas (1978) found that the heterogeneity of stomatal types in Celastraceae does not restrict its taxonomic value but actually enhances it but only when the combination is constant in both stomatal types and their proportions.

The interpretation of stomatal types and their use in taxonomy can be problematic; this is due to the occurrence of intermediate forms and the derivation of the same stomatal types from multiple ontogenic routes. In three previous studies, (Table 3.3) the stomata of *S. claviflorum* were reported to be anomocytic, but in this study I interpret the stomatal types as a mixture of anisocytic and cyclo-staurocytic (Plate 3.1-E).

Table 3.3. Comparison of results of stomata studies from different authors. Species are arranged alphabetically in subgeneric groups.

Species (names in bracket are used in other studies)	**This study**	**Khatijah et al. (1992)**	**Noorma and Moore (1996)**	**Kantachot et al. (2007)**
Subg. *Syzygium*				
S. aqueum (= *E. aquea*)	paracytic	-	paracytic	paracytic
S. aromaticum	paracytic	-	-	anomocytic
S. borneense (= *S. cinereum*)	paracytic	-	-	anomocytic
S. cumini	paracytic and anisocytic	-	-	paracytic and anisocytic
S. diospyrifolium	paracytic	-	-	anomocytic
S. fastigiatum (= *E. fastigiata*)	paracytic	-	anomocytic	paracytic
S. formosum	paracytic	-	-	-
S. grande (= *E. grandis*)	paracytic	paracytic	paracytic	-
S. jambos (= *E. jambos*)	paracytic and anisocytic	-	paracytic and anomocytic	paracytic
S. malaccense (= *E. malaccensis*)	paracytic and anisocytic	-	paracytic	paracytic
S. megacarpum	paracytic	-	-	paracytic
S. nervosum (= *E. operculata*)	paracytic	paracytic	-	paracytic
S. oblatum (= *E. oblata*)	paracytic and anisocytic	paracytic	-	-
S. ripicola	paracytic and anisocytic	-	-	paracytic and anisocytic
S. siamense	paracytic and anisocytic	-	-	paracytic
S. zimmermannii	paracytic and anisocytic	-	-	paracytic
Subg. *Acmena*				
S. acuminatissimum (= *E. cumingiana*)	Cyclo-staurocytic	anomocytic (cyclocytic like)	-	-
Subg. *Sequestratum*				
S. antisepticum (= *E. grata*)	anisocytic and anomocytic	anisocytic	-	-
S. nitidulum (= *E. nitidula*)	anisocytic and anomocytic	anisocytic	-	-
S. stapfianum (= *E. stapfiana*)	anisocytic and anomocytic	anisocytic	-	-
S. zeylanicum (= *E. spicata*)	anisocytic and anomocytic	anisocytic	anomocytic	-
Subg. *Perikion*				
S. attenuatum (= *E. rhamphiphylla*)	anisocytic and cyclo-staurocytic	anisocytic	paracytic and anomocytic	-
S. claviflorum (= *E. claviflora*)	anisocytic and cyclo-staurocytic	anomocytic	anomocytic	anomocytic

Firstly, the guard cells are constantly surrounded by three to four subsidiary cells following the pattern of anisocytic and cyclo-staurocytic respectively. Secondly, the cells surrounding the guard cells are more heavily cutinized than the other epidermal cells which suggests that these are in fact subsidiary cells. The difficulty in distinguishing between anomocytic and anisocytic stomata had been noted by various authors (Metcalfe & Chalk, 1950; Patel & Inamdar, 1971; van Welzen & Baas, 1984) especially if the subsidiary cells are not distinguishable from other epidermal cells and when they are more or less equal in size. The same may be said in distinguishing anisocytic and encyclocytic/cyclocytic stomatal types when the subsidiary cells are of the same size. In this case, van Staveren & Baas (1973) recognized an intermediate type (aniso-encyclocytic) in addition to anisocytic and encyclocytic stomata for Icacinaceae. In this study, a stomata is interpreted as anisocytic when the subsidiary cells are not radially arranged to form a ring pattern and when the stomata are surrounded by three unequal subsidiary cells but those surrounded by four or more radially arranged subsidiary cells are classified here as cyclo-staurocytic. The difficulty in distinguishing staurocytic and encylocytic types has been acknowledged by some authors and hence the term stauro-encyclocytic has been coiled (van Cotthem, 1970; Wilkinson, 1979). Khatijah et al. (1992) classified the stomata of *S. acuminatissimum* as anomocytic and noted that they appeared cyclocytic because the inner wall of the adjacent cells lies partly below the guard cells giving the impression of subsidiary cells. However in this study, I classify this stomatotype as cyclocytic because these adjacent cells form distinctly narrow rings of subsidiary cells surrounding the guard cells. In other examples seen in Noorma and Moore (1996), the discrepancy in the stomatal type results is purely due to error of identification of the stomatal types. Other cases follow similar lines of explanation and will not be dealt here in detail.

In the paracytic and anisocytic stomata, the subsidiary cells can be differentiated or may be undifferentiated from other epidermal cells, for example in *S. apodophyllum* and *S. coryanthum* (F.Muell.) L.A.S.Johnson, the subsidiary cells are hardly different from the epidermal cells and they seem to intergrade with anomocytic stomata (Plate 3.1-B). However, the arrangement of the cells surrounding the guard cells clearly betrays their paracytic and anisocytic type.

Paracytic and anisocytic stomata can be derived from three ontogenetic pathways: mesogenous, mesoperigenous and perigenous routes, plus additional intermediate routes (Farooqui, 1981a,b, 1982), and depending on which ontogenetic pathway the species follow, mesogenous subsidiary cells can be indistinguishable from epidermal cells and perigenous cells can be differentiated as subsidiary cells (Baranova, 1992). In *Leptospermum* (Myrtaceae) for example, Johnson (1980) found the cyclocytic stomata follow a polyperigenous pathway and the paracytic stomata follow a para-mesoperigenous pathway.

Anisocytic stomata are widespread and occur in subg. *Syzygium*, subg. *Perikion* and more predominantly in subg. *Sequestratum* but are absent in subg. *Acmena*. Paracytic stomata seem to be confined to subg. *Syzygium* and are found in subg. *Perikion* only in *S. apodophyllum* and *S. coryanthum*. Cyclo-staurocytic stomata are confined to subg. *Acmena* and subg. *Perikion* and anomocytic stomata to subg. *Sequestratum*.

Crystals

The crystals found in plants are mostly composed of calcium oxalate and they may occur in different forms and locations (macropattern) in plant tissues (Franceschi & Horner, 1980). Crystal macropattern is reported to be species specific and under genetic control (Kausch & Horner, 1982). Druses are predominant in subg. *Syzygium* while prismatic crystals are predominant in subg. *Acmena*, subg *Perikion* and subg *Sequestratum*. (see Table 3.2). Though the crystal type and frequency seem taxonomically important, no apparent crystal macropattern was observed within the leaves of *Syzygium*. In other studies, the crystal macropatterns in the leaves of *Peperomia* (Piperaceae) (Horner et al., 2009), *Ticodendron* (Ticodendraceae) (Lersten & Horner, 2008b), Fagaceae and Nothofagaceae (Lersten & Horner, 2008a) failed to signal any taxonomic pattern. However crystals have been taxonomically valuable in comparison among families or higher level rank (Metcalfe & Chalk, 1950; Dickinson, 2000).

Midrib vascular bundle

The midrib vascular type observed in this study generally concurs with Khatijah et al. (1992). The term 'included phloem' which she used in describing the vascular

system of *S. claviflorum* and *S. attenuatum* is interpreted here as incurved margins. 'Included phloem' is a condition found in secondary growth of vascular plants and its usage should be confined to wood anatomy. In this study I recognized three major vascular systems: arc-shaped (straight, incurved and interrupted margins), complex open and cylindrical. These major vascular systems and their variations are possibly related to each other either in an evolutionary or developmental sense. Keating (1984) suggested that in the Myrtaceae, a semicircular trace could have evolved in two ways, firstly the trace became reduced to a broad then narrow arc by simple reduction and secondly the trace became incurved adaxially and then flattened as in *Eucalyptus obliqua* L'Hér. and *Eucalyptus micrantha* A.Cunn. ex DC., and with further loss of the adaxial xylem portion as in *Syzygium smithii*. However, he cautioned that his hypothesis is based on scanty materials of only seven samples representing five genera.

The taxonomic value of these vascular types is mixed, being prevalent in some groups but not in others. For example, at subgeneric level, subgenera *Acmena*, *Perikion* and *Sequestratum* have almost a consistent vascular type with some variation gravitating toward vasculature with incurved margins and adaxial phloem partition, while in subg. *Syzygium* it is diverse. Within subg. *Syzygium*, for example, among the six species with cylindrical vascular type, there are three distinct groups with similar morphological characters: the first group (*S. diospyrifolium*, *S. formosum* and *S. harmandii*) have big flowers, racemose inflorescence and terete twigs, the second group (*S. leptostemum* and *S. polyanthum*) have small flowers, paniculate inflorescences and distinct white terete twigs; and the third group (*S. fastigiatum*) has small flowers, paniculate inflorescences and winged twigs. This further suggests that in subg. *Syzygium*, the vascular types may be of taxonomic value at finer infrageneric level such as section or subsection.

Hairs, foliar sclereids, oil glands, palisade tissue and cork warts

Syzygium species are rarely hairy. For example, Schmid (1972) estimated from the literature that only 5% of *Syzygium* s.l. species are hairy compared to 90% in *Eugenia*. The hairs in *Syzygium* have been reported as multicellular, and either

uniseriate or multiseriate (Briggs & Johnson, 1979). In this study I found multicellular and multiseriate hairs only in *Syzygium vestitum*. The presence of hairs is of diagnostic value in this case. Other groups in Myrtaceae have been reported with unicellular hairs, either simple, sometimes 2-armed or funnel-shaped (Metcalfe, 1950; Schmid 1972a, b; Briggs & Johnson, 1979; Kantachot et al. 2007; Cardoso et al. 2009).

Other anatomical characters such as foliar sclereids, cuticle ornamentation and bundle sheath extensions are rare and consistent; therefore I find these characters are valuable for diagnostic purposes when combined with other characters such as stomatal types, midrib vascular system and crystals. The presence of a hypodermis is inconsistent within species and thus cannot be used for species diagnosis. The number of palisade layers and proportion of palisade in mesophyll are extremely variable among different species and within the same species. Therefore, they do not have much taxonomic value. This is not surprising since some leaf anatomical features are often under the influence of the environment. For example, in *Syzygium*, Gamage et al. (2003) demonstrated that cuticle thickness, stomatal density, epidermis thickness and palisade mesophyll thickness varies for the same species under different light exposure. By contrast, Cardoso et al. (2009) indicated that percentage palisade in mesophyll is diagnostic for neotropical genera in Myrtaceae.

Cork warts and oil glands are present and abundant in all species, I do not see any noticeable pattern in the frequency of cork warts and oil glands among different species. However Merrill and Perry (1939a) noted that the oil gland size and punctation density are often useful for species diagnosis.

Petiole

In this study the petiole vascular system showed some variation between different samples of the same species, for example the petiole vascular system may or may not be similar to the midrib vascular system. This inconsistency was also demonstrated in other studies (Jarvie & Koerniati, 1986; Khatijah et al., 1992). The sclerenchyma sheath shows the same inconsistency as the vascular system. However, the presence or absence of brachysclereids in the petiole ground tissue

is consistent and diagnostic. Brachysclereids were only found in *S. diospyrifolium*, *S. siamense* and *S. praecox* (Roxb.) N.C.Rathakrishnan & N.C.Nair. Crystal types in the petiole always correspond with those in the lamina. Since the petiole anatomy is dependent on the level of sectioning, I suspect the irregularity of the petiole results in this study is due to inconsistency in the sectioning point which is largely due to the difficulty in standardizing the sectioning point for species with very short petioles (≤ 5 mm).

3.4.2 Notes on taxonomic groups

Subgenus *Syzygium*. The presence of paracytic stomata and druses are predominant and consistently present in this group whereas anisocytic stomata are both less common and inconsistently present. Not only is this the largest subgenus but it is also the most diverse in terms of leaf anatomy. For example, there are five types of midrib vascular system, with arch and straight margin being the most common (see table 3.2). Except for *S. sterrophyllum* and *S. subdecussatum* (Duthie) I.M.Turner, unlike subg. *Acmena* and subg. *Perikion*, most species in this group are without adaxial phloem partition. Other characters that are unique but rare in this subgenus are foliar sclereids, abaxial palisade layer and bundle sheath extensions.

Subgenus *Acmena*. Cyclocytic stoma and prismatic crystals are prominent and present in all species. With the exception of *S. mulgraveanum*, most species here have adaxial phloem partitioning. The latter structure can be well to poorly developed. The midrib vascular margins can be straight or incurved, and in the incurved margins, they can be well developed (*Piliocalyx francisii* Guillaumin, *S. acuminatissimum* and *S. hedraiophyllum*) or fragmented and poorly developed (*S. divaricatum*, *S. graveolens* and *S. gustavioides*).

Subgenus *Sequestratum*. A combination of predominantly anisocytic and anomocytic stomata and prismatic crystals are present in all species. Within this group, the midrib vascular system is quite consistent with straight margins and adaxial phloem partition present in almost all species. A deviation from the typical vascular system in this group is found in *S. multibracteolatum*, *S. tenuirame* (Miq.) Merr. and *S. wilsonii* which possibly represent an intermediate

form of the incurved margins vascular system (see in this chapter section 3.3.1. under *general generic description* on midrib).

Subgenus *Perikion*. The anatomical characters in this group are very variable in comparison with the other groups in midrib vascular system and stomatal types (see table 3.2 and section on subgeneric description). However, prismatic crystals always predominate.

3.5 Conclusion

General generic and subgeneric descriptions of *Syzygium* leaf anatomy were given. Critical comparative analysis of the leaf anatomical characters among the subgeneric groups were made. Stomatal types and midrib vascular system were reinterpreted in reference to previous studies. Three leaf anatomical characters, namely stomatal types, crystals and midrib vascular system, were found to be correlated with the subg. *Acmena*, *Sequestratum* and *Syzygium*. However, the leaf anatomical characters of subg. *Perikion* are diverse and overlapped, notably with subg. *Acmena* and *Sequestratum*. There are four stomatal types (anisocytic, anomocytic, cyclo-staurocytic and paracytic) in *Syzygium* and these either occur exclusively or in combination with other types to reflect the subgeneric groupings. The frequency of druses or prismatic crystals appears to be valuable in characterising subgeneric groups. There are three major midrib vascular systems with five subtypes in the first major system. These vascular systems are characterised by the presence or absence of adaxial phloem partition, margin curvature and xylem orientation and placement. Most species in subg. *Acmena*, *Perikion* and *Sequestratrum* possessed adaxial phloem partition. Midrib vascular system with incurved margins is predominant in subg. *Acmena* and occurs less frequently in other groups. Vascular system with straight margins is the most common type in *Syzygium.* The subg. *Syzygium* formed the largest group and is the most diverse in leaf anatomical characters.

Chapter 4 Phylogenetic and phenetic analyses of *Syzygium* Gaertn (Myrtaceae) inferred from DNA sequence, anatomical and macromorphological data

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4.1 Introduction

The taxonomy of *Syzygium* and its generic allies in the Old World has been confusing and complex. The historical basis and the classification problems have been extensively reviewed by many authors and are reviewed in Chapter 1. In recent years, the use of molecular data has started to improve their classification and has brought several changes in tribal and generic concepts within the Myrtaceae. Briggs and Johnson (1979) proposed an informal classification of Myrtaceae with the Old World syzygioid species grouped into *Acmena* alliance. This was further divided into *Acmena* suballiance and *Syzygium* suballiance. The former group, including the genera *Acmena*, *Acmenospermum*, *Piliocalyx* and *Waterhousea*, is characterised by the presence of seed intercotyledonary intrusion while the latter group, consisting of *Syzygium,* is without such tissue in the seed. The relative position of the *Acmena* alliance in relation to other Myrtaceous groups was later supported by phylogenetic analysis of morphological and anatomical data (Johnson and Briggs, 1984).

Harrington and Gadek (2004) conducted phylogenetic analysis using the internal transcribed spacers (ITS) and external transcribed spacer (ETS) of nuclear ribosomal DNA (rDNA) from 65 Australasian species. Their findings neither support the *Acmena* and *Syzygium* suballiances nor the widely accepted genera *Acmena, Acmenosperma*, *Anetholea, Cleistocalyx*, *Jambosa*, *Syzygium*, and *Waterhousea*. Biffin et al. (2006), using a larger and wider taxon sampling, analysed the chloroplast DNA sequences (*mat*K, *ndh*F and *rpl*16) and supported Harrington and Gadek's (2004) findings that the current segregate genera of *Syzygium* s.l. are not monophyletic. Four major clades were recognized (subg. *Syzygium*, subg. *Acmena*, subg. *Sequestratum* and subg. *Perikion*) in the chloroplast DNA study (Figure 4.1).

Craven and Biffin (2010) proposed a broader generic circumscription of *Syzygium* that fully encompasses *Acmena*, *Acmenosperma*, *Cleistocalyx*, *Piliocalyx*, *Waterhousea* and other satellite genera. Six subgenera and seven sections were recognised and formalised. Their classification is based on earlier nuclear and chloroplast phylogenetic trees from Harrington and Gadek (2004) and Biffin et al. (2006) respectively. Their findings also highlighted some important morphological characters that are correlated with the supported clades such as the presence-absence of hypanthium fibre bundles, placenta orientation, ovule orientation, presence-absence of testa and presence-absence of seed intercotyledonary intrusion. The importance of seed characters in generic delimitation had been stressed by Merrill and Perry (1939a). Two of Craven and Biffin's subgenera, *Sequestratum* and *Perikion* correspond to the Henderson's species grouping under sect. *Syzygium* group 4 and 5 respectively. Henderson's classification was based on hypanthium shape and length.

Parnell (1999) utilized macromorphological data from Thai species in phenetic and phylogenetic analyses with *Cleistocalyx* and subg. *Acmena* as outgroups, to elucidate taxonomic groups within subg. *Syzygium*. He proposed dividing Thai *Syzygium* into one monophyletic group (*Jambosa*) and one big polyphyletic group. However, this was not supported by nuclear and chloroplast DNA studies (Harrington & Gadek, 2004; Biffin et al., 2006).

Despite the advancement of molecular studies in the classification of *Syzygium*, morphology is still important in characterising the clades recovered from phylogenetic analyses for the practical purpose of identification and in understanding character evolution. At suprageneric level, Lucas (2007) optimised morphological characters onto nuclear and chloroplast phylogenetic trees and showed that morphological characters in fleshy fruited species in the neotropics are homoplasious but the combination of them is useful for clade diagnosis. Wilson et al. (2001) showed that, although morphological based phylogeny of Myrtaceae was poorly resolved, there was some degree of congruence with nuclear DNA phylogeny; four of the same clades (*Acmena*, Myrtoid, Eucalypt and *Tristania* groups) were recovered by both phylogenies. In their study, vessel-ray pitting provides some support for both the *Acmena* and Eucalypt groups, while

large scalariform pits are a synapomorphy for the *Acmena* group. However both of these characters are homoplasious. At infrageneric level, the analysis of Thai *Syzygium* by Parnell (1999) demonstrated that many morphological features show overlap between species or group of species.

Many morphological characters remain untested, including anatomical characters for species occurring in the species-rich Southeast Asian region. Most characters that have been used in phylogenetic studies above generic rank (Johnson & Briggs, 1984; Wilson et al., 2001) are taxonomically uninformative for infrageneric delimitation. Therefore, there is a need to discover other novel morphological characters that could be used for clade diagnosis at generic or infrageneric level. By including leaf anatomical and other untested macromorphological characters, and broadening species sampling to include Southeast Asia region, the specific aims addressed in this chapter are to:

1. Critically examine and compare morphological based phylogenetic trees with molecular based hypotheses.
2. Identify leaf anotamical and macromorphological characters that are diagnostic for the monophyletic groups.
3. Study morphological character evolution in *Syzygium*.
4. Determine the phylogenetic position and relationships among species of *Syzygium* that are included in this study.

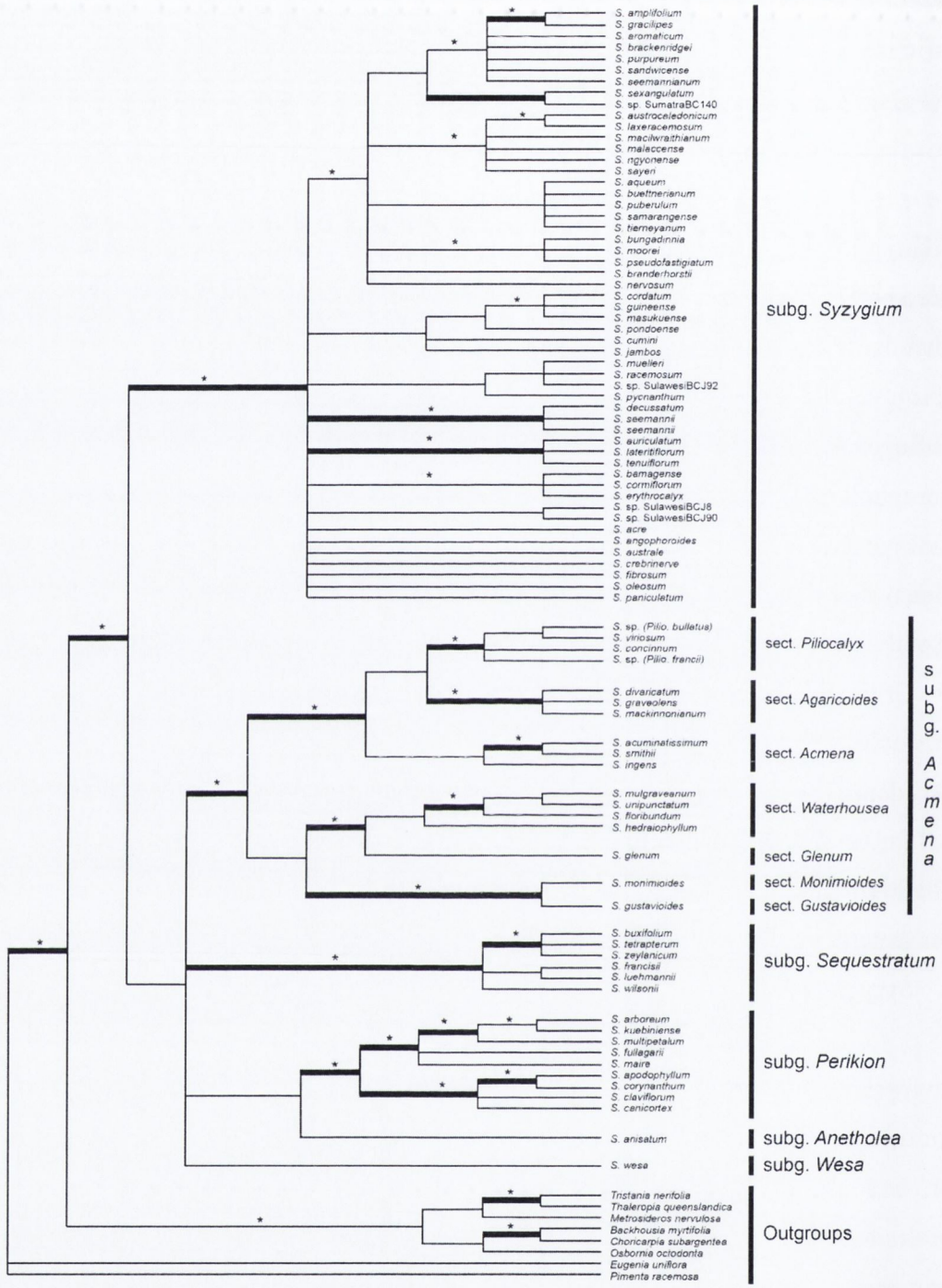


Figure 4.1. Strict consensus of 1,000 most parsimonious trees in an analysis of combined chloroplast DNA data (*mat*K, *ndh*F and *rpl*16). Bold branches represent those receiving 90% or greater bootstrap support, asterisks indicate branches with Bayesian posterior probability of 95% or greater (from Craven & Biffin, 2010).

4.2 Material and methods

To achieve the objectives of this study, the strategies employed were to use morphological and DNA data first to construct phylogeny and second, to perform species ordination to elucidate taxa groupings based on morphological similarities or dissimilarities. The topologies resulted from the two morphological analyses (phylogenetics and ordinations) were compared to nuclear DNA phylogenetic trees. Prior to this, additional nuclear DNA (ETS-ITS) species sequences from Southeast Asia were added to the established nuclear DNA phylogeny dataset (Harrington & Gadek, 2004) to broaden the sampling. Following these studies, morphological characters were optimised onto the nuclear DNA phylogenetic tree. The character transformations for the morphological and nuclear DNA phylogenetic trees were compared to extract taxonomically and phylogenetically important morphological characters. ETS and ITS DNA sequences were chosen because there were already established datasets for *Syzygium* and well documented protocols for their amplifications.

4.2.1 Macromorphology and leaf anatomy data

The taxon sampling for the morphological (macromorphology and leaf anatomy) and DNA datasets was different and only similar for 31 species. For the morphological matrix, 81 ingroup and 2 outgroup species were selected. Eighty percent of the species sampled were mainly from Southeast Asia with a few widespread species whilst the remaining 20% occur in Australia and Papua. The macromorphological characters were recorded from herbarium specimens and the literature (Merrill & Perry, 1939; Henderson, 1949; Hartley & Perry, 1973; Hartley & Craven, 1977; Kochummen, 1978; Hyland 1983; Chantaranothai & Parnell, 1994b, 2002). The leaf anatomical characters were obtained by making transverse sections and cuticular macerations of herbarium specimens (for detail see Chapter 3). Thirty-four morphological characters were scored, of which 29 were qualitative and 5 were quantitative. The data were coded as unordered binary or multistate characters.

Characters that are suspected to functionally correlate with another character were excluded. For example, arrangement of the ovules in the hypanthium is related to and probably dependent on the shape of the hypanthium. Characters where the

homology was doubtful were excluded. For example, the number of lateral secondary veins is difficult to determine because some of them are acrodromous veins and these are ontologically homologous to intramarginal veins; the testa was not scored because it may be homologous with seed intercotyledonary intrusion. Some character data, due to insufficient material or difficulty in determination, were incomplete for a substantial number of species and they are therefore not included, for example the number of ovules and the occurrence of hypanthium fibres. Autapomorphic characters are excluded, for example leaf pubescent is autapomorphic because it is present only in *S. vestitum*. Because no mean values for quantitative data were recorded in this study, the gap-coding method could not be used (Kitching et al., 1998); instead ranges were used to distinguish between character states. In order to define character states for each continuous character, a graph of maximum value versus species was plotted and disjunction in the dataset determined by examining the slope of the graph at the point of inflection. This would be the point forming the basis of the range for discrete coding of the continuous value. Only characters that exhibit variation in their range of measurements are included in this analysis.

4.2.2 Morphological characters and character states used in the phylogenetic analysis of *Syzygium*.

Characters were coded as follow.

Leaf anatomy

1. Stomata: 0 = paracytic; 1 = anisocytic; 2 = anomocytic; 3 = cyclocytic; 4 = staurocytic. The stomata either occur exclusively or in combination side by side with other stomatal types. In this dataset, cyclocytic and staurocytic stomata are recognised as two different stomal types instead of cyclo-staurocytic stomata in Chapter 3.

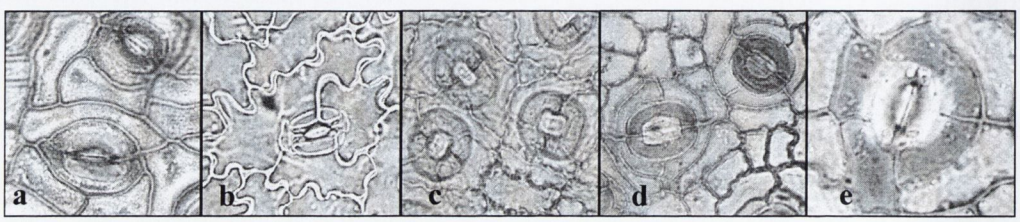


Figure 4.2. Stomatal types. (a) paracytic stomata; (b) anisocytic stomata; (c) anomocytic stomata; (d) cyclocytic stomata; (e) staurocytic stomata.

2. Epidermis abaxial anticlinal cell wall: 0 = straight; 1 = straight-curved; 2 = curved; 3 = curved-undulate; 4 = undulate.

3. Lamina cuticle texture: 0 = smooth; 1 = striate.

4. Leaf crystals: 0 = druses predominant, prismatic crystals absent or infrequent; 1 = prismatic crystals predominant, druses absent or infrequent; 2 = druses and prismatic crystals in equal frequency.

5. Midrib adaxial surface cross-section: 0 = grooved/concave; 1 = flat; 2 = convex.

6. Midrib abaxial surface cross-section: 0 = convex/angled; 1 = flat.

7. Midrib adaxial phloem partition: 0 = absent; 1 = present. The adaxial phloem partition in some species may be well or poorly developed. In the latter case, this is scored as present.

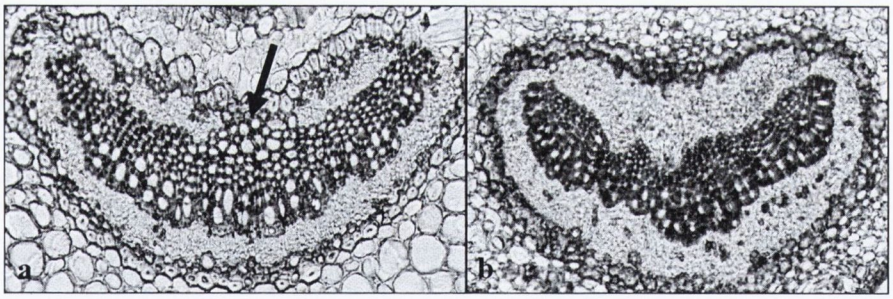


Figure 4.3. Adaxial phloem partition. (a) midrib vascular system with adaxial phloem partition (arrow); (b) midrib vascular system without adaxial phloem partition.

8. Midrib vascular system: 0 = arc; 1 = arc with incurved margins; 2 = arc with interrupted bundles; 3 = circular; 4 = complex open system.

9. Midrib sclerenchyma: 0 = discontinuous; 1 = continuous.

10. Lamina adaxial cell shape: 0 = equal width and height; 1 = wider than high; 2 = higher than wide.

11. Lamina abaxial cell shape: 0 = equal width and height; 1 = wider than high; 2 = irregular.

12. Adaxial palisade layer: 0 = 1 layer; 1 = 2 layers; 2 = 3 layers.

13. Abaxial palisade layer: 0 = absent; 1 = present.

14. Lateral vein bundle sheath extension: 0 = absent; 1 = present.

15. Foliar sclereid: 0 = absent; 1 = present.

Macromorphology

16. Twig cross-section (old): 0 = terete; 1= angular and/or winged.

17. Leaf arrangement: 0 = opposite or subopposite; 1 = verticillate.

18. Leaf base: 0 = strongly attenuate; 1 = cuneate or slightly attenuate; 2 = cordate or rounded.

19. Leaf ratio (maximum dimension): 0 = 3 times longer than wide or less; 1 = more than 3 times longer than wide.

20. Leaf texture (dried): 0 = chartaceous or thinly coriaceous; 1 = thickly coriaceous.

21. Leaf colour (dried): 0 = dark brownish; 1 = light brownish or yellowish; 2 = greenish. Although the colour of herbarium specimen are dependant on drying method, here I found consistency in the leaf colour for specimens of the same species throughout different herbaria, thereby suggesting that this character could be attributed to the leaf phytochemistry.

22. Leaf venation type: 0 = Type A.I; 1 = Type A.II; 2 = Type A.III; 3 = Type B; 4 = Type C. See Chapter 2 for more detail on the leaf venation types.

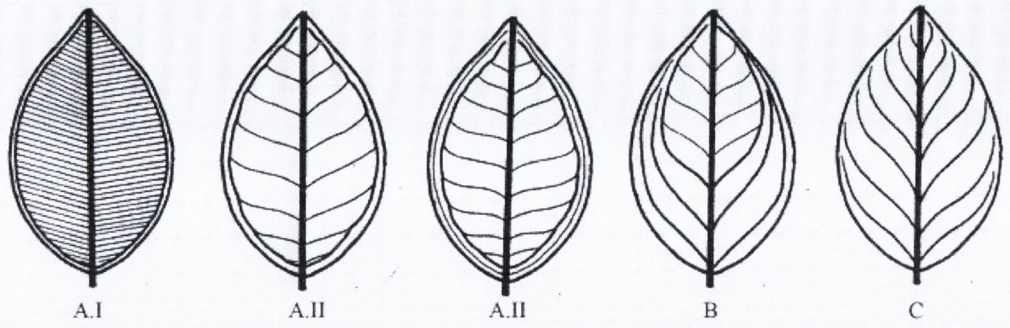


Figure 4.4. Leaf venation types.

23. Inflorescence type: 0 = paniculate; 1 = racemose or solitary.

24. Hypanthium shape: 0 = obconic/pyriform; 1 = clavate/elongated. See Chapter 2 for more detail.

25. Calyx coherence: 0 = free; 1 = calyptrate.

26. Petal coherence: 0 = free; 1 = coherent.

27. Anther: 0 = anther locules elongate and parallel, dehiscence by longitudinal slits; 1 = anther locules divaricate, dehiscence by apical slits.

28. Ovule placentation and orientation: 0 = placenta axile-apical; 1 = placenta axile-median.

29. Seed intercotyledonary intrusion: 0 = absent; 1 = present.

Quantitative characters

30. Leaf length maximum: 0 = 0–20 cm; 1 = equal or more than 20 cm

31. Petiole ratio (petiole length/blade length): 0 = 0–0.15; 1 = equal or more than 0.19

32. Hypanthium diameter: 0=1–10 mm; 1 = equal or more than 15 mm.

33. Outer stamen length maximum: 0 = 0–12 mm; 1 = equal or more than 15 mm.

34. Style length maximum: 0 = 0–17 mm; 1 = equal or more than 20 mm.

4.2.3 DNA data

For the DNA sequence data matrix, 79 ingroup and 2 outgroup species were included, of which 14 were sequenced in this study and 67 were either downloaded from GenBank (http://www.ncbi.nlm.nih.gov/genbank/) or obtained from the study of Harrington and Gadek (2004) from the main author (see Appendix 4.1 for list of voucher specimens). Tissue for the DNA extraction was obtained from the private collection of Pranom Chantaranothai at Khon Kaen University, Thailand. Seventy-five percent of the species sampled occur in Australia and few in Papua whilst 25% occur in Southeast Asia. ETS sequences were not available for *S. acuminatissimum*, *S. tetrapterum* and *S. zeylanicum* and ITS sequences were not available for *S. hemisphericum*. In the combined ETS and ITS dataset these unavailable sequences were coded as missing.

4.2.4 DNA methods

Total genomic DNA was extracted from silica dried leaf tissue using a modified version of the CTAB method of Doyle and Doyle (1987) as described in Hodkinson et al. (2007). The internal transcribed spacers (ITS) and external transcribed spacers (ETS) of nuclear ribosomal DNA were used in this study. Three sets of primers were used to amplify double strands of the entire ITS region of nuclear DNA, which includes the 5.8S subunit, and flanking internal transcribed spacers, ITS-1 and ITS-2. A further set of primers was used to amplify the 3' end of the ETS region (Table 4.1).

Table 4.1. Primers used for amplification and sequencing.

Region-name	Primer sequence (5'-3')	Source
ITS5M	GGAAGGAGAAGTCTAACAAGG (f)	Liston et al., 1996
ITS25R	TATGCTTAAACTCAGCGGGT(r)	Nickrent et al., 1994
ITS5	GGAAGTAAAAGT CGTAACAAGG(f)	White et al., 1990
ITS2	GCTGCGTTCTTCATCGATGC(r)	White et al., 1990
ITS3	GCATCGATGAAGAACGCAGC(f)	White et al., 1990
ITS4	TCCGCTTATTGATATGC(r)	White et al., 1990

ETS9bp	CATGGGCGTGTGAGTGGGTGA(f)	Wright et al., 2001
ETS18s	GAGCCATTCGCAGTTTCACAG(r)	Wright et al., 2001

All the polymerase chain reaction (PCR) amplifications were carried out in 50 µL reactions containing reagents as outlined in Table 4.2. The PCR were performed using a Biometra Tprofessional thermal cycler (Bio-Sciences) under the conditions of 95°C for 90 s (premelting), 35 cycles of 95°C for 30 s (denature), 55°C for 1 min (annealing), and 72°C for 90 s (extension), and finally 72°C for 7 mins (final extension). The PCR product was purified with the the JETquick™ spin column technique (GENOMED GmbH) (following the manufacturer's protocol).

Table 4.2. Mastermix composition for PCR. Addition of 3 µl of total DNA gave a 50 µl reaction.

Reagent	**Volume (µl) per sample**
Go Taq DNA polymerase at 5 units μl^{-1} (Promega)	0.25
5x Go Taq Flexibuffer (Promega)	10.00
Ultra pure water	29.75
dNTPs, each at 10mM (Invitrogen)	1.00
$MgCl_2$ (25mM –for a final concentration of 2.5mM)	5.00
Forward primer (100ngμl^{-1})	0.50
Reverse primer (100ngμl^{-1})	0.50
Total	47.00

Sequencing of the PCR product was carried out using the cycle sequencing method with Big Dye Terminator v 3.1 cycle sequencing RR-100 (Applied Biosystems™) for both the forward and reverse primers on ABI Prism 3130*xl* Genetic Analyser (Applied Biosystems) following the manufacturer's protocol. The electropherograms from the automated sequencing were processed using Autoassembler version 2.1 software (Applied Biosystems).

These sequences together with the sequences obtained from other sources (GenBank and the study of Harrington and Gadek (2004)) were then imported into PAUP* version 4.0b 10 (Swofford, 2001) and aligned by eye. Hypothesised insertion and deletion events (indels) were not made here.

4.2.5 Phylogenetic analyses

The morphological and DNA datasets were analysed separately, using parsimony analysis (Fitch, 1971) implemented in PAUP ver. 4.0b 10 (Swofford, 2001). For the morphological dataset, phylogenetic analyses were conducted for (1) the qualitative dataset and (2) the qualitative and quantitative dataset.

For the DNA dataset, the matrices include (1) ETS sequences (2) ITS sequences and (3) combined ETS and ITS sequences. General heuristic search strategies were performed on morphology and DNA datasets using tree-bisection-reconnection (TBR) branch-swapping, random stepwise addition sequence (RAS), holding only one tree at each step during stepwise addition, gaps were treated as missing, multistate characters were interpreted as uncertainty, all characters were unordered and had equal weight. In the first tree search, only a few replications were allowed to run to find the length of the most parsimonious trees (MPTs). Following that, the second tree search was conducted with 100 RAS for the morphology dataset and 500 RAS for the DNA dataset saving no more than 100 trees of length greater than or equal to a tree length value (Chuckscore) that is set considerably lower than the initial MPT. This strategy allowed the tree search to go through many RAS replicates in a reasonable time. The RNA secondary structural portioning of the ITS data matrix recommended by Biffin et al. (2007) was not implemented here because these were shown to affect only longer branch nodes and not shorter internal branches, i.e. it increases support among the genera in Myrtaceae but not within the genera. Harrington and Gadek (2004) showed that it was valid to combine the ETS and ITS dataset based on their result of the partition homogeneity test ($P = 0.11$). The majority-rule consensus trees of the ETS and ITS datasets are congruent in that they shared many similar clades that are supported by high bootstrap values (see Figure 4.9 and 4.10).

Clade support for the morphological dataset was assessed using decay analysis[5] (Bremer, 1994) whilst bootstrap analysis (Felsenstein, 1985) was used for the DNA dataset. For the decay analysis, a parsimony analysis was performed in PAUP using the same search strategy but this time saving only trees that are one step longer than the MPT. A strict consensus tree was generated following the analysis. The analysis was repeated many times, each time increasing the tree length to be saved until the strict consensus tree was completely collapsed. All the strict consensus trees were compared to find the decay values, i.e. the number of extra steps needed to "collapse" a branch. Bootstrap analysis was performed using fast heuristic search of 1000 RAS, without branch swapping. Only branch support values above 50% were displayed.

Parsimony-based character optimisation implemented in the MESQUITE program ver. 1.12 (Maddison & Maddison, 2009) was used to optimize 29 qualitative morphological characters onto one of the 16,700 MPTs of combined ETS-ITS dataset using parsimony. The character consistency index (ci) and retention index (ri) for the morphological and ETS-ITS phylogenetic trees were calculated. Because of the high number of characters in the analyses, only the most important character transformations are shown in the morphological and ETS-ITS phylogenetic trees (Figure 4.15 – 4.22 and 4.25 – 4.34).

The topologies of the phylogenetic trees are compared to the result of nuclear DNA of Harrington and Gadek (2004) and Chloroplast DNA of Biffin et al. (2006). Interpretation of subgeneric groupings is based on the morphological criteria and classification proposed by Craven and Biffin (2010).

4.2.6 Phenetic analysis

Because the aim of the phenetic analysis was to elucidate taxonomic groupings above species level within *Syzygium*, each species was treated as operational

[5] The result of bootstrapping for the morphological data was insignificant (i.e. zero) because there were too few synapomorphic characters to allowed a meaningful nonparametric bootstrapping (Zander, 2003)

taxonomic unit (OTU). The multivariate method of nonmetric multidimensional scaling (NMDS) was used to cluster species based on their proximities. A total of 81 *Syzygium* species was used for the analysis. The morphological characters used here are the same as for the phylogenetic analysis. However, since the NMDS method does not allow use of polymorphic characters, the 34 character states utilised in the phylogenetic analysis were broken down into 65 character states and coded individually in binary state, '0'= absent or '1'= present (see Appendix 4.2 for list of character states). The analysis was performed using PROXSCAL multidimensional scaling algorithm as implemented in SPSS ver. 16, with no restriction imposed on data, binary Euclidean distance was used for calculating the proximities and the analysis was executed in 500 random start. PROXSCAL performs multidimensional scaling of proximity data to find a least-squares representation of the objects in a low-dimensional space (Commandeur & Heiser, 1993).

4.3 Results

Table 4.3 summarises the characteristics of the morphological, ETS, ITS and combined ETS-ITS datasets. Table 4.4 summarises the results of the parsimony analyses of the morphological, ETS, ITS and combined ETS-ITS datasets.

Table 4.3. Summary of morphological, ETS, ITS and combined ETS-ITS datasets.

	Morphology (qualitative)	Morphology (qualitative and quantitative)	ETS	ITS	Combined ETS and ITS
No of taxa	83	83	81	81	81
No of characters	29	34	459	631	1090
No. of constant character	0	0	204	393	597
No. of informative characters	29	34	141	136	277
No. of uninformative characters	0	0	114	102	216

Table 4.4. Summary of parsimony analyses of morphological, ETS, ITS and combined ETS-ITS datasets.

	Morphology (qualitative)	Morphology (qualitative and quantitative)	ETS	ITS	Combined ETS and ITS
No. of MPT	500	1,100	33,200	9,500	16,700
Tree length	240	262	599	637	1,267
Ensemble Consistency index (CI)	0.20	0.20	0.57	0.49	0.50
Ensemble Retention index (RI)	0.66	0.65	0.60	0.66	0.62
Rescaled Consistency index (RC)	0.13	0.13	0.34	0.33	0.32
Homoplasy index (HI)	0.80	0.80	0.43	0.51	0.48

4.3.1 Morphological phylogenetic analysis

In the qualitative morphological data set analysis, the heuristic search resulted in 500 MPTs (240 steps, CI = 0.20, RI = 0.66) (Table 4.4). In the strict consensus tree (Figure 4.5), the subg. *Sequestratum* was recovered, with Decay Index (DI) 3. The subgenera *Acmena* and *Perikion* were recovered as paraphyletic. The three subgenera *Sequestratum*, *Acmena* and *Perikion* were recovered as one clade but weakly supported with DI = 1, while subg. *Syzygium* was unresolved. Other smaller clades that are supported with DI value more than one are S. *attopeuense* and *S. borneense* (DI = 6); *S. balsameum* and *S. tetragonum* (DI = 3); *S. diospyrifolium*, *S. formosum* and *S. harmandii* (DI = 8); *S. acuminatissimum*, *S. divaricatum* and *S. graveolens* (DI = 3); *S. gustavioides* and *S. multipetalum* (DI 3); *S. apodophyllum* and *S. canicortex* (DI = 3). Within the subg. *Sequestratum*, there are a few species that are well supported with DI values ranging from 3 – 7.

In the qualitative and quantitative morphological data matrix analysis, the heuristic search resulted in 1,100 MPTs (262 steps, CI = 0.20, RI = 0.65) (Table 4.3). In the strict consensus tree (Figure 4.6), subg. *Sequestratum* was recovered, with (DI = 2), while subgenera *Acmena*, *Perikion* and *Syzygium* were unresolved. Other smaller clades that are recovered with DI value more than one followed these in the quantitative analysis but with slightly lower DI values. The *Jambosa* group (*S. aqueum, S. diospyrifolium, S. formosum, S. harmandii, S. megacarpum,*

S. jambos, S, malaccense and *S. siamense*) and *Cleistocalyx* group (*S. khaoyensis, S. nervosum* and *S. phengklaii*) were recovered (DI = 2) in the quantitative and qualitative morphological analysis (Figure 4.6) but not in the qualitative morphological analysis (Figure 4.5). The majority-rule consensus tree and one of the MPT of the qualitative and quantitative morphological analysis are given in Figure 4.7 and 4.8 respectively.

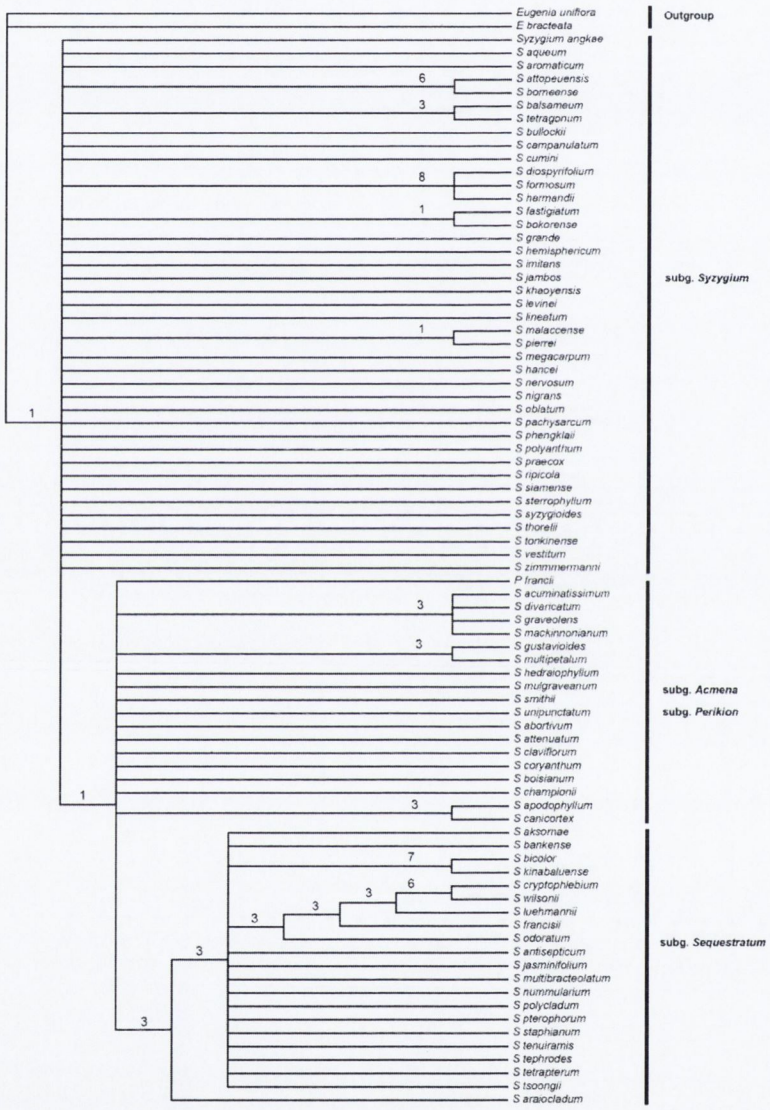


Figure 4.5. Strict consensus tree of 500 MPTs resulting from parsimony analysis of qualitative morphological data. Decay Indices (DI) are indicated above the branches.

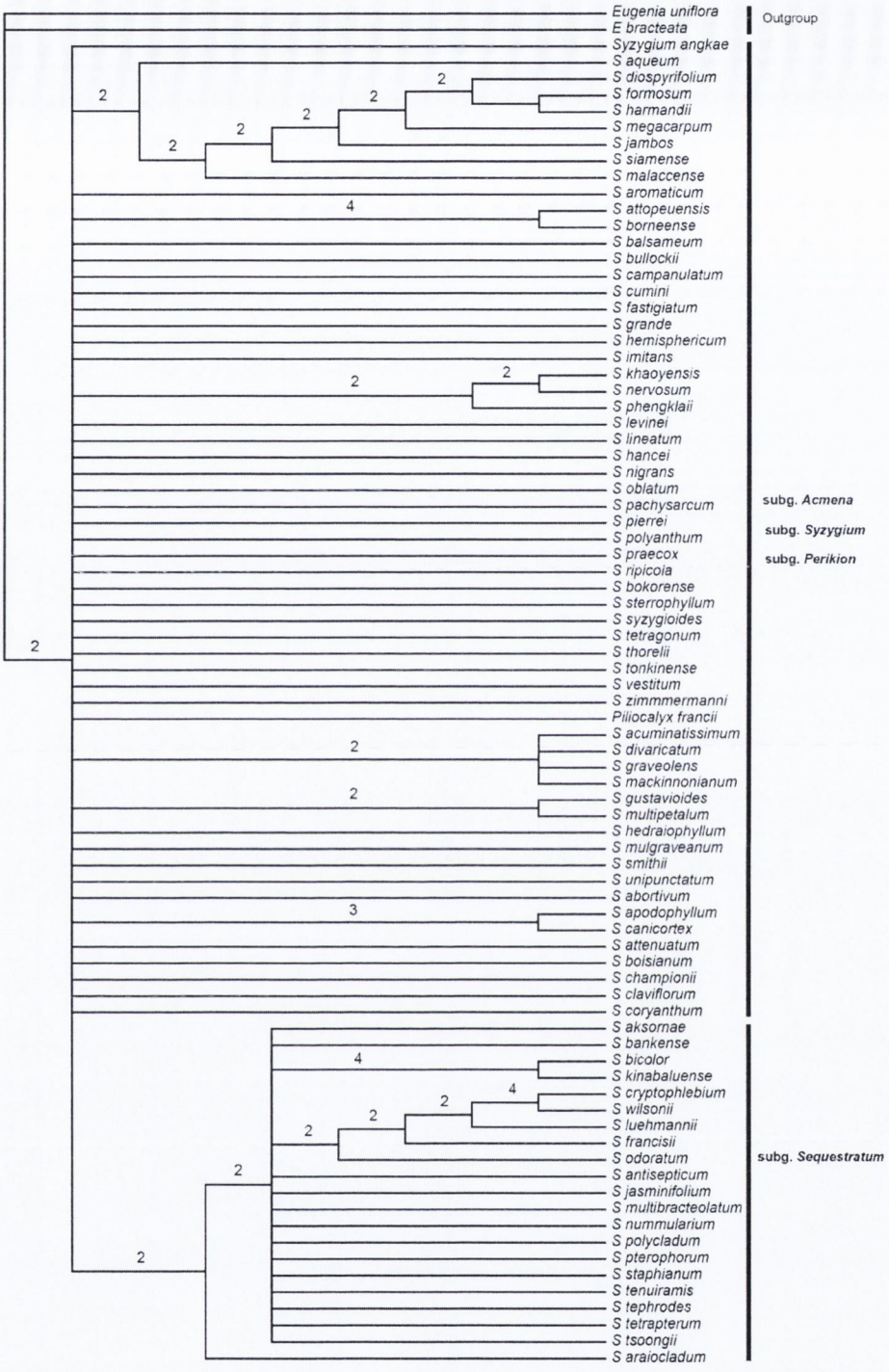


Figure 4.6. Strict consensus tree of 1,100 MPTs resulting from parsimony analysis of qualitative and quantitative morphological data. Decay Indices (DI) are indicated on the branches.

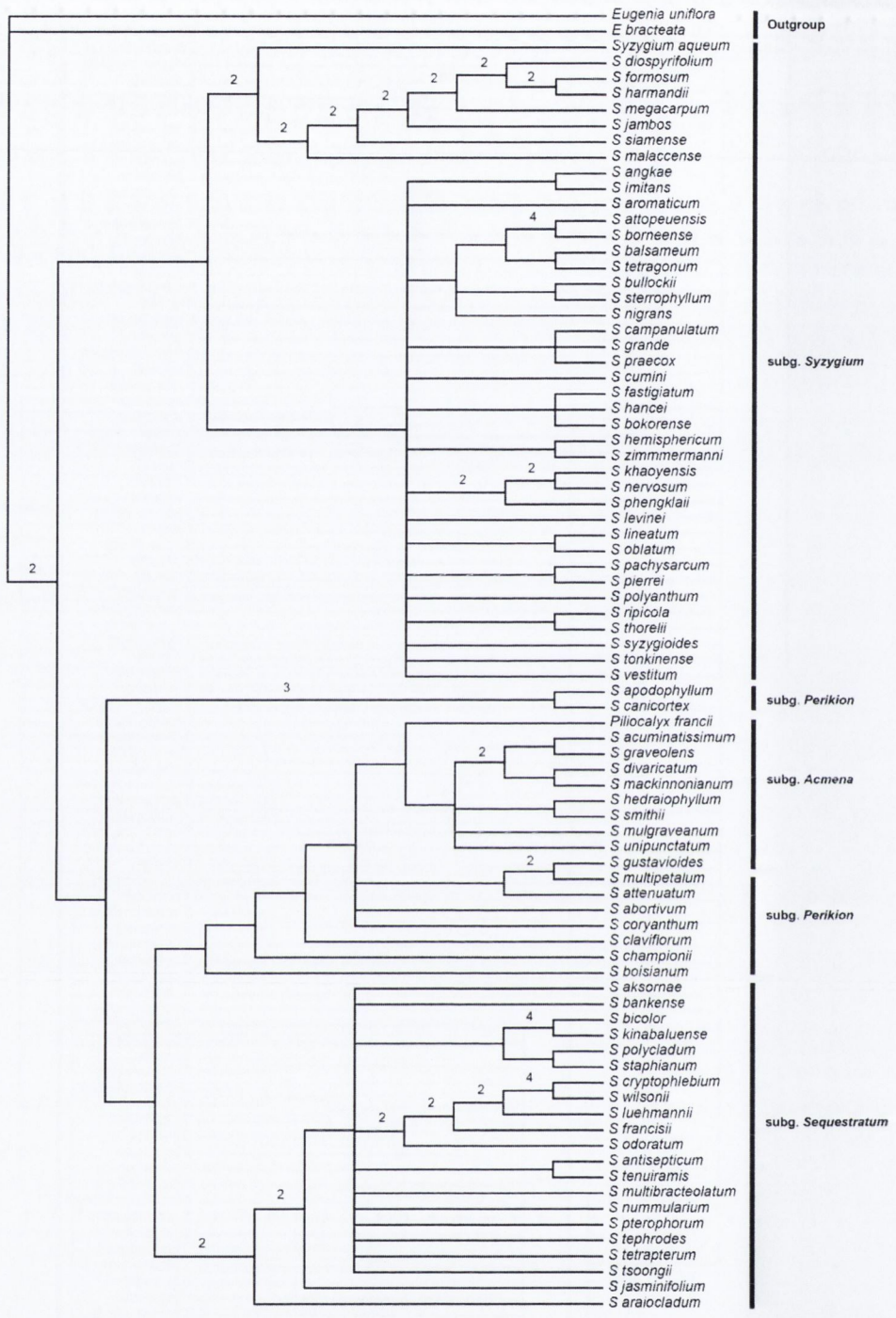


Figure 4.7. Majority-rule consensus tree from 1,100 MPTs resulting from parsimony analysis of qualitative and quantitative morphological data. Decay Indices (DI) are indicated on the branches.

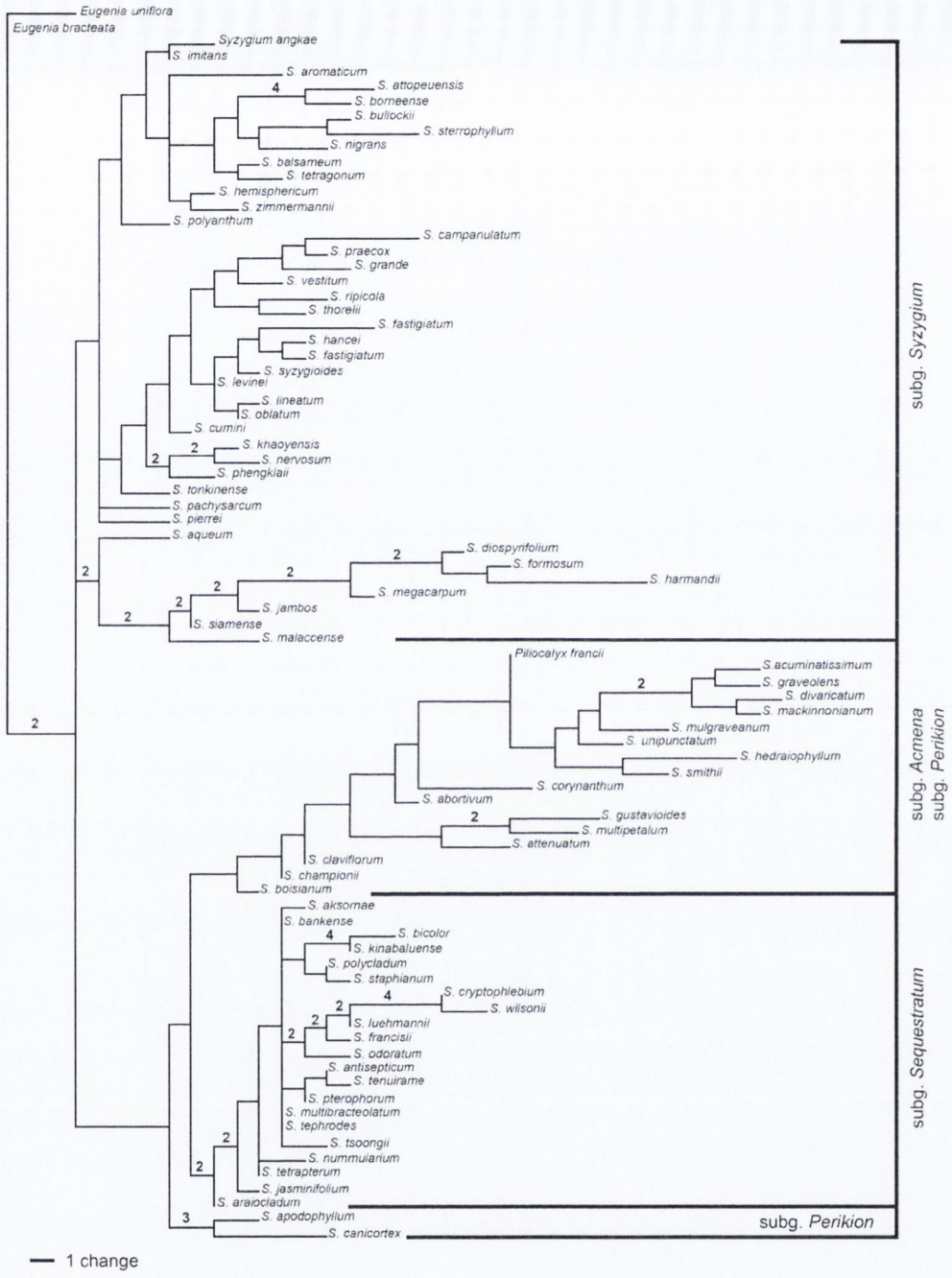


Figure 4.8. One of the trees from 1,100 MPTs resulting from parsimony analysis of qualitative and quantitative morphological data. Decay Indices (DI) are indicated on the branches.

4.3.2 DNA phylogenetic analysis

The phylogenetic trees from ITS and ETS analyses on their own (non combined) followed closely to the result of Harrington and Gadek (2004) (see Figure 4.9 and 4.10). The majority-rule consensus trees of the ETS (Figure 4.9) and ITS datasets (Figure 4.10) are congruent in that they shared many similar clades that are supported by high bootstrap values.

For the combined ETS and ITS analysis, the heuristic search found 16,700 most parsimonious trees (1,267 steps, CI = 0.50, RI = 0.62) (Table 4.3). The subgenera *Syzygium*, *Sequestratum* and *Perikion* were resolved as monophyletic with high bootstrap values (BS) of 90%, 98% and 80% respectively in the strict consensus tree (Figure 4.11). The subg. *Sequestratrum* was placed as sister to the remaining subgenera. The subg. *Syzygium* is sister to *Acmena, Anetholea, Perkion* and *Wesa.* The subgenera *Acmena*, *Anetholea* and *Wesa* were paraphyletic. *Syzygium aromaticum, S. campanulatum, S. cumini, S. diospyrifolium, S. grande, S. hancei, S. hemisphericum, S. jambos, S. nigrans, S. ripicol*a and *S. thoreli*, in which the DNA sequences were generated for the first time from this study, were grouped in subg. *Syzygium*, while *S. antisepticum* was placed in subg. *Sequestratum.* The majority-rule consensus tree and one of the MPT of the combined ETS and ITS analysis were given in Figure 4.12 and 4.13 respectively.

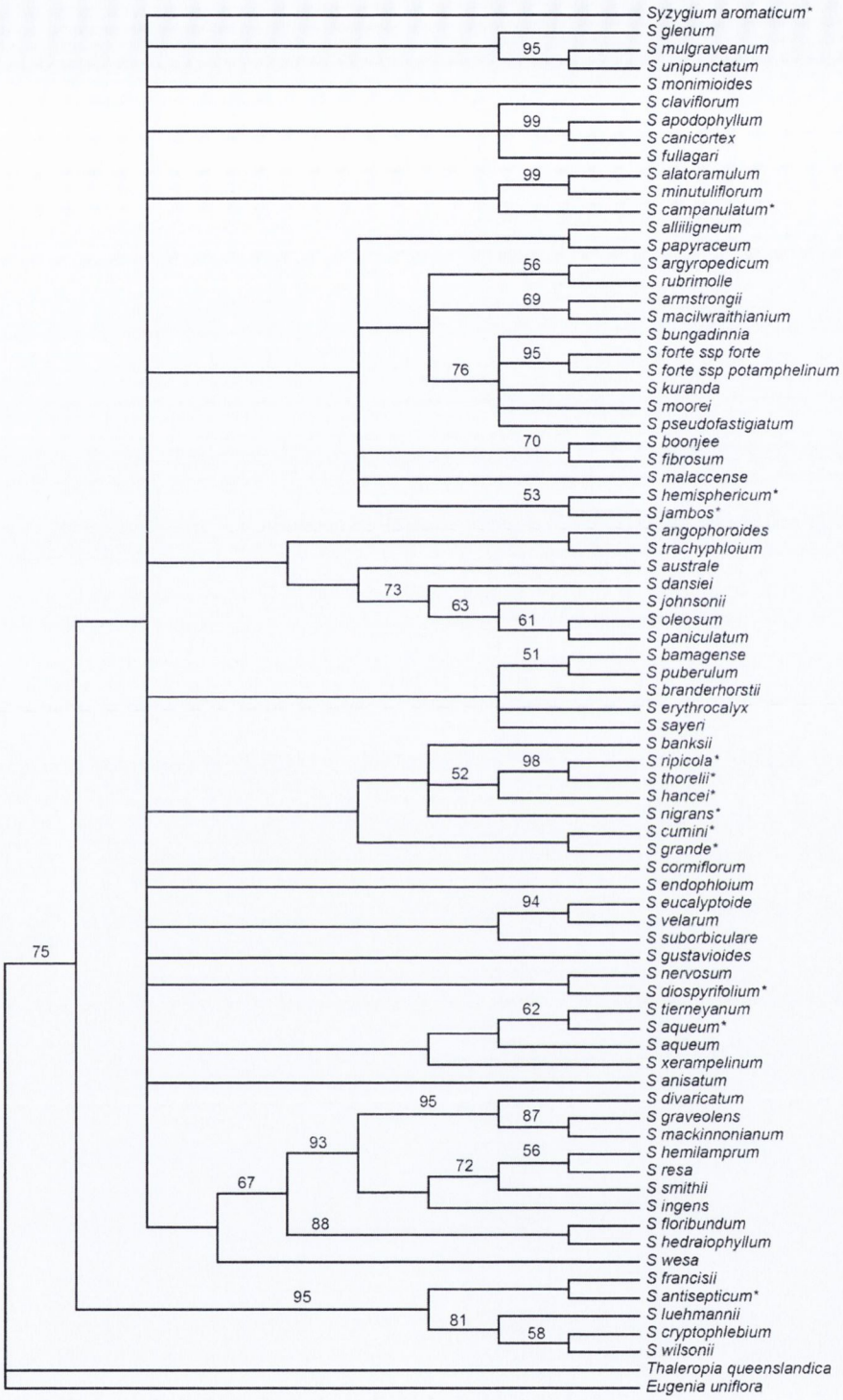


Figure 4.9. Majority-rule consensus tree of 33,200 MPTs resulting from parsimony analysis of ETS data. Bootstrap values over 50% are indicated above branches. Asterisks after species names are data generated from this study.

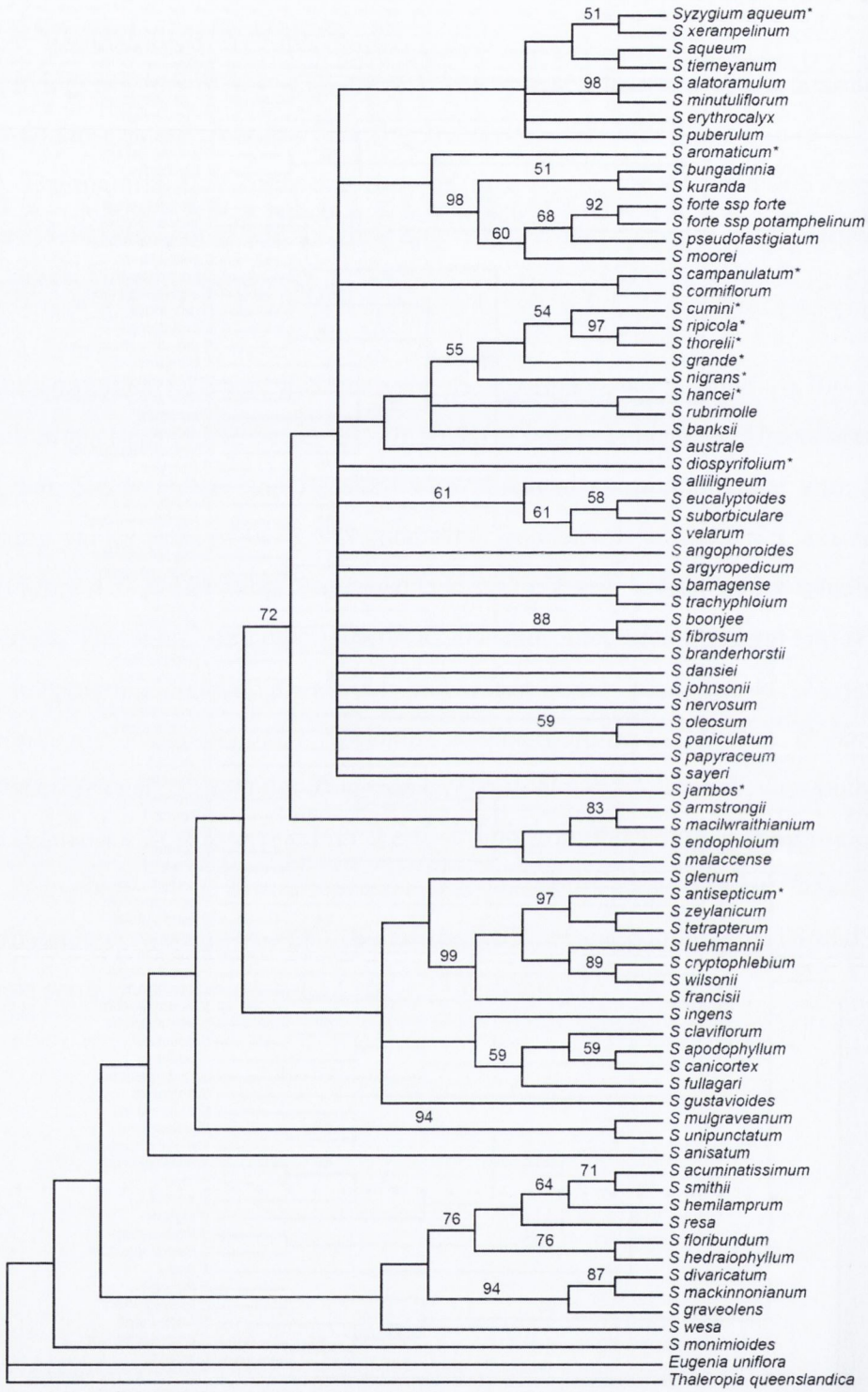


Figure 4.10. Majority-rule consensus tree of 9,500 MPTs resulting from parsimony analysis of ITS data. Bootstrap values over 50% are indicated above branches. Asterisks after species names are data generated from this study.

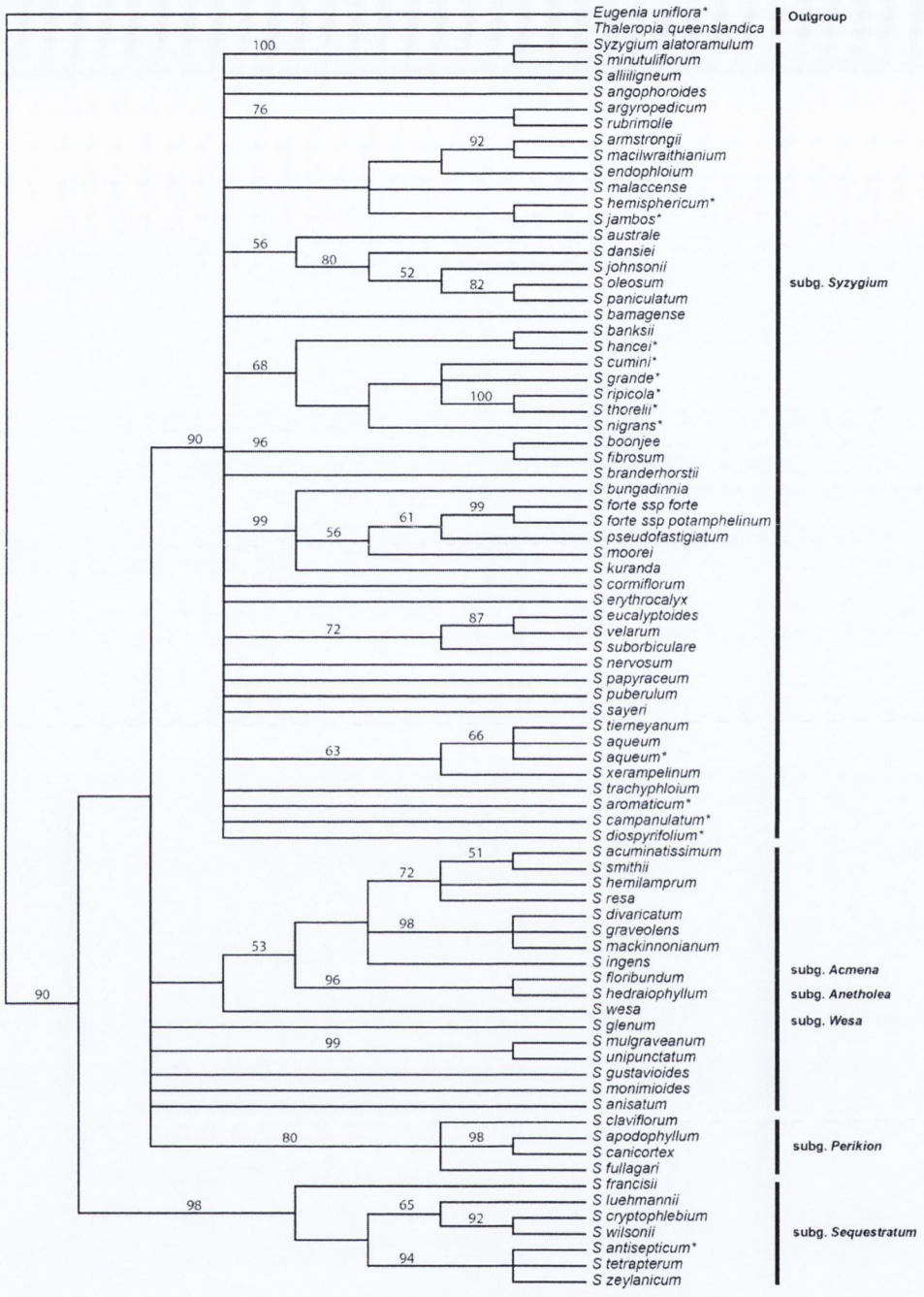


Figure 4.11. Strict consensus tree of 16700 MPTs resulting from parsimony analysis of ETS and ITS data (1267 steps, CI = 0.5154, RI = 0.6189). Bootstrap values over 50% are indicated above branches. Asterisks after species names are data generated from this study.

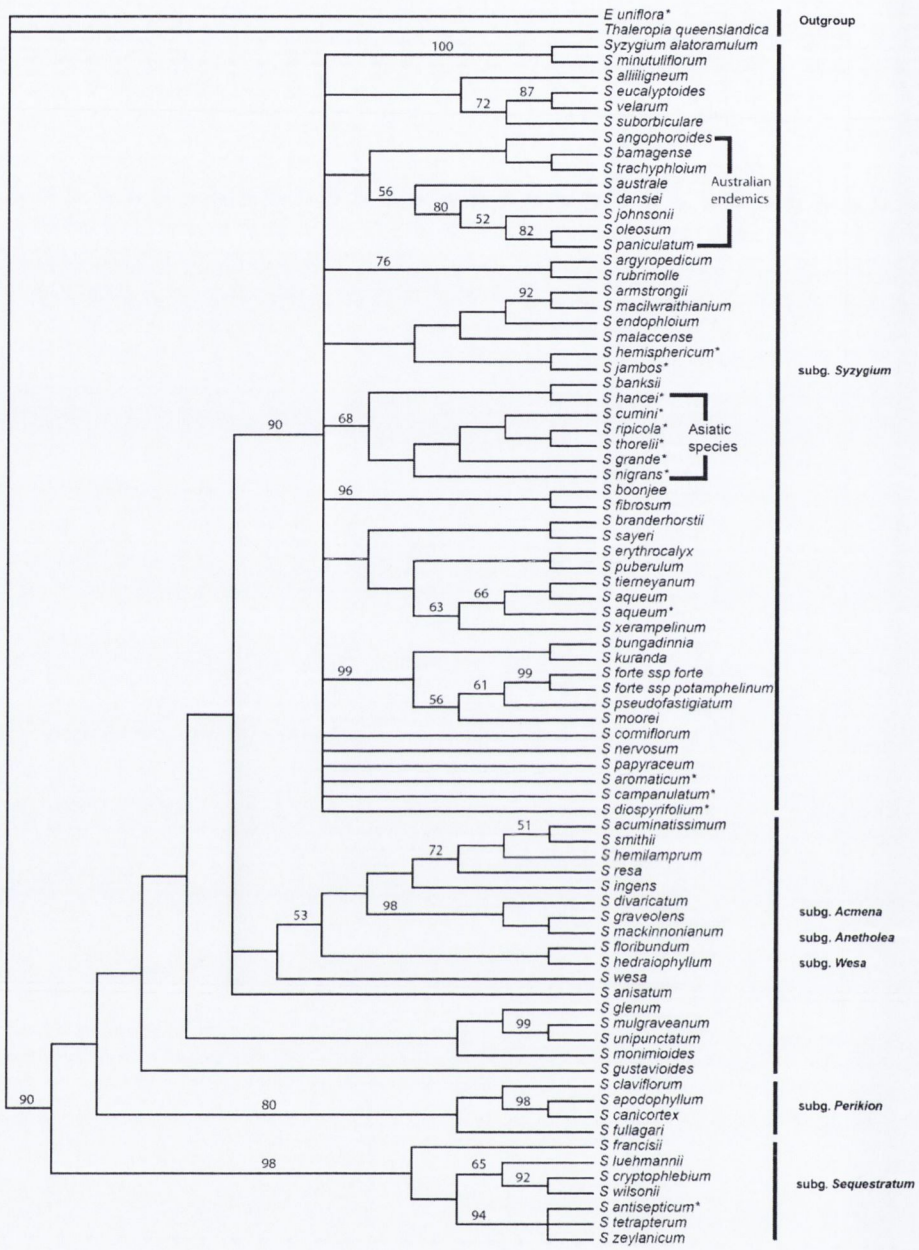


Figure 4.12. Majority-rule consensus tree of 16,700 MPTs resulting from parsimony analysis of ETS and ITS data. Bootstrap values over 50% are indicated above branches. Asterisks after species names are data generated from this study.

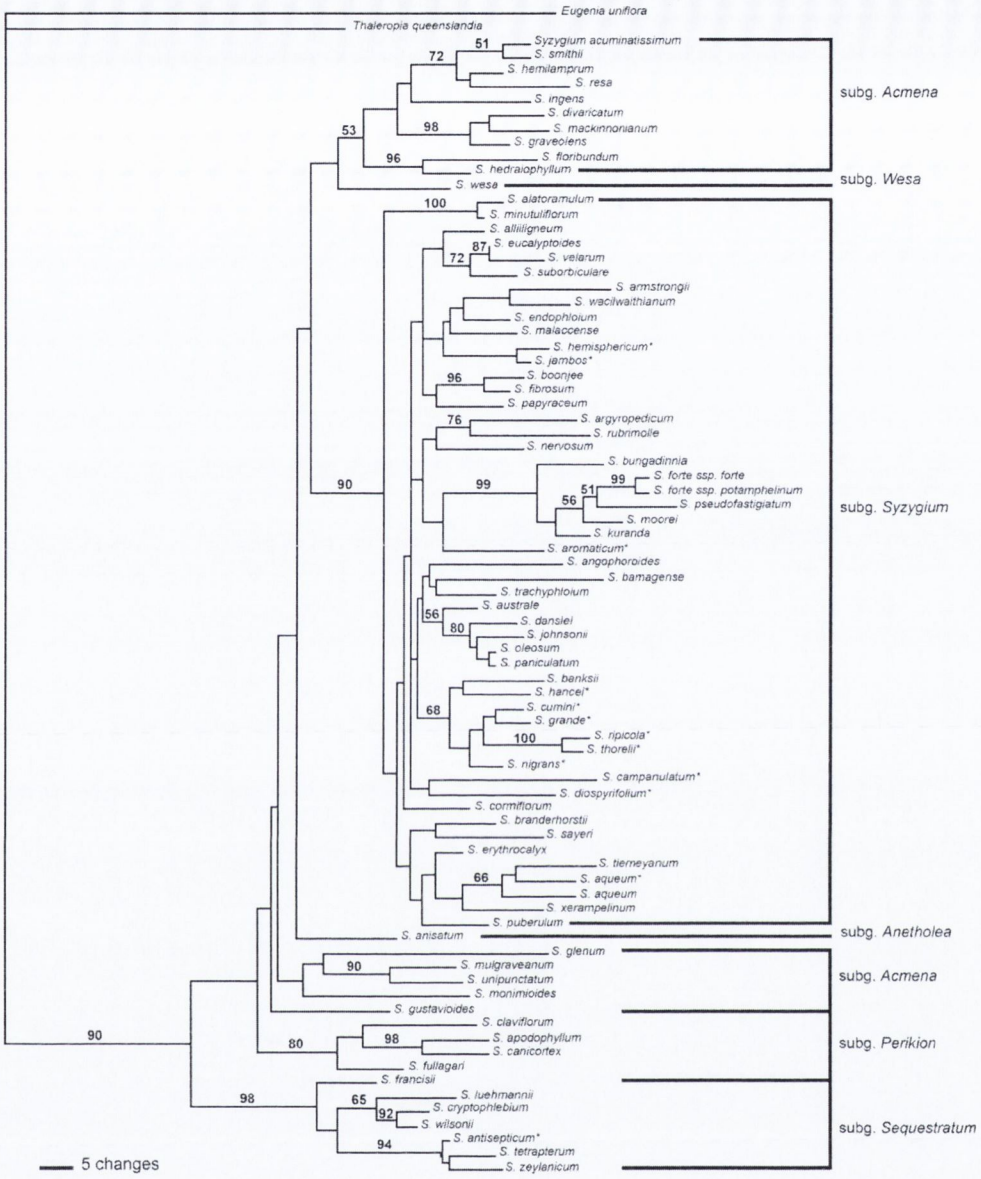


Figure 4.13. One of the 16,700 MPTs resulting from parsimony analysis of ETS and ITS data. Bootstrap values over 50% are indicated above branches. Asterisks after species names are data generated from this study.

4.3.3 Morphological character evolution

The character consistency index (ci) and retention index (ri) for the morphological and ETS-ITS analyses are given in Table 4.5.

The consistency index (ci) is a measure of character homoplasy, higher values mean less homoplasy. A character is homoplasious if the ci value is not equal to one. However this also means that the ci value is inflated if a character is invariable or uninformative. The retention index (ri) is another way of measuring how phylogenetically informative a character is. A ri of '0' for a character shows that no phylogenetic information is present but on the other hand, a high ri value shows that it is more phylogenetically informative (Kitching et al., 1998). Therefore, in interpreting the usefulness of a character, both ci and ri values are usually taken into account. Generally, the magnitude of the ci and ri in the results derived from morphological dataset and ETS-ITS dataset are in agreement. Character optimisation on the ETS-ITS DNA phylogeny for leaf anatomical characters should be interpreted with caution because of the lack of information for many of the species. In addition to that the species composition in the morphological and DNA analysis is different. Thirty of the thirty-four morphological characters included in this study are homoplasious. The leaf arrangement (character 17), anther locules (character 27), placentation (character 28) and flower size (character 32) are not homoplasious (ci = 1, for morphological dataset). The midrib abaxial texture, lateral vein bundle sheath extension and petiole-blade length ratio are uninformative (ri = 0, for morphological dataset). The results of the character optimization in this study showed that all subgenera in *Syzygium* are defined by a combination of homoplasious characters. Hypotheses of character polarity in *Syzgium* based on morphological phylogeny and character optimisation on the combined ETS-ITS tree is summarised in Table 4.6. This hypothesized character polarity is probably an over simplified picture, as most of these characters are homoplasious and their evolutionary routes are complex involving many reversals and parallel developments.

Table 4.5. Character consistency index (ci) and retention index (ri). Values in bold are ri ≥ 0.7 in the morphological analysis. Character optimisation on the ETS-ITS DNA phylogeny for leaf anatomical characters should be interpreted with caution because of the lack of information for many of the species.

Character	Morphology (qualitative and quantitative) cladogram		ETS-ITS cladogram	
	ci	ri	ci	ri
(1) Stomata	0.75	**0.97**	0.96	0.92
(2) Epidermis abaxial anticlinal cell wall	0.17	0.54	0.31	0.08
(3) Lamina cuticle texture	0.14	0.25	0.20	0.20
(4) Leaf crystal	0.50	**0.95**	0.50	0.87
(5) Midrib adaxial surface texture	0.18	0.18	0.67	0.25
(6) Midrib abaxial surface texture	0.33	0.00	1.00	0.00
(7) Midrib adaxial phloem partition	0.17	**0.86**	0.33	0.88
(8) Midrib vascular system	0.44	**0.72**	0.67	0.40
(9) Midrib sclerenchyma	0.13	0.46	0.44	0.29
(10) Lamina adaxial cell shape	0.14	0.61	0.30	0.42
(11) Lamina abaxial cell shape	0.29	0.38	0.50	0.80
(12) Adaxial palisade layer	0.13	0.68	0.54	0.60
(13) Abaxial palisade layer	0.20	0.43	0.25	0.00
(14) Lateral vein bundle sheath extension	0.33	0.00	0.33	0.00
(15) Foliar sclereid	0.17	0.17	0.50	0.67
(16) Twig texture	0.10	0.61	0.55	0.00
(17) Leaf arrangement	1.00	**1.00**	1.00	0.00*
(18) Leaf base	0.11	0.41	0.17	0.17
(19) Leaf ratio	0.11	0.39	0.06	0.17
(20) Leaf texture	0.11	0.69	0.07	0.38
(21) Leaf colour	0.13	0.58	0.24	0.30
(22) Leaf venation type	0.17	0.51	0.28	0.21
(23) Inflorescence type	0.20	**0.80**	0.20	0.20
(24) Hypanthium shape	0.20	**0.86**	0.20	0.60
(25) Calyx coherence	0.33	0.67	0.25	0.40
(26) Petal coherence	0.09	0.69	0.07	0.38
(27) Anther locule orientation	0.50	**0.75**	1.00	1.00
(28) Ovule placentation	1.00	**1.00**	0.50	0.91

(29) Seed intercotyledonary intrusion	0.25	**0.75**	0.25	0.77
(30) Leaf length	0.20	0.43	-	-
(31) Petiole/blade length ratio	0.250	0.00	-	-
(32) Hypanthium diameter	1.00	**1.00**	-	-
(33) Outer stamen length	0.20	0.69	-	-
(34) Style length	0.25	0.57	-	-

* The ri value in ETS-ITS analysis is '0' because verticillate leaves character is represented only by one species (*S. diosyprifolium*).

Table 4.6. Hypothesized character polarity in *Syzygium* based on morphological and ETS-ITS phylogeny, character numbers in bold have a ri ≥ 7 in the morphological phylogeny, characters 6, 14 & 31with ri = 0 are omitted.

Character	Plesiomorphic → apomorphic
1	Morphology dataset: Paracytic →? anisocytic → anomocytic; cyclocytic; staurocytic ETS-ITS DNA dataset: Anomocytic →? anisocytic → (1) staurocytic, (2) cyclocytic → paracytic → anisocytic
2	Anticlinal cell wall undulate → straight; straight-curved; curved-undulate
3	Lamina cuticle smooth → ornamented
4	Morphology dataset: Druses predominant, prismatic crystals absent or infrequent → Prismatic crystals predominant, druses absent or infrequent ETS-ITS DNA dataset: Prismatic crystals predominant, druses absent or infrequent → druses predominant, prismatic crystals absent or infrequent
5	Midrib adaxial surface grooved/concave → flat; convex
7 & 8	Morphology dataset: Arc without adaxial phloem partion and straight margins → (1) circular; complex open system; arc without adaxial phloem partion, margin interrupted into free bundles, (2) arc with adaxial phloem partition, margin straight → arc with adaxial phloem partition, margin incurved ETS-ITS DNA dataset: Arc with adaxial phloem partition and straight margins → (1) arc with adaxial phloem partition, margin incurved, (2) arc without adaxial phloem partition, margin straight → circular; complex open system; arc without adaxial phloem partition, margin interrupted into free bundles
9	Midrib sclerenchyma continuous → discontinuous

10	Lamina adaxial cell shape wider than high → equal width and height; higher than wide
11	Lamina abaxial cell shape wider than high → equal width and height; irregular
12	Palisade layer on adaxial surface 1 layer → 2 layers ↔ 3 layers
13	Abaxial palisade layer absent → present
15	Foliar sclereid absent → present
16	Twig texture terete, compressed or subangular → angular or winged
17	Leaf arrangement opposite or subopposite → verticillate
18	Leaf base cuneate or slightly attenuating → strongly attenuating; cordate or rounded.
19	Leaf ratio three times longer than wide or less → more than three times longer than wide
20	Leaf texture chartaceous or thinly coriaceous → thickly coriaceous
21	Leaf colour light brownish or yellowish → dark brownish; greenish
22	Leaf venation type A.II → A.I; A.III; B; C
23	Inflorescence racemose/ solitary → paniculate
24	Morphology dataset: Hypanthium obconic/pyriform → clavate/elongated ETS-ITS DNA dataset: Hypanthium clavate/elongated → obconic/pyriform
25	Calyx free → calyptrate
26	Petals coherence free → coherent
27	Anther locules elongate and parallel, dehiscence by longitudinal slits → locules divaricate, dehiscence by apical slits.
28	Placentation axile-median → placentation axile-apical
29	Seed intercotyledonary intrusion absent → present
30	Small leaf → large leaf (leaf length 0–20 cm → length equal or more than 20 cm)
32	Hypanthium small → large (hypanthium diameter 1–10 mm → equal or more than 15 mm)
33	Stamen short → long (outer stamen length 0–12 mm → equal or more than 15 mm)
34	Style short → long (length 0-17 mm → equal or more than 20 mm)

4.3.4 Phenetic analysis

The NMDS solutions for the first two dimensions are shown in Figure 4.14 (normalised raw stress = 0.05208). The species points are circumscribed into groups according to the classification of Craven and Biffin (2010). There are three major groups in the NMDS diagram: the points representing species from subg.

Syzygium are distributed along the lower-right side; points at the upper-left of the ordination represent subgenera *Acmena* and *Perikion*, with subg. *Acmena* at the top and subg. *Perikion* at the bottom; points at the lower-left of the ordination represent subg *Sequestratum* but with one species from subg. *Perikion* (*S. apodophyllum*) circumscribed.

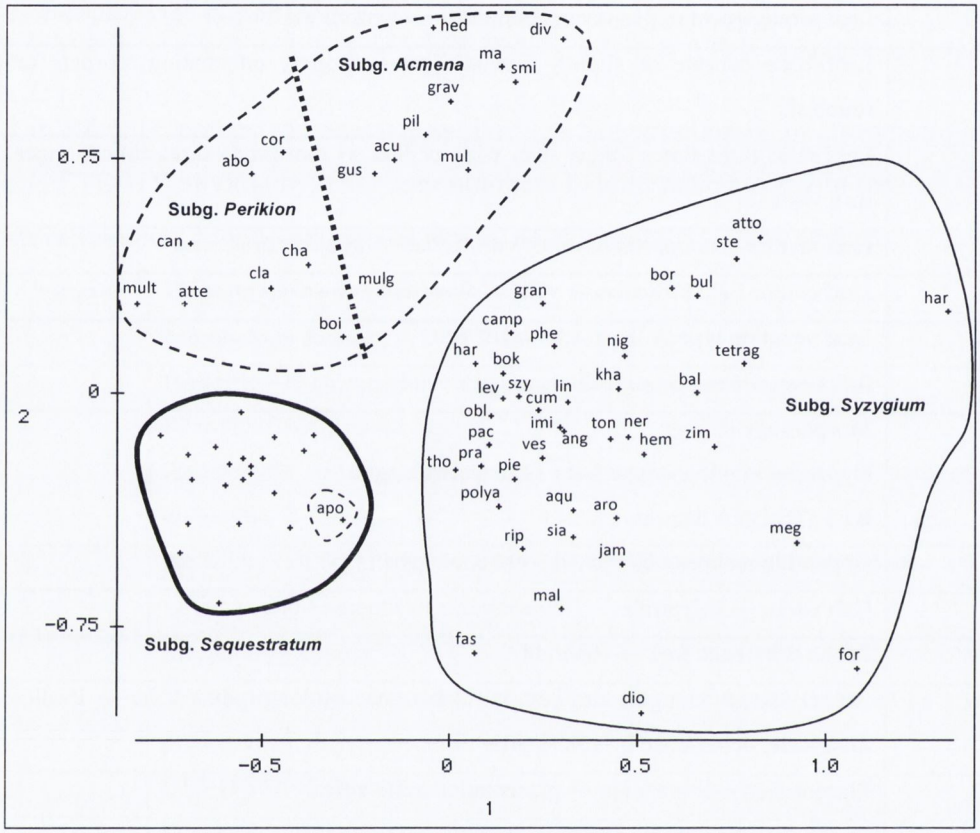


Figure 4.14. NMDS ordination of the qualitative and quantitative morphological dataset. Circumscription in unbold line = subg. *Syzygium*, bold line = subg. *Sequestratum*, dashes = subgenera *Acmena* and *Perikion*, divided by bold dotted line.

The species in the subg. *Sequestratum* are not labelled. The species abbreviations are as follows: ***abo*** = *S. abortivum*; ***acu*** = *S. acuminatissimum*; ***ang*** = *S. angkae*; ***apo*** = *S. apodophyllum*; ***aqu*** = *S. aqueum*; ***aro*** = *S. aromaticum*; ***atte*** = *S. attenuatum*; ***atto*** = *S. attopeuense* ; ***bal*** = *S. balsameum*; ***boi*** = *S. boisianum*; ***bok*** = *S. bokorense*; ***bor*** = *S. borneense*; ***bul*** = *S. bullockii;* ***can*** = *S. canicortex*; ***cha*** = *S. championii*; ***cla*** = *S. claviflorum*; ***cor*** = *S. corynanthum*; ***cum*** = *S. cumini*; ***dio*** = *S. diospyrifolium*; ***div*** = *S. divaricatum*; ***fas*** = *S. fastigiatum;* ***for*** = *S. formosum*; ***fra*** = *S. francisii*; ***gra*** = *S. graveolens*; ***gran*** = *S. grande*; ***gus*** = *S. gustavioides*; ***har*** = *S. harmandii*; ***hed*** = *S.*

hedraiophyllum; **hem** = *S. hemisphericum*; **imi** = *S. imitans*; **jam** = *S. jambos*; **kha** = *S. khaoyensis*; **lev** = *S. levinei*; **lin** = *S. lineatum*; **mac** = *S. mackinnonianum*; **mal** = *S. malaccense*; **meg** = *S. megacarpum*; **mek** = *S. mekongense*; **mulg** = *S. mulgraveanum*; **multip** = *S. multipetalum*; **ner** = *S. nervosum*; **nig** = *S. nigrans*; **obl** = *S. oblatum*; **pac** = *S. pachysarcum*; **phe** = *S. phengklaii*; **pie** = *S. pierrei*; **pil** = *Piliocalyx francii*; **pol** = *S. polyanthum*; **pra** = *S. praecox*; **pte** = *S. pterophorum*; **rip** = *S. ripicola*; **sia** = *S. siamense*; **smi** = *S. smithii*; **ste** = *S. sterrophyllum*; **syz** = *S. syzygioides*; **tetrag** = *S. tetragonum*; **tho** = *S. thorelii*; **ton** = *S. tonkinense*; **tso** = *S. tsoongii*; **uni** = *S. unipunctatum* **ves** = *S. vestitum*; **zim** = *S. zimmermanni*.

4.3.5 Species placement in the phenetic and phylogenetic analyses

The species placement in the phenetic and phylogenetic analyses is given in Table 4.7. The subg. *Syzygium* is the largest group (41 spp.), followed by subg. *Sequestratum* (21 or 22 spp.), subg. *Acmena* (10 spp.) and subg. *Perikion* (8 or 9 spp.). *Syzygium apodophyllum* was placed in subg. *Perikion* in the ETS-ITS and chloroplast DNA analyses (Harrington & Gadek, 2004; Biffin et al., 2006) but falls into subg. *Sequestratum* in the NMDS analysis.

Table 4.7. Species position in the respective subgenera. Superscript number represent the analyses that support the circumscription: 1 – NMDS ordination of morphological data; 2 – Morphological phylogeny, strict consensus tree; 3 – Morphological phylogeny, majority-rule consensus tree; 4 – ETS and ITS nuclear DNA phylogeny, strict consensus tree; 5 – *mat*K, *ndh*F and *rpl*16 chloroplast DNA phylogeny, strict consensus tree (Biffin et al., 2006).

Subg. *Syzygium*[1,3]	*Acmena-Perikion* clade[1,3]		Subg. *Sequestratum*[1,2,3]
	Subg. *Acmena*	Subg. *Perikion*	
Syzygium angkae	*Piliocalyx francii*[5]	*S. abortivum*	*S. aksornae*
S. aqueum[5]	*S. acuminatissimum*[4]	*S. apodophyllum*[4,5]	*S. antisepticum*[4]
S. aromaticum[4]	*S. divaricatum*[4,5]	*S. attenuatum*	*S. araiocladum*
S. attopeuensis	*S. graveolens*[4,5]	*S. boisianum*	*S. apodophyllum*[1]
S. balsameum	*S. gustavioides*[5]	*S. canicortex*[4,5]	*S. bankense*[5]
S. bokorense	*S. hedraiophyllum*[4,5]	*S. championii*	*S. bicolor*
S. borneense	*S. mackinnonianum*[4,5]	*S. claviflorum*[4,5]	*S. cryptophlebium*[4]
S. bullockii	*S. mulgraveanum*[5]	*S. corynanthum*	*S. francisii*[4,5]
S. campanulatum[4]	*S. smithii*[4,5]	*S. multipetalum*[5]	*S. jasminifolium*
S. cumini[4,5]	*S. unipunctatum*[5]		*S. kinabaluense*
S. diospyrifolium[4]			*S. luehmannii*[4,5]
S. fastigiatum			*S. multibracteolatum*
S. formosum			*S. nummularium*
S. grande[4]			*S. odoratum*
S. hancei[4]			*S. polycladum*
S. harmandii			*S. pterophorum*

S. hemisphericum[4] *S. imitans* *S. jambos*[4,5] *S. khaoyensis* *S. levinei* *S. lineatum* *S. malaccense*[4,5] *S. megacarpum* *S. nervosum*[5] *S. nigrans*[4] *S. oblatum* *S. pachysarcum* *S. phengklaii* *S. pierrei* *S. polyanthum* *S. praecox* *S. ripicola*[4] *S. siamense* *S. sterrophyllum* *S. syzygioides* *S. tetragonum* *S. thorelii*[4] *S. tonkinense* *S. vestitum* *S. zimmmermanni*			*S. staphianum* *S. tenuirame* *S. tephrodes* *S. tetrapterum*[4,5] *S. tsoongii* *S. wilsonii*[4,5]

4.4 Discussion

4.4.1 Phylogenetic relationship and character optimization

In the morphological analyses (strict consensus trees; Figures 4.5 and 4.6), only subg. *Sequestratum* is resolved as monophyletic with support of DI ranging from 2−3). However, the clades recovered by the morphological analysis in the majority-rule consensus tree (Figure 4.7) showed some degree of congruence with strict consensus ETS and ITS analysis (Figure 4.11) whereby in both the morphological and DNA analyses subg. *Syzygium* and subg. *Sequestratum* are monophyletic. In the majority-rule consensus tree for morphological analysis, the subg. *Acmena* and *Perikion* are paraphyletic and form a monophyletic group sister to subg. *Sequestratum* but without any DI support. The phylogenetic trees derived from the morphological data (Figure 4.7 and 4.8) showed that the subg. *Syzygium* diverged earlier than subg. *Acmena*, *Perikion* and *Sequestratum*, but this is the reverse in ETS-ITS and chloroplast derived phylogenetic trees where subg. *Sequestratum* was the first and followed by *Perikion*, *Acmena* and *Syzygium* (Figure 4.12 and 4.13). This is because the outgroup choice was different in the morphology and DNA analysis.

In the combined ETS and ITS analyses, as expected, the phylogenetic tree topology are is agreement with Harrington and Gadek (2004) since the data used here is largely derived from the their study (see Figure 4.11, 4.12 and 4.13). In comparison to the findings from chloroplast DNA (Biffin et al. 2006; Craven & Biffin, 2010), the subg. *Perikion*, *Syzygium* and *Sequestratum* are monophyletic and strongly supported with bootstrap values of 80%, 90% and 98% respectively, while subg. *Acmena* is paraphyletic and subg. *Anisata* and *Wesa* are not supported with any bootstrap value. In the chloroplast DNA study, the subg. *Acmena* was monophyletic with BS more than 90% (Biffin et al., 2006). Table 4.8 highlights the important morphological characters in the four subgenera based on the morphological and ETS-ITS analyses. This table also complements the following discussion on the four subgeneric groups.

Table 4.8. Distribution of important generic level morphological characters.

Character	*Syzygium*	*Acmena*	*Perikion*	*Sequestratum*
1	Paracytic or paracytic-anisocytic	Cyclocytic	Paracytic-anisocytic, cyclocytic-anisocytic and staurocytic-anisocytic	Anomocytic-anisocytic
4	Druses predominant and prismatic crystals absent or infrequent, rarely in equal frequency, e.g. *S. campanulatum*	Prismatic crystals predominant and druses absent or infrequent	Prismatic crystals predominant and druses absent or infrequent	Prismatic crystals predominant and druses absent or infrequent, rarely in equal frequency, e.g. *S. francisii*
7 & 8	Midrib vascular system mostly without adaxial phloem partition, rarely present (except in *S. sterrophyllum*). Mostly arc, sometimes with incurved margin or with interrupted bundles; circular; complex open system	Midrib vascular system mostly with adaxial phloem partition, rarely without (except in *S. mulgraveanum*). Mostly arc with incurved margin, sometimes without.	Midrib vascular system mostly with adaxial phloem partition, rarely without (except in *S. attenuatum*). Mostly arc with incurved margin, sometimes without.	Midrib vascular system mostly with adaxial phloem partition, rarely without (except in *S. staphianum* and *S. odoratum*). Mostly arc without incurved margin, rarely without.
24	Hypanthium mostly obconic or pyriform, rarely clavate or elongated	Hypanthium obconic or pyriform	Hypanthium clavate or elongate	Hypanthium mostly clavate or elongated
27	Anther locule elongate and parallel	Anther mostly divaricate, rarely elongate and parallel	Anther locule elongate and parallel	Anther locule elongate and parallel

28	Placentation axile-median	Placentation mostly axile apical, rarely axile-median, e.g. *S. gustavioides*	Placentation axile median	Placentation axile median
29	Seed without intercotyledonary intrusion	Seed mostly with intercotyledonary intrusion, sometimes without	Seed with or without intercotyledonary intrusion	Seed without intercotyledonary intrusion

Subg. *Syzygium*. The subg. *Syzygium* is a large and morphologically diverse group of which the monophyly has been established using both chloroplast and nuclear DNA sequences (Harrington and Gadek, 2004; Biffin et al., 2006). Although this group is not defined by any unique morphological characters, it is defined by a set of homoplasious morphological characters. The best combination of non-unique characters that occur in the majority of the species if not all, concluded from previous studies is: anther locules parallel, placentation axile-median, arranged irregularly or radiating, seeds without intercotyledonary intrusion and cotyledons free (Craven and Biffin 2010). The following, non-unique characters that occur in most of the species in this group were found in this study and support its monophyly: paracytic and anisocytic stomata, druses predominant while prismatic crystals absent or infrequent, midrib vascular system arch and without adaxial phloem partition. In addition, unique characters that occur in subg. *Syzygium* but only in a few species were: foliar sclereids (*S. hemisphericum*, *S. jambos*, *S. malaccense*, *S. nigrans*, *S. phengklaii*, *S. pierrei* and *S. siamense*); verticillate leaves arrangement (*S. diospyrifolium*, *S. formosum* and *S. harmandii*); midrib vascular system arc with interrupted bundles (*S. nervosum*), circular (*S. diospyrifolium*, *S. fastigiatum*, *S. fastigiatum* and *S. polyanthum*) or complex open bundle system (*S. balsameum* and *S. tetragonum*). These unique characters are perhaps useful for characterizing smaller clades below subgeneric level. However, the topologies within subg. *Syzygium* derived from morphological and ETS-ITS datasets are inconsistent. Phylogenetic analyses using ETS-ITS DNA recovered *S. banksii*, *S. cumini*, *S. grande*, S. *hancei*, *S. nigrans*, *S. ripicola* and *S. thorelii* as one clade (BS = 68%) within subg. *Syzygium* but this was not the case in the morphological analysis (Figure 4.12). All of the species in this group, except for *S. banksii*, have their centre of distribution in Southeast Asia, whereas the Australian endemic species form another clade within subg. *Syzygium*

(Figure 4.12). This suggest that geography is a better predictor of phylogenetic relatedness for some clades. The *Jambosa* group has been recognised as a genus or subgenus by some authors, based on its large leaves, flowers and fruit, and spreading petals (Parnell, 1999). Indeed this group was recovered as monophyletic within subg. Syzgium (DI = 2, Figure 4.6) in the morphological analysis when quantitative data are included (leaf length - character 30; hypanthium diameter - character 32; outer stamen length - character 33; style length - character 34), hereby corroborating the result of Parnell (1999). This group was not recovered in the qualitative morphological analysis (Figure 4.5) and ETS-ITS DNA analysis (Figure 4.11), which could imply that leaf and flower size are phylogenetically uninformative. The clade consisting of *S. diospyrifolium*, *S. formosum* and *S. harmandii* was well supported by characters of verticillate leaf arrangement and circular midrib vascular system (DI = 8 in qualitative morphology analysis; DI = 2 in qualitative and quantitative morphology analysis).

Subg. *Sequestratum.* Subg. *Sequestratum* or its equivalent grouping is defined by a combination of homoplasious characters such as its glaucous hypanthium and fruit, head-like inflorescence, elongated hypanthium, anther locules parallel, placentation axile-median, arranged in two longitudinal rows, seed without intercotyledonary intrusion and cotyledons free (Henderson, 1949; Hyland, 1983; Biffin et al., 2006; Craven and Biffin 2010). This subgenus is comparable to the informal groups of Henderson's (1949) section *Syzygium*-group 4 and Hyland's (1983) *Syzygium*-group 4. This group is consistently recovered with a high support value in the morphological study (Figure 4.5 and 4.6) and nuclear DNA analysis (Figure 4.11) in this study, in Harrington and Gadek (2004) and in chloroplast DNA analysis (Biffin et al., 2006). Consistent with previous authors (Henderson, 1949; Biffin et al., 2006; Craven and Biffin, 2010), with the exception of glaucous flowers and fruit and head-like inflorescence, all the characters were optimised and the result supported the monophyly of subg. *Sequestratum*. Glaucous flowers and fruit characters were not optimised and they were not scored in the matrix. The head-like inflorescence character is polymorphic within the subg. and occurs in other subgenera. Additional characters supporting this group in this study were anisocytic and anomocytic stomata,

prismatic crystals predominant while druses absent or infrequent, and midrib vascular system arch with adaxial phloem partition.

Subg. *Acmena* and *Perikon*. In the morphological analysis, the clade subg. *Acmena* and *Perikion* was recovered,without DI support as one clade in the majority-rule consensus tree (Figure 4.7) but not in the strict consensus tree (Figure 4.6). In this study, the *Acmena-Perikion* clade is differentiated from other subgeneric clades in having an arc with incurved margins in the midrib vascular system and seed intercotyledonary intrusion in most species. It is similar to subg. *Sequestratum* in having predominantly prismatic crystals and druses absent or infrequent and the midrib vascular system mostly with adaxial phloem partition. In the ETS-ITS DNA analysis, which is based on the dataset from Harrington and Gadek (2004), subg. *Perikion* is represented by *S. apodophyllum, S. canicortex, S. claviflorum* and *S. fullagari* (BS = 80%). In the chloroplast DNA phylogenetic analysis (Biffin et al., 2006; Craven & Biffin, 2010), these species together with five additional species formed a monophyletic group with BS more than 90%. The subg. *Perikion* is defined by the presence of numerous fibre bundles in the hypanthium wall, ovule placentation axile-median, arranged in two longitudinal rows but sometimes irregularly arranged, and seeds with or without intercotyledonary intrusion (Biffin et al, 2006; Craven & Biffin, 2010). Character optimization in the ETS-ITS phylogenetic tree does not show any unique characters due to low species number (four). In the morphological analyses, *Syzygium abortivum, S. boisianum, S. championii, S. claviflorum* and *S. corynanthum* formed a paraphyletic group with subg. *Acmena* in the majority-rule consensus tree (Figure 4.7) but not in the strict consensus tree (Figure 4.6). The position of *S. attenuatum* concurred with Henderson (1949), who had grouped this species together with *S. claviflorum* (Henderson's sect. *Syzygium*- group 5) based on hypanthium type.

4.4.2. Morphological character evolution

In the following discussion see in Section 4.3, Table 4.5 for the ci and ri values and Table 4.6 for the summary of morphological character polarisation.

4.4.2.1 Vegetative macromorphological characters

Vegetative macromorphological characters, with the exception of leaf arrangement (ci = 1, ri = 1), were the most homoplasious characters with low ci values on both morphological and ETS-ITS DNA phylogenetic trees. Verticillate leaf arrangement is synapomorphic for the clade consisting of *S. diospyrifolium*, *S. formosum* and *S. harmandii*. Other vegetative characters scored here, which include the twig texture and leaf characters (base, shape, texture, colour and venation types), are highly homoplasious.

4.4.2.2 Leaf anatomical characters

The stomatal types (character 1), leaf crystals (character 4) and midrib vascular system (character 8) including adaxial phloem partition (character 7) are the key synapomorphies that define the subgeneric clades. The following are discussions on the four anatomical characters.

Stomata

In the morphological phylogeny, paracytic and anisocytic stomata are plesiomorphic (Figure 4.15). In the ancestral species, both of these stomatal types may have occurred together or paracytic stomata could be plesiomorphic to anisocytic stomata. In the clade of subg. *Acmena-Perikion-Sequestratum*, ancestral group with paracytic stomata gave way to anisocytic stomata which later gave way to anomocytic, cyclocytic and staurocytic stomata (Figure 4.15). In the character optimisation of ETS-ITS DNA phylogeny, anomocytic and anisocytic stomata are plesiomorphic and both may have occurred together (Figure 4.16). Anisocytic stomata may have derived from anomocytic stomata. The anisocytic stomata may have evolved into staurocytic or cyclocytic stomata. Paracytic stomata were later derived from cyclocytic stomata and this, on occasion, again give rise to anisocytic stomata (Figure 4.16). In all the hypothesized cases, there is a trend in the increment of subsidiary cell number during the character transformation and at least one event where the subsidiary cells were lost or

reduced. Johnson and Briggs (1984), in their morphologically based cladistic analysis of Myrtaceae considered anomocytic as the primitive type and paracytic as derived, on the basis that anomocytic is less specialised than paracytic. The evolution of stomatal types in *Syzygium* may be far more complex than the optimization presented here because (1) multiple stomatal types occur on a single species and (2) each stomatal type is possibly derived from different or multiple ontogenic routes, therefore it is still unclear whether different

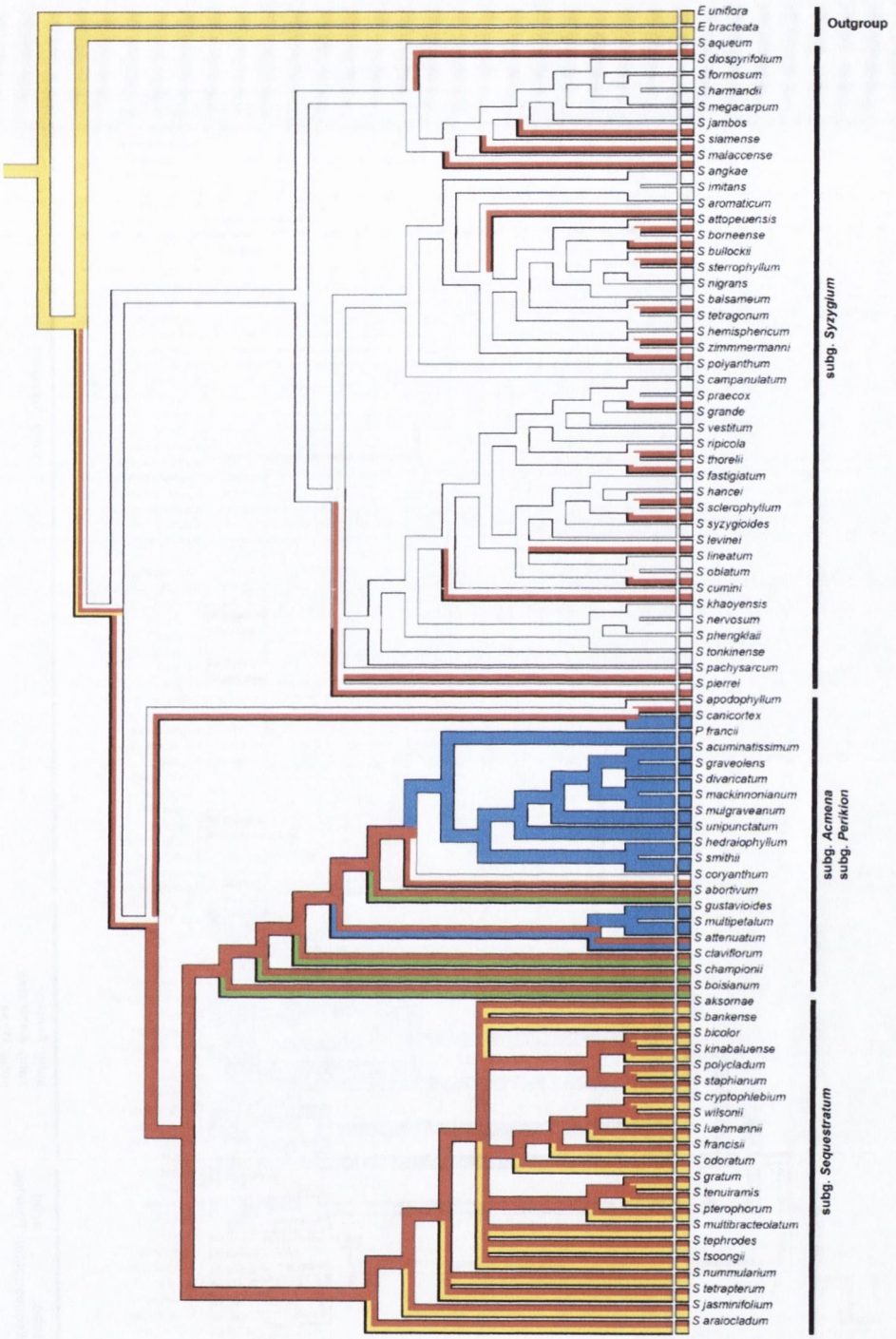


Figure 4.15. Character optimization of stomatal types on one of the 1,100 MPTs of qualitative and quantitative morphological data. White = paracytic; red = anisocytic; yellow = anomocytic; blue = cyclocytic; green = staurocytic. Squares at ends of branches denote taxa whose character have been investigated.

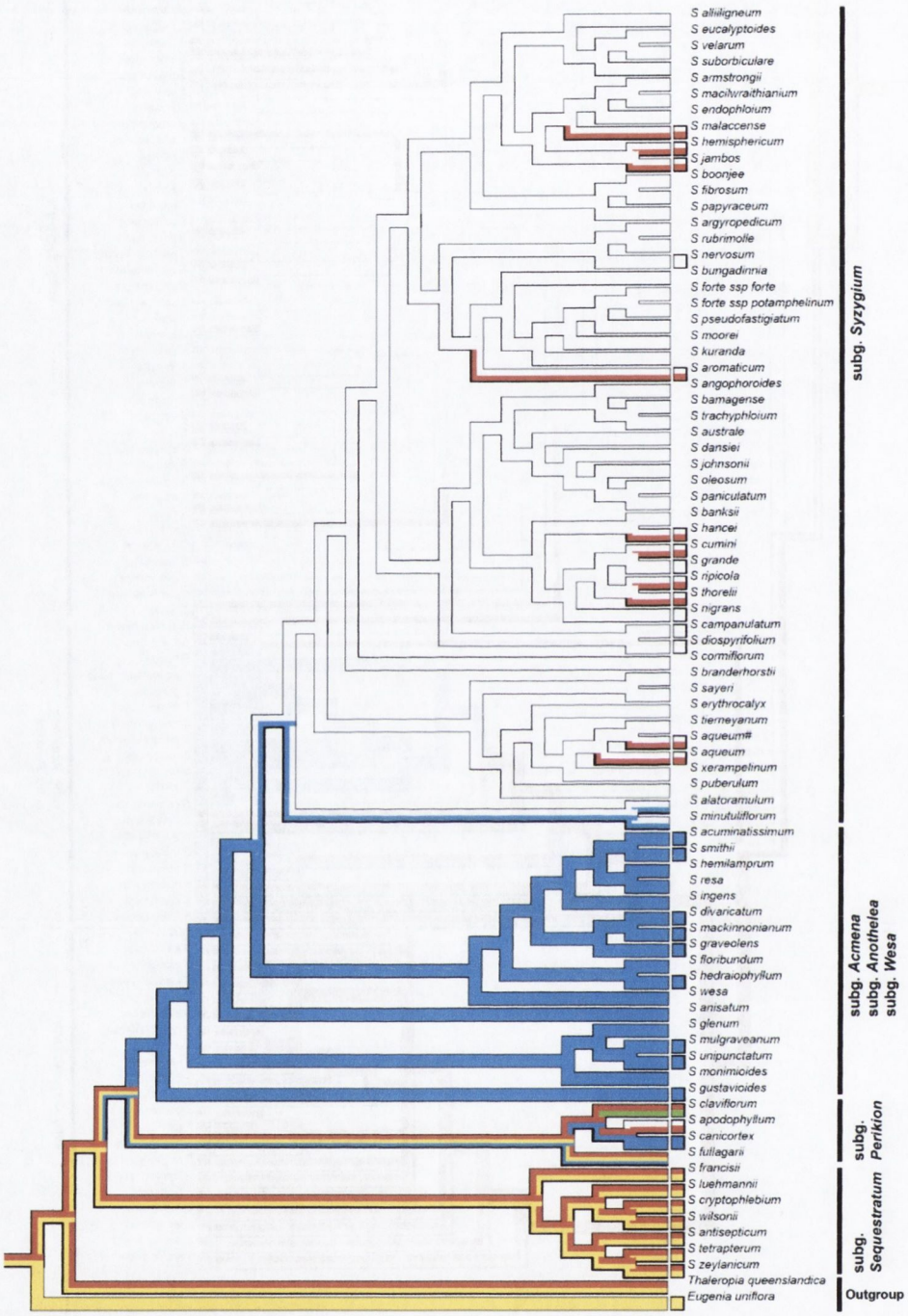


Figure 4.16. Character optimization of stomatal types on one of the 16,700 MPTs of combined ETS and ITS data. White = paracytic; red = anisocytic; yellow = anomocytic; blue = cyclocytic; green = staurocytic. Squares at ends of branches denote taxa whose character have been investigated.

or even similar stomatal types are homologous. In this study, due to the lack of developmental data, it is assumed that all stomatal types are homologous. Further investigation is required on the ontogeny of the stomatal types of *Syzygium* to determine their homology and plasticity.

Crystals

Prismatic crystals predominance is a synapomorphy for the clade of subg. *Acmena*, *Perikion* and *Sequestratum* whereas druses predominance is synapomorphic for subg. *Syzygium* (morphological phylogeny: ci = 0.5, ri = 0.951). Crystals have been taxonomically valuable in comparisons among families or higher level rank (Metcalfe & Chalk, 1950; Dickinson, 2000). Crystal macropattern for example, that is the location of crystals in plant organs, is reported to be species specific and under genetic control (Kausch & Horner, 1982). The importance of crystals in *Syzygium* taxonomy is documented for the first time in this study. Figure 4.17 and 4.18 show the character optimisation of crystal types on the morphological and molecular phylogenetic trees respectively.

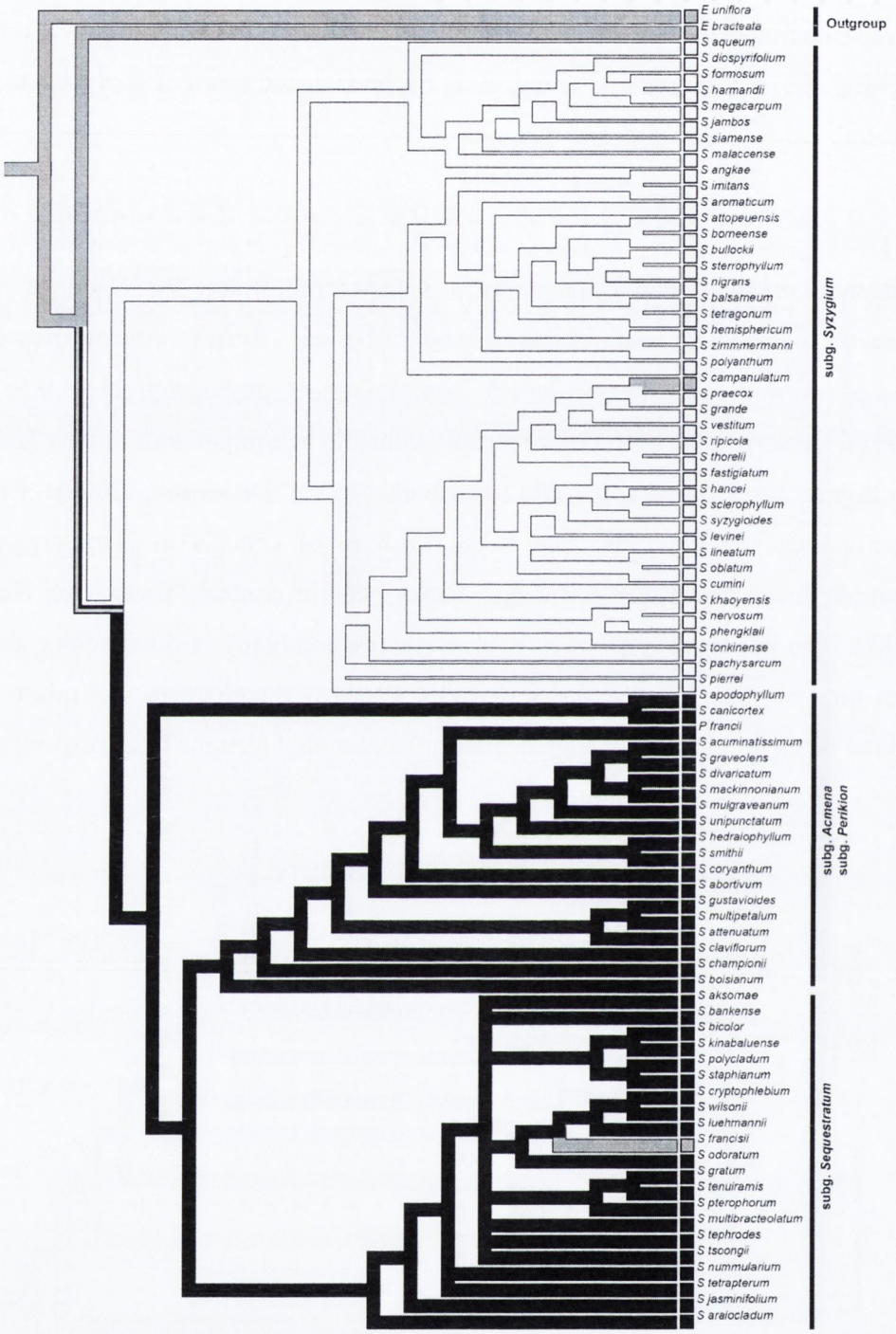


Figure 4.17. Character optimization of leaf crystals on one of the 1,100 MPTs of qualitative and quantitative morphological data. White = druses predominant and prismatic crystals absent or infrequent; black = prismatic crystals predominant and druses absent or infrequent; grey = druses and prismatic crystals in equal frequency. Squares at ends of branches denote taxa whose character have been investigated.

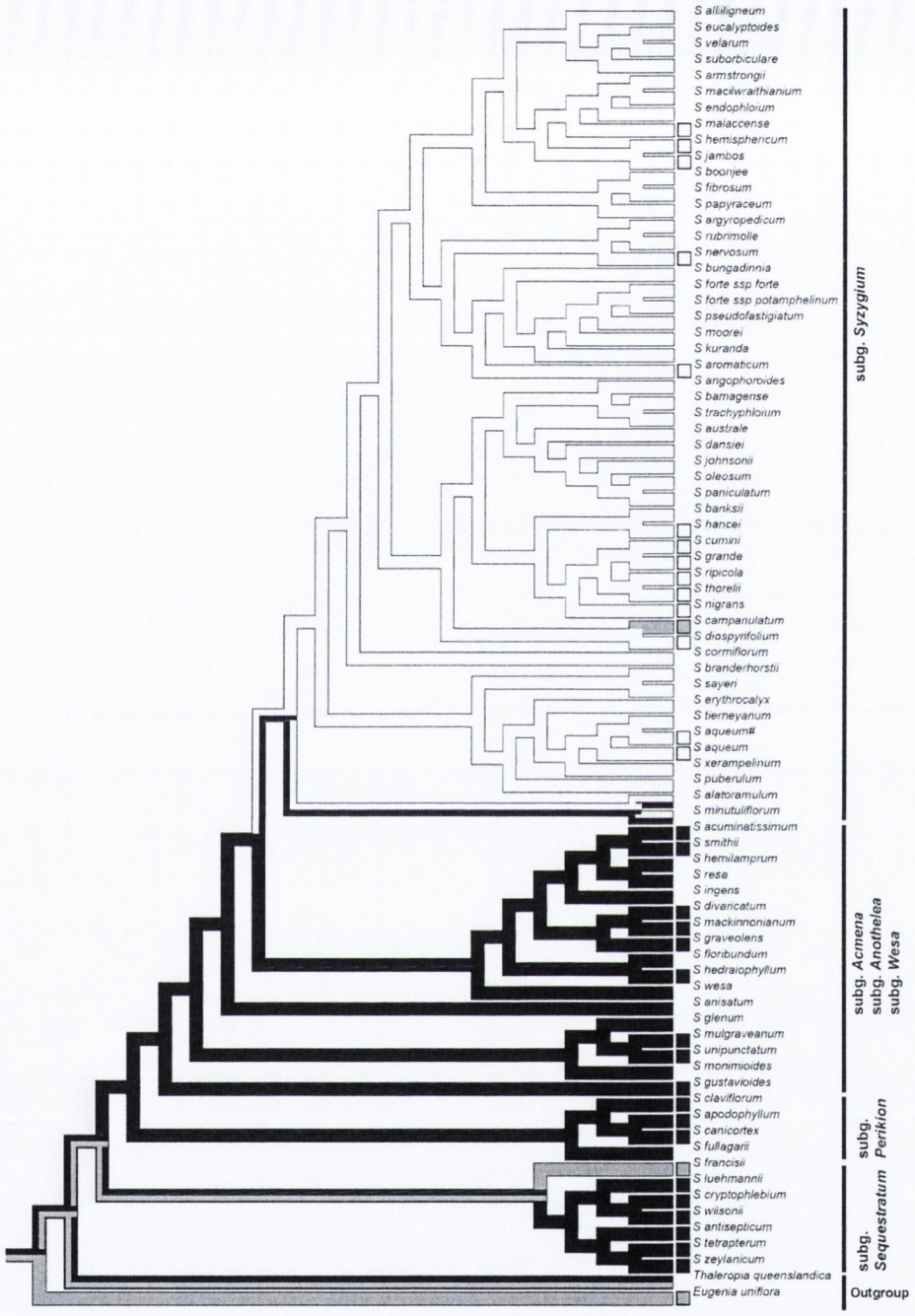


Figure 4.18. Character optimization of leaf crystals on one of the 16,700 MPTs of combined ETS and ITS data. White = druses predominant and prismatic crystals absent or infrequent; black = prismatic crystals predominant and druses absent or infrequent; grey = druses and prismatic crystals in equal frequency. Squares at ends of branches denote taxa whose character have been investigated.

Midrib vascular system

Midrib adaxial phloem partition is synapomorphic for subg. *Acmena*, *Perikion* and *Sequestratum* (Figures 4.19 and 4.20). In the morphological phylogeny, a midrib vascular system that is an arc without adaxial phloem partition and with straight margins is plesiomorphic (Figure 4.21). However in the optimisation of ETS-ITS DNA phylogeny, the plesiomorphic state is arc with adaxial phloem partition and with straight margins (Figure 4.22).

On this basis, I hypothesize that there are three aspects to the vascular character transformations (Figure 4.23):

1. The midrib vascular transformation from subg. *Syzygium* to the clade *Acmena-Perikion-Sequestratum* would involve the development of an adaxial phloem partition (Figure 4.23 – b, e). The origin of the adaxial phloem partition is puzzling but crucial in understanding the character transformation between subg. *Syzygium* and the clade *Acmena-Perikion-Sequestratum*. A plausible explanation is that the plesiomorphic state of vascular system with adaxial phloem partition could be a simple arc. The straight margins of this simple arc became incurved and flattened. When two end points of the margins meet, these are fused to become the adaxial phloem partition. The incurved margins may be fused with the main xylem body or alternatively fragmented, becoming reduced and eventually lost (Figure 4.24). The foregoing hypothesis would explain the variations or intermediate vascular types seen in subg. *Acmena*, *Perikion* and *Sequestratrum*: (1) the adaxial phloem partition in the clade *Acmena-Perikion-Sequestratum* may be complete or poorly developed, (2) the incurved margin which is distinctive in most species in subg. *Acmena* may be fragmented or continuous, (2) in some species in subg. *Acmena* (*S. graveolens*) and subg. *Sequestratum* (*S. multibracteolatum*, *S. tenuirame* and *S. wilsonii*), the incurved margins are fused into the main xylem body. This hypothesis for the origin of adaxial phloem partition, however, does not explain the obtained result from the character optimization, that is the trend from plesiomorphic to apomorphic state is from a straight margin to an incurved margin (Figure 4.23 – b, e) and the abrupt transformation from incurved margin with adaxial phloem partition to straight margin without adaxial phloem partition (figure 4.23 – f, b). This suggests that the

character transformations in the presence and absence of adaxial phloem partition, and straight and incurved margins are complex, and can not be fully explained from the character optimisation alone. The extent of reversibility or loss of anatomical features is still a matter of considerable discussion and purely speculative without information on development on variability within species.

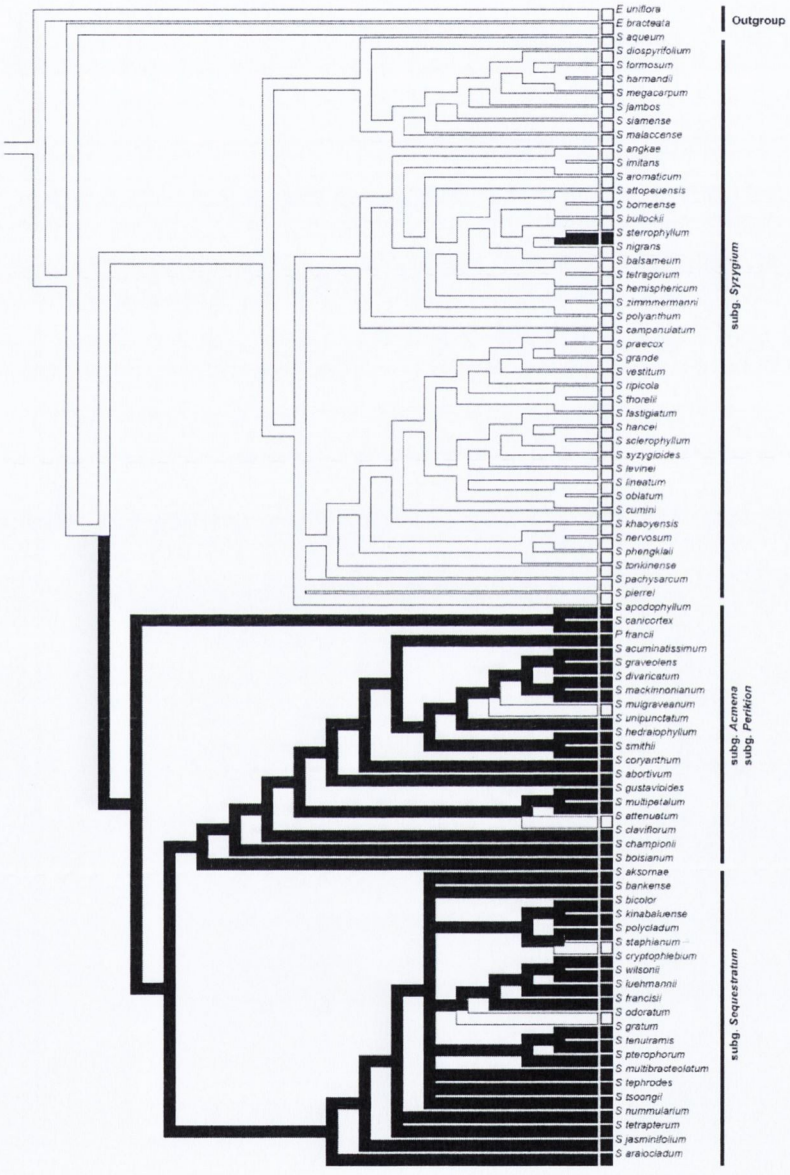


Figure 4.19. Character optimization of midrib adaxial phloem partition on one of the 1,100 MPTs of qualitative and quantitative morphological data. White = absent; black = present. Squares at ends of branches denote taxa whose character have been investigated.

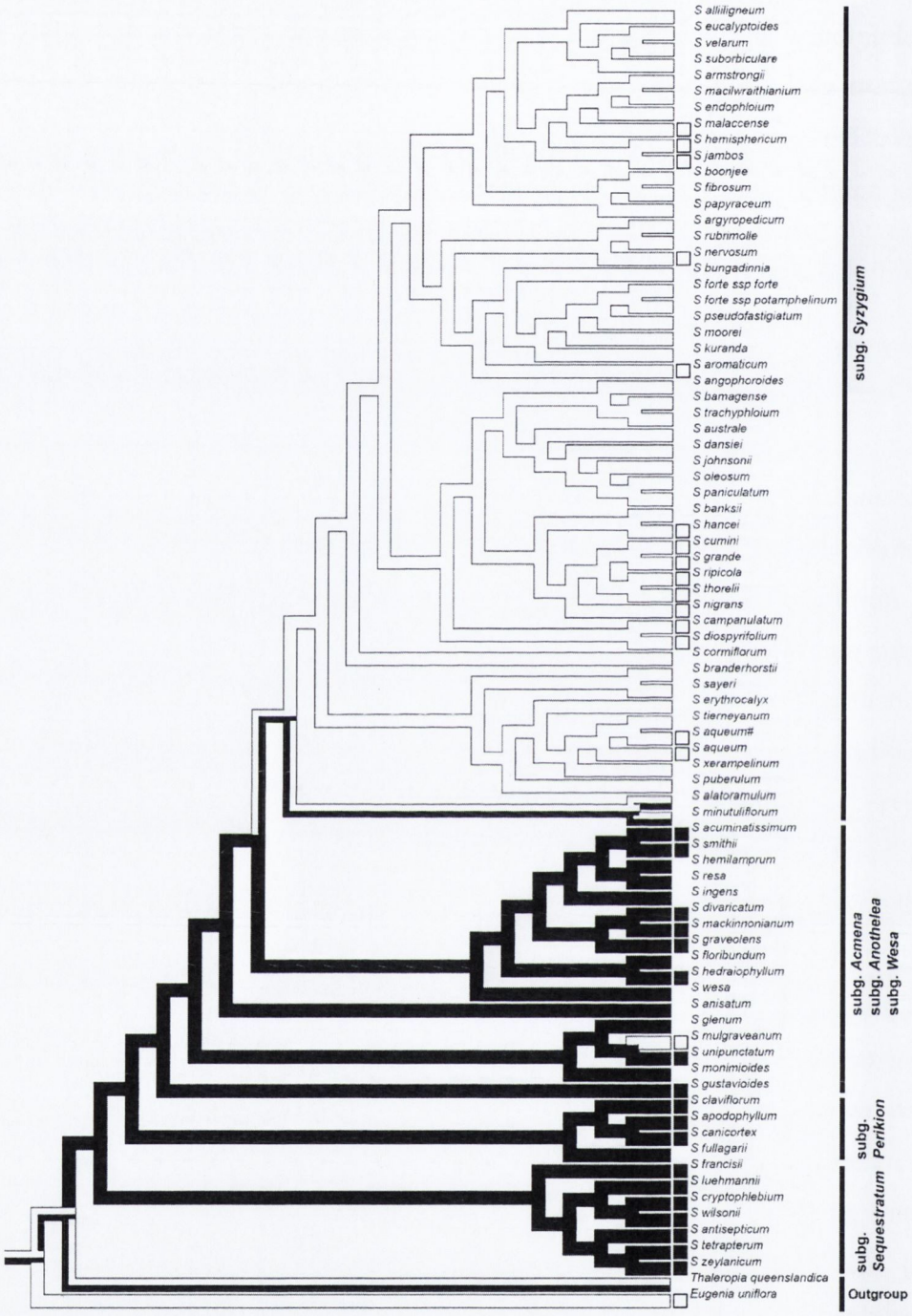


Figure 4.20. Character optimization of midrib adaxial phloem partition on one of the 16,700 MPTs of combined ETS and ITS data. White = absent; black = present. Squares at ends of branches denote taxa whose character have been investigated.

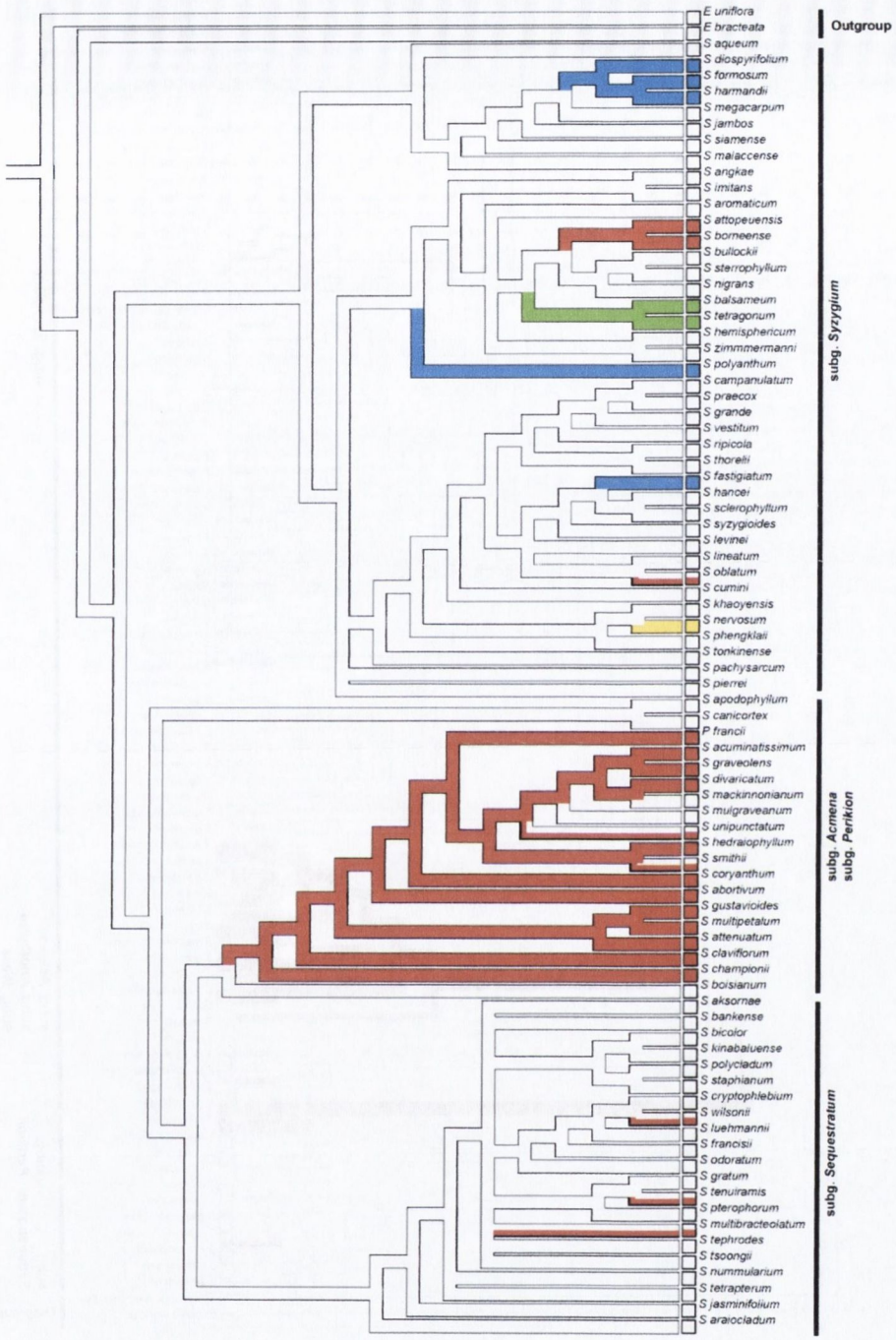


Figure 4.21. Character optimization of midrib vascular system on one of the 1,100 MPTs of qualitative and quantitative morphological data. White = arc; red = arc with incurved margins; yellow = arc with interrupted bundles; blue = circular; green = open complex system. Squares at ends of branches denote taxa whose character have been investigated.

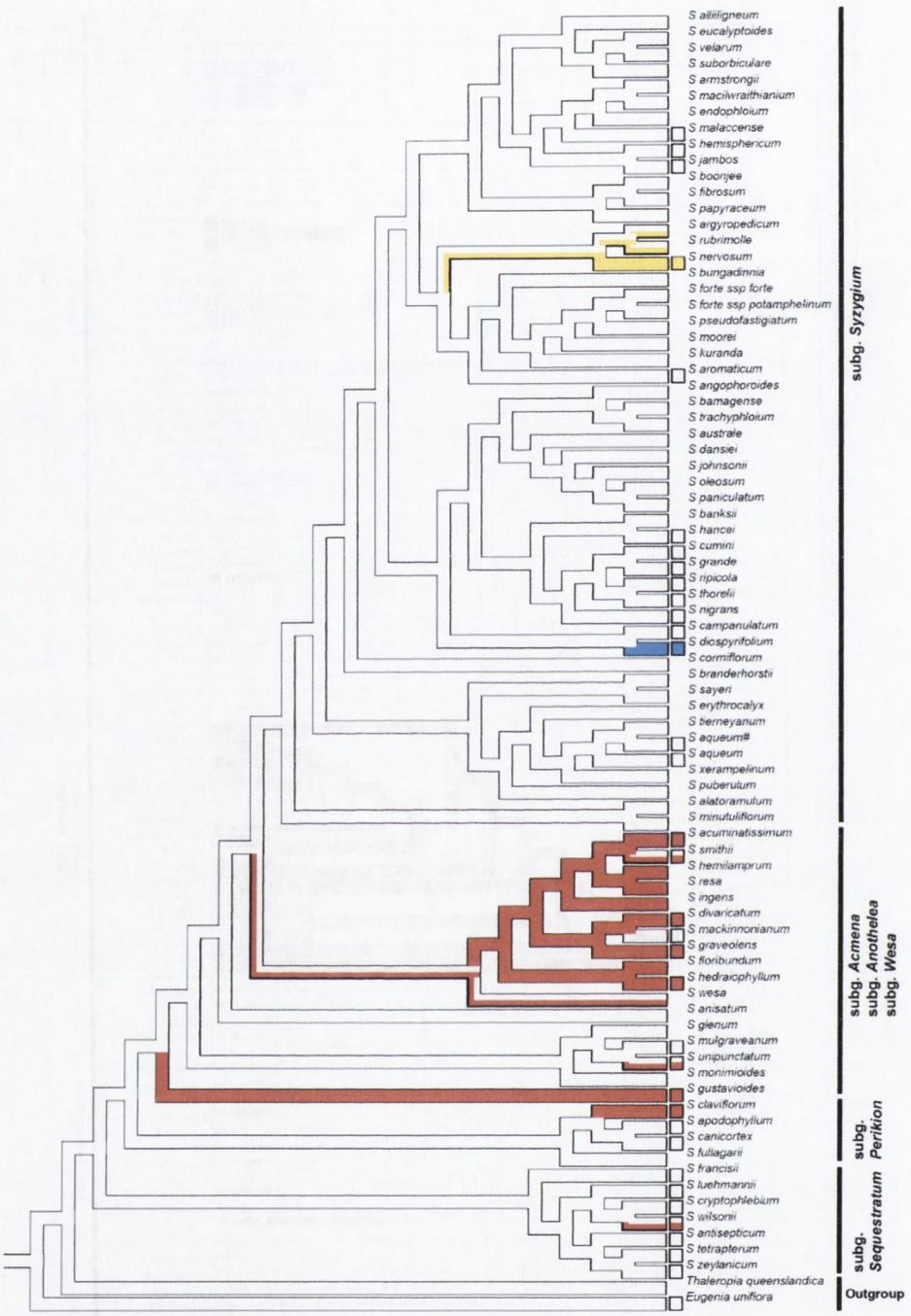


Figure 4.22. Character optimization of midrib vascular system on one of the 16,700 MPTs of combined ETS and ITS data. White = arc; red = arc with incurved margins; yellow = arc with interrupted bundles; blue = circular. Squares at ends of branches denote taxa whose character have been investigated.

2. Within the clade *Acmena-Perikion-Sequestratum*, the vascular transformation from subg. *Sequestratum* to subg. *Acmena* would involve changes from straight margins to incurved margins (Figure 4.23 – e, f).

3. Within the subg. *Syzygium*, arc vascular system with straight margins are plesiomorphic to arc vascular system with margins interrupted into free bundles, circular vascular system and complex open system (Figure 4.23 – b, c, d). Keating (1984) suggested that, in the Myrtaceae, an arc trace could have evolved in two ways, firstly the trace became reduced to a broad then narrow arc by simple reduction and secondly the trace became incurved adaxially and then flattened and sometimes with further loss of the adaxial xylem portion (Figure 4.24). In accordance with Keating's (1984) hypothesis, the third aspect is conveniently explained in that the simple arc vascular system, which is plesiomorphic in subg. *Syzygium*, had undergone few modifications by fragmentations and reductions at the margins or elongation to derive other vascular types. The earlier event may have given rise to a complex open system or arc vascular with interrupted open bundles and latter event, the elongation may have derived the circular vascular system (Figure 4.23 & 4.24).

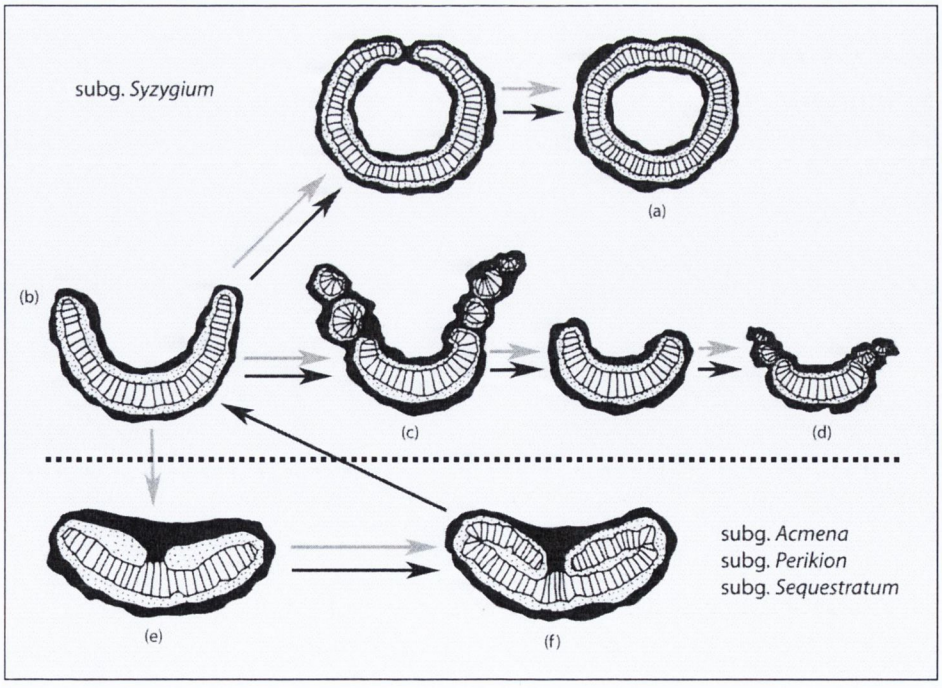


Figure 4.23. Midrib vascular systems in *Syzygium*. (a) cylindrical; (b) arc with straight margins; (c) complex open system; (d) arc with interrupted margins; (e) arc with straight margins and adaxial phloem partition; (f) arc with incurved margins. Xylem hatched, phloem dotted, sclerenchyma shaded in black. Arrow indicates route of character transformations: grey arrow based on morphological phylogeny; black arrow based on ETS-ITS phylogeny.

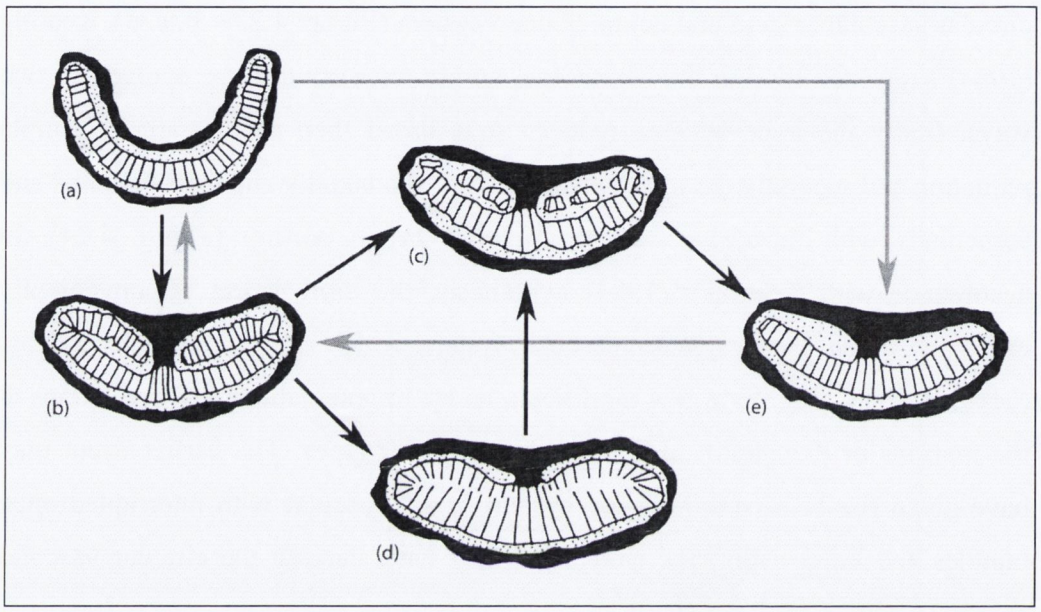


Figure 4.24. Comparison of Keating (1984) and this study on the hypothetical transformations of midrib vascular system in *Syzygium*. Arrow indicates route of character transformations: black arrow based on Keating (1984); grey arrow based on morphological and ETS-ITS phylogeny in this study. (a) arc with straight margins; (b) arc with incurved margins and adaxial phloem partition; (c) arc with reduced incurved margins and adaxial phloem partition; (d) arc with fused incurved margins and adaxial phloem partition; (e) arc with straight margins and adaxial phloem partition. Xylem hatched, phloem dotted, sclerenchyma shaded in black.

4.4.2.3 Reproductive macromorphological character

Inflorescence

Inflorescence characters were equally homoplasious in comparison to leaf anatomical character but less homoplasious than other macromorphological characters. An unbranched inflorescence (racemose) is plesiomorphic to a branched inflorescence (paniculate) (figures 4.25 and 4.26)). Parallel development of a branched inflorescence occurred in all the subgeneric clades.

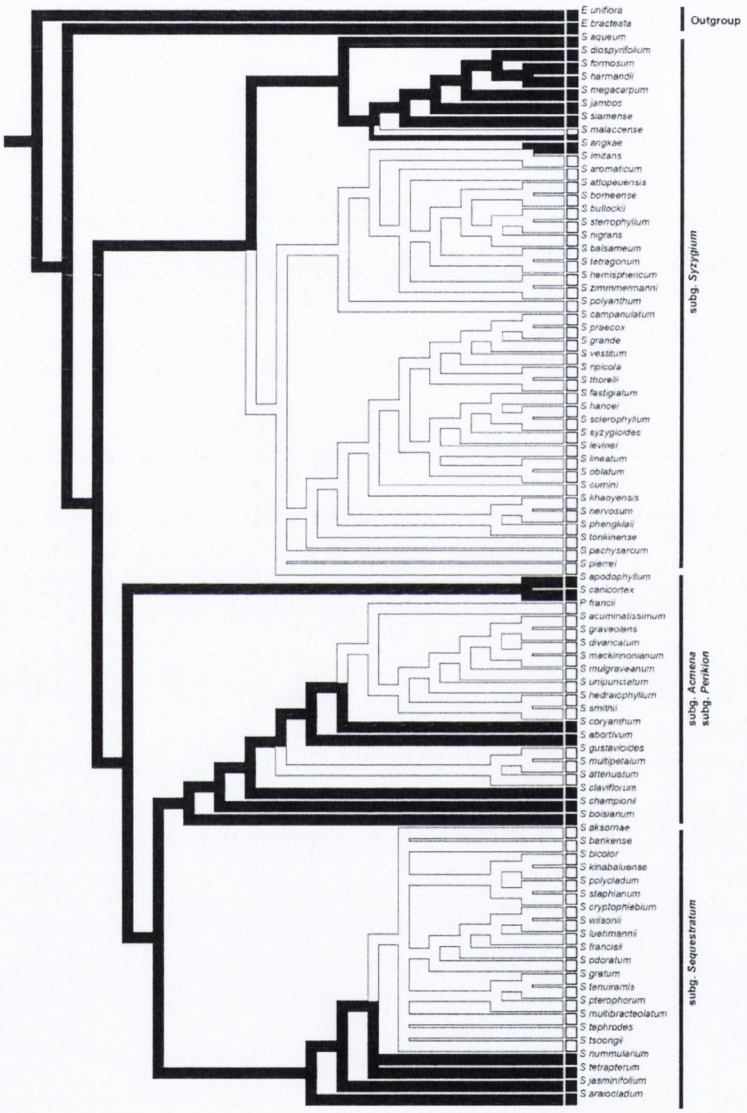


Figure 4.25. Character optimization of inflorescence type on one of the 1,100 MPTs of qualitative morphology data. White = panicle inflorescence; black = racemose or solitary inflorescence. Squares at ends of branches denote taxa whose character have been investigated.

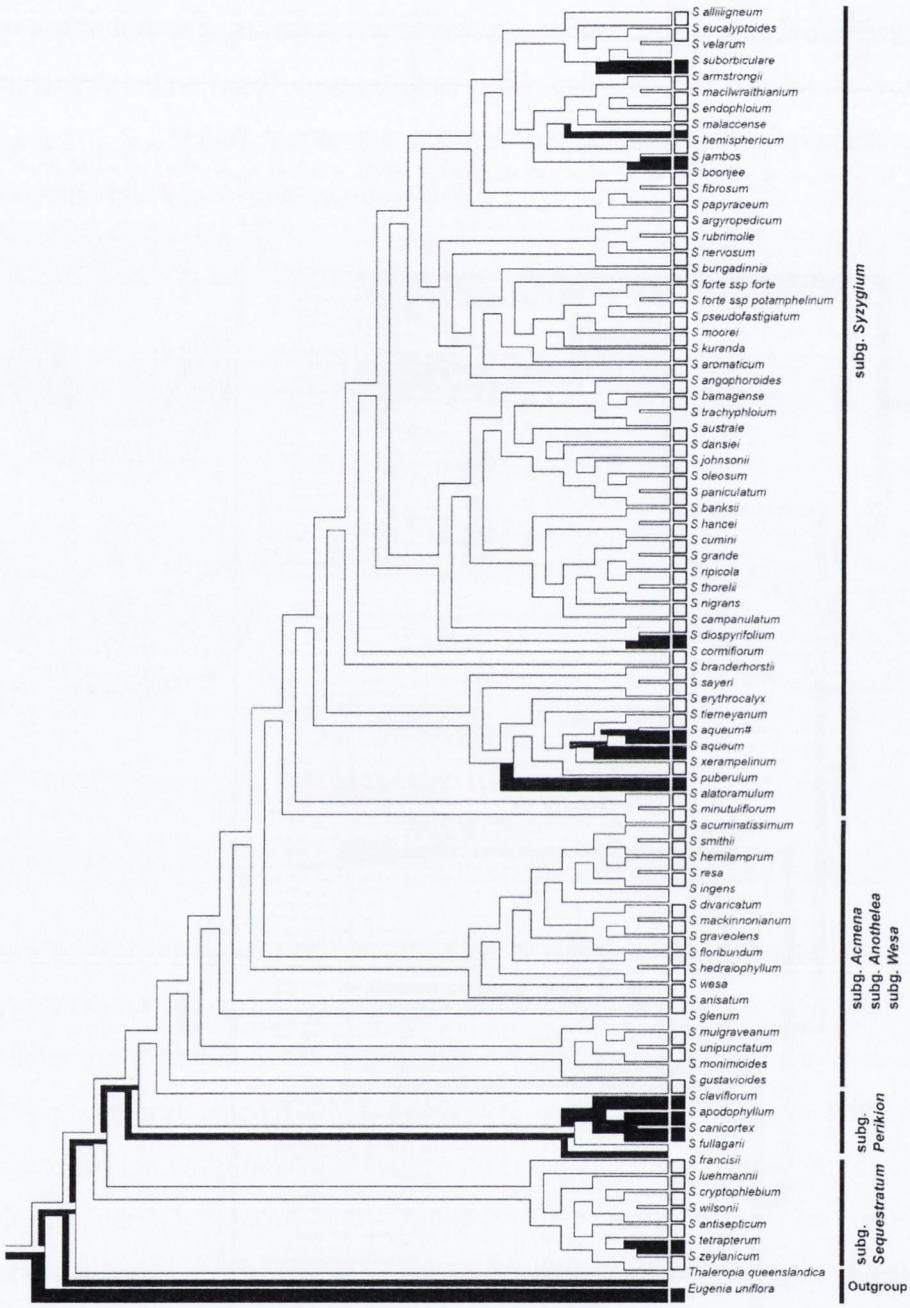


Figure 4.26. Character optimization of inflorescence type on one of the 16,700 MPTs of combined ETS and ITS data. White = panicle inflorescence; black = racemose or solitary inflorescence. Squares at ends of branches denote taxa whose character have been investigated.

Flower

Pyriform or obconic hypanthia are plesiomorphic to clavate or elongate hypanthia in the morphological phylogeny (figure 4.27) but not in the ETS-ITS DNA phylogeny (figure 4.28). In the morphological phylogeny, three transformation events coincide at the node of subg. *Acmena*, excluding *S. gustavioides*: these are the reversal of clavate or elongate hypanthium to obconic or pyriform hypanthium, the reversal of unbranched to branched inflorescence and the development of axile-apical placentation. These events however were not shown in the ETS-ITS DNA phylogeny. Sepal coherence (character 25) that was used to characterize the genus *Cleistocalyx* is not synapomorphic and may have evolved in three parallel developments (ci = 0.33, ri = 0.67).

Elongate and parallel anther locules are plesiomorphic to divaricate locules (Figure 4.29 and 4.30). In the ETS-ITS phylogeny (Figure 4.30), this character is synapomorphic for subg. *Acmena*, excluding *S. gustavioides*. However in the morphological phylogeny (Figure 4.29), there are two parallel developments, one in the clade of *S. acuminatissimum*, *S. divaricatum*, and *S. mackinnonianum* and the second one in *S. smithii*.

Axile-median ovule placentation is plesiomorphic to axile-apical in both the morphological (Figure 4.31) and ETS-ITS optimisation (Figure 4.32). This character is synapomorphic for the clade of subg. *Acmena* (excluding *S. gustavioides*) in the morphological phylogeny but in the ETS-ITS phylogeny, there are two parallel developments, both in clades belonging to subg. *Acmena*. In the morphological phylogeny, it is interesting to note that the development of obconic or pyriform hypanthium shape coincides with axile-apical placentation because the ovules are arranged in single transverse row. In this study, I found that the hypanthium shape is correlated with ovule arrangement, usually a longitudinal row arrangement occurs in clavate or elongated hypanthium and in obconic or pyriform hypanthium, the ovules are irregularly radiating or in single transverse row. However, as with morphological characters, some species in subg. *Sequestratum* have intermediate ovule arrangement between longitudinal rows and radiating or irregular arrangement. Because of the difficulty in indentifying

this character and their correlation with hypanthium shape, they were excluded in this study.

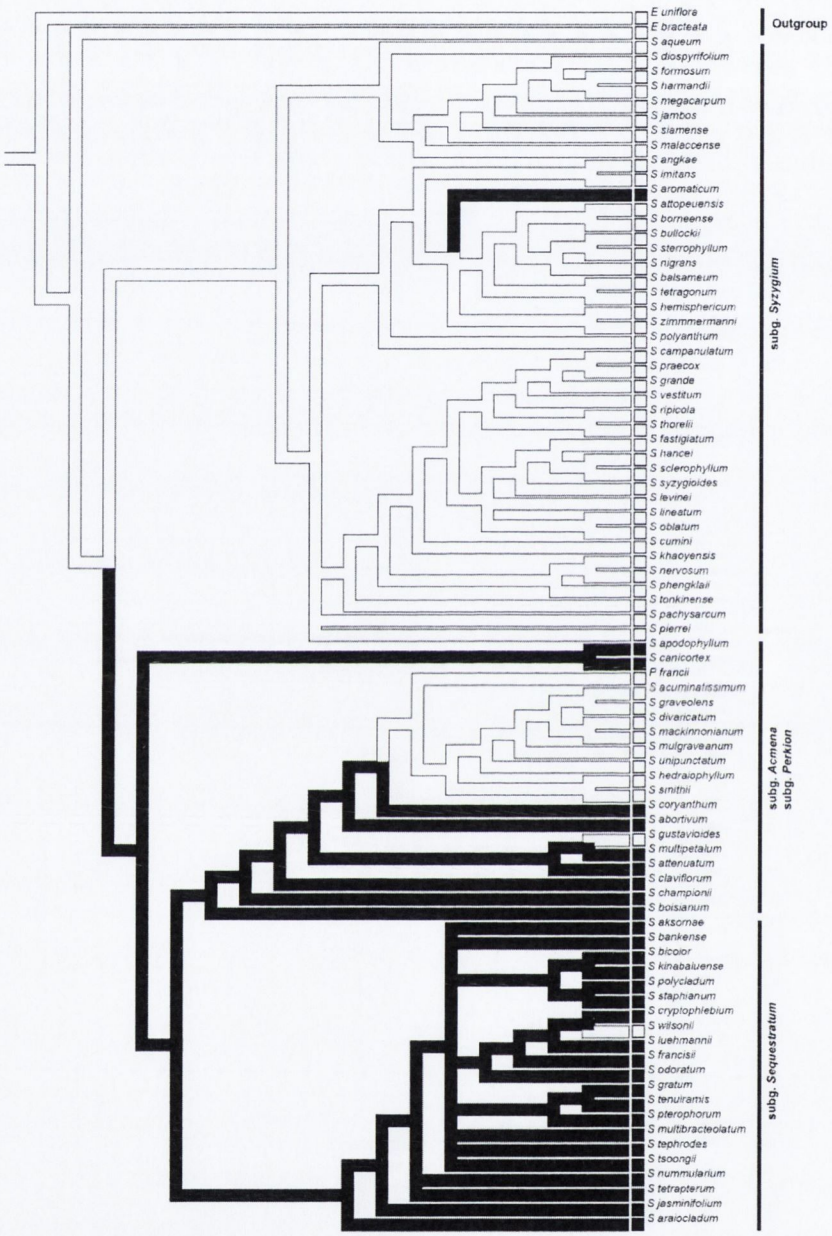


Figure 4.27. Character optimization of hypanthium shape on one of the 1,100 MPTs of qualitative morphology data. White = obconic or pyriform; black = clavate or elongated. Squares at ends of branches denote taxa whose character have been investigated.

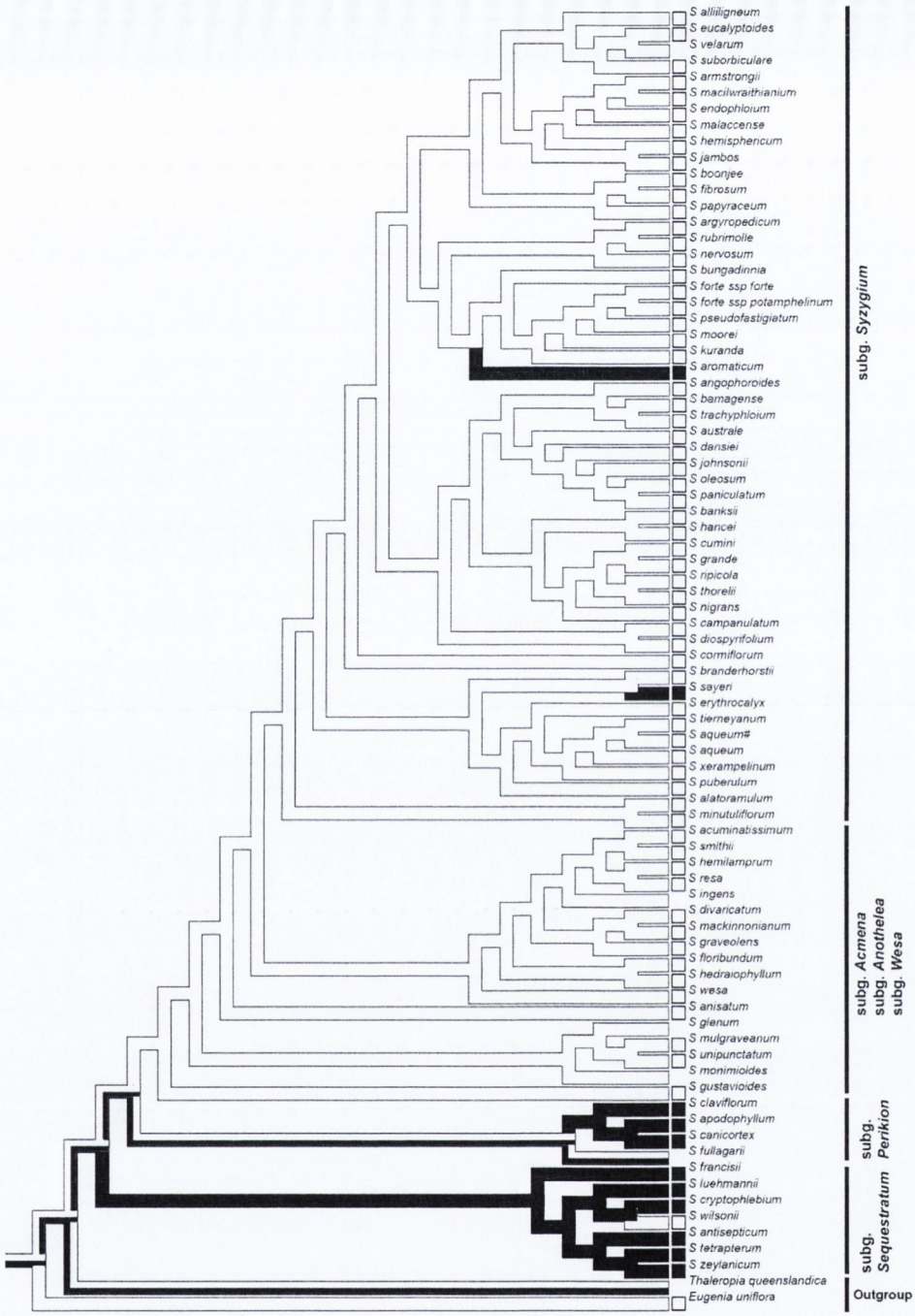


Figure 4.28. Character optimization of hypanthium shape on one of the 16,700 MPTs of combined ETS and ITS data. White = obconic or pyriform; black = clavate or elongated. Squares at ends of branches denote taxa whose character have been investigated.

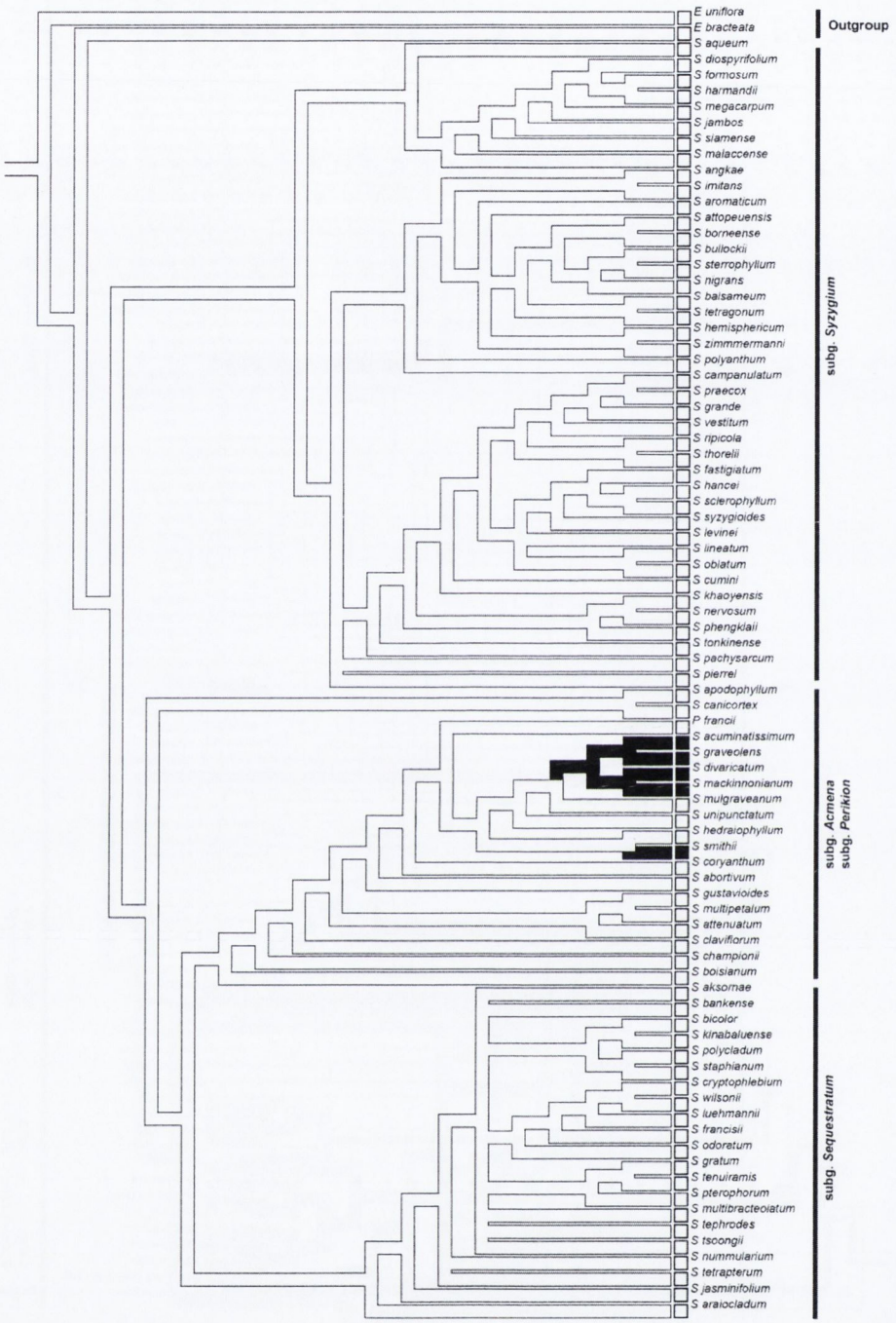


Figure 4.29. Character optimization of anther locule type on one of the 1,100 MPTs of qualitative and quantitative morphological data. White = anther locules elongate and parallel, dehiscence by longitudinal slits; black = anthers locules divaricate, dehiscence by apical slits. Squares at ends of branches denote taxa whose character have been investigated.

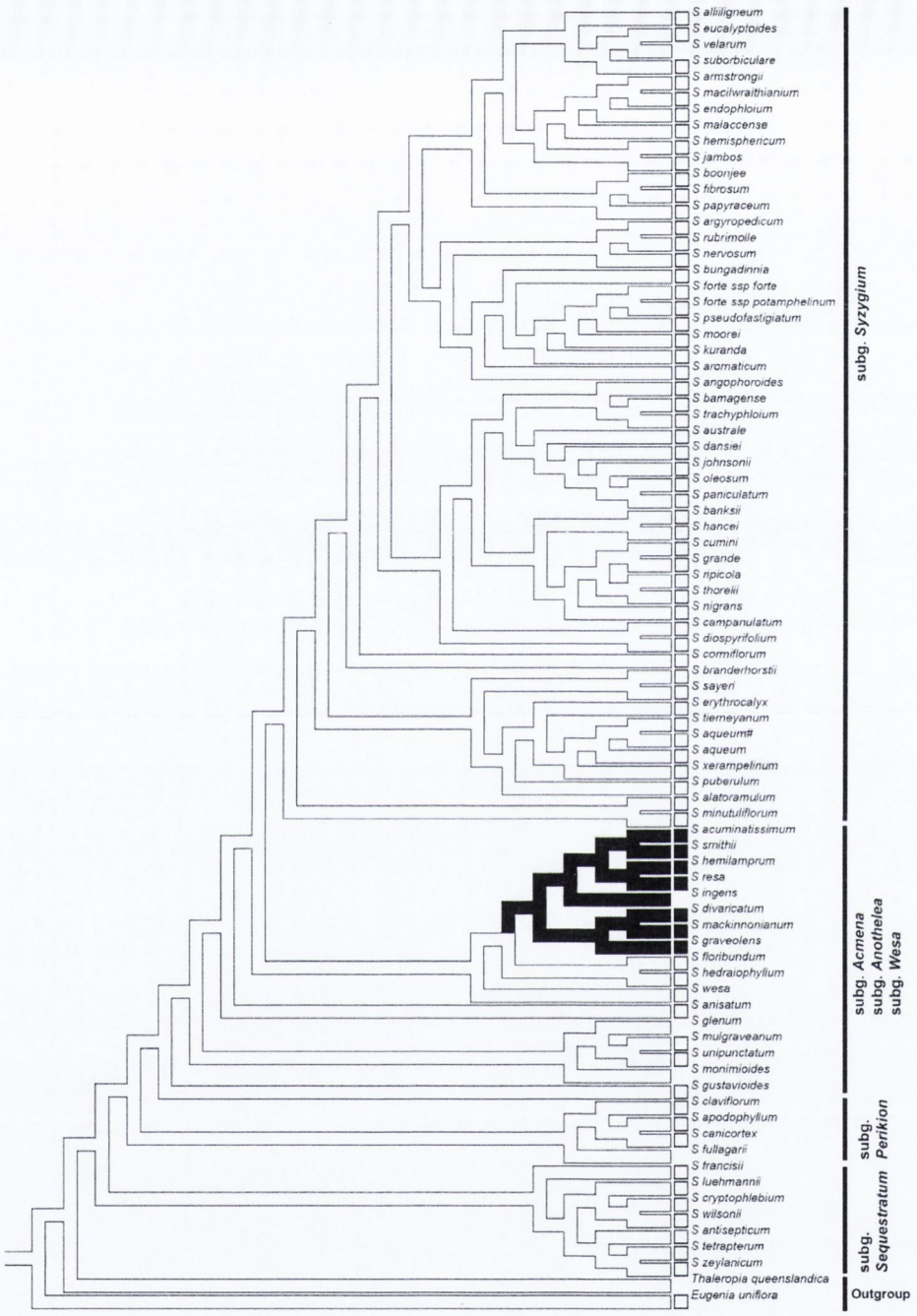


Figure 4.30. Character optimization of anther locule type on one of the 16,700 MPTs of combined ETS and ITS data. White = anther locules elongate and parallel, dehiscence by longitudinal slits; black = anthers locules divaricate, dehiscence by apical slits. Squares at ends of branches denote taxa whose character have been investigated.

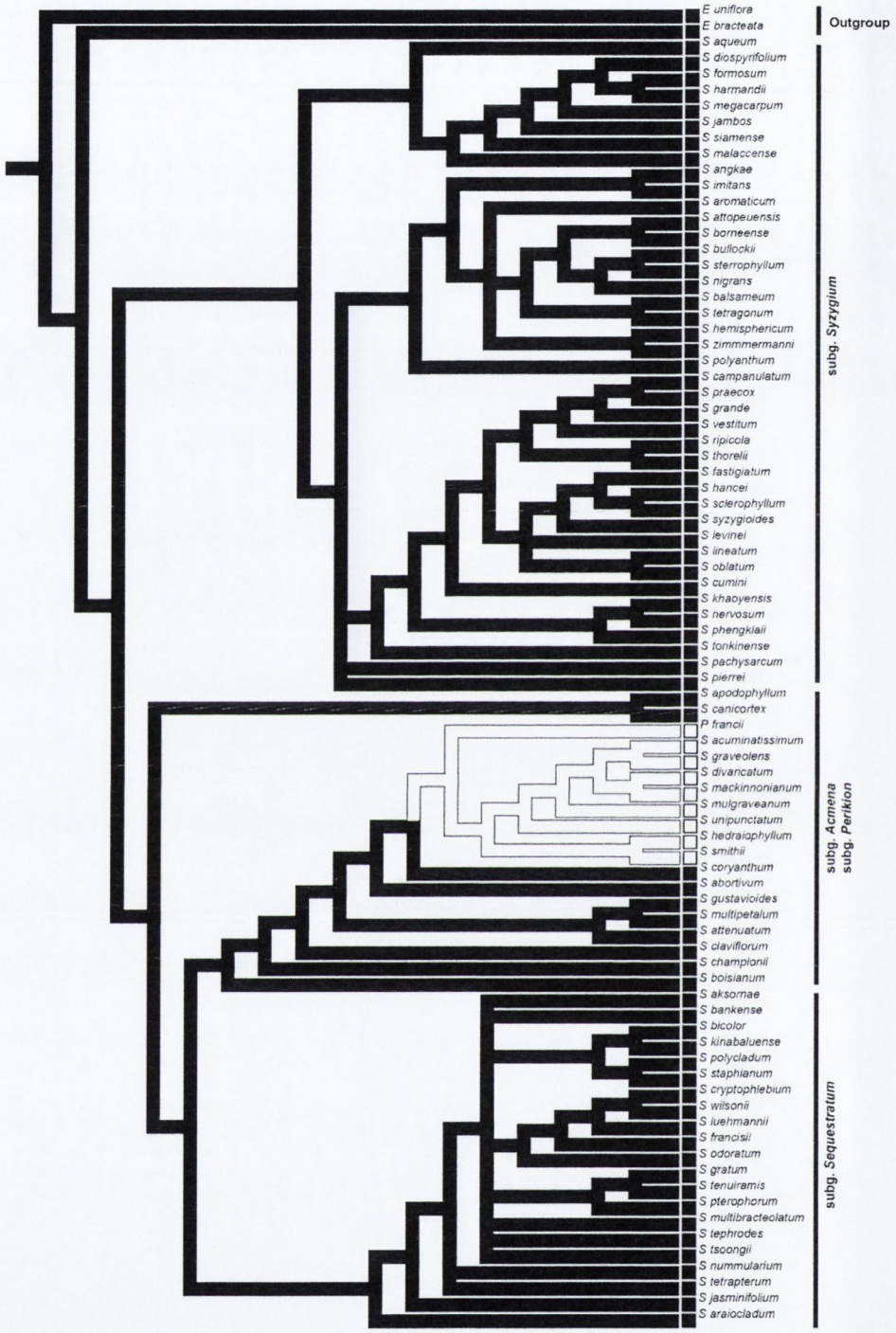


Figure 4.31. Character optimization of ovule placentation on one of the 1,100 MPTs of qualitative and quantitative morphology data. White = axile-apical; black = axile-apical. Squares at ends of branches denote taxa whose character have been investigated.

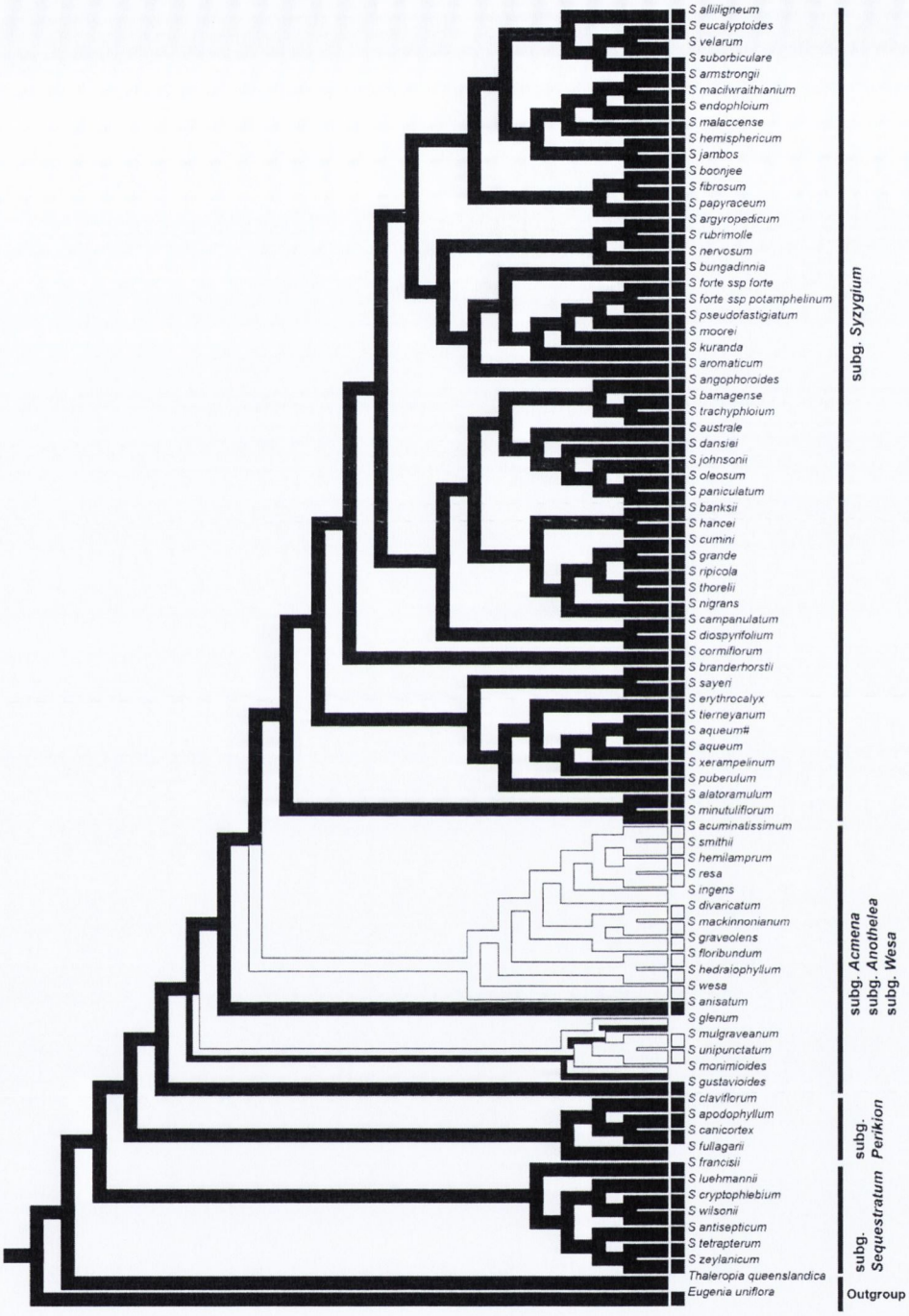


Figure 4.32. Character optimization of ovule placentation on one of the 16,700 MPTs of combined ETS and ITS data. White = axile-apical; black = axile-apical. Squares at ends of branches denote taxa whose character have been investigated.

Seed

Seeds without intercotyledonary intrusion is plesiomorphic and the opposite is apomorphic (Figures 4.33 and 4.34). In the morphological phylogeny (Figure 4.33), this character is synapomorphic for the subg. *Acmena* and *Perikion* but with two reversal events, one in *S. corynanthum* and the other in the clade of *S. gustavioides*, S. *multipetalum* and *S. attenuatum*. In the ETS-ITS phylogeny (Figure 4.34), there are three parallel developmental events, two in the subg. *Acmena* clade and one in subg. *Perikion* clade. The taxonomic value of seed structure which includes the testa, intercotyledonary intrusion and cotyledon adhesion in *Syzygium* has been highlighted by previous authors (Merrill & Perry, 1938; Hartley & Craven, 1977; Hyland, 1983). Hartley and Craven (1977) suggested that intercotyledonary tissue is derived from placenta (or funicle) since its direction of ramification in the seeds is correlated with the placentation type, that is apical in subg. *Acmena* and lateral in subg. *Perikion*. According to Hyland (1983) and Biffin et al. (2006), intercotyledonary tissue may be derived from the chalaza and is homologous to the testa. In this study, testa was not scored because of the uncertainty in its homology to seed intercotyledonary intrusion and the difficulty in recognising this character in dried herbarium specimen.

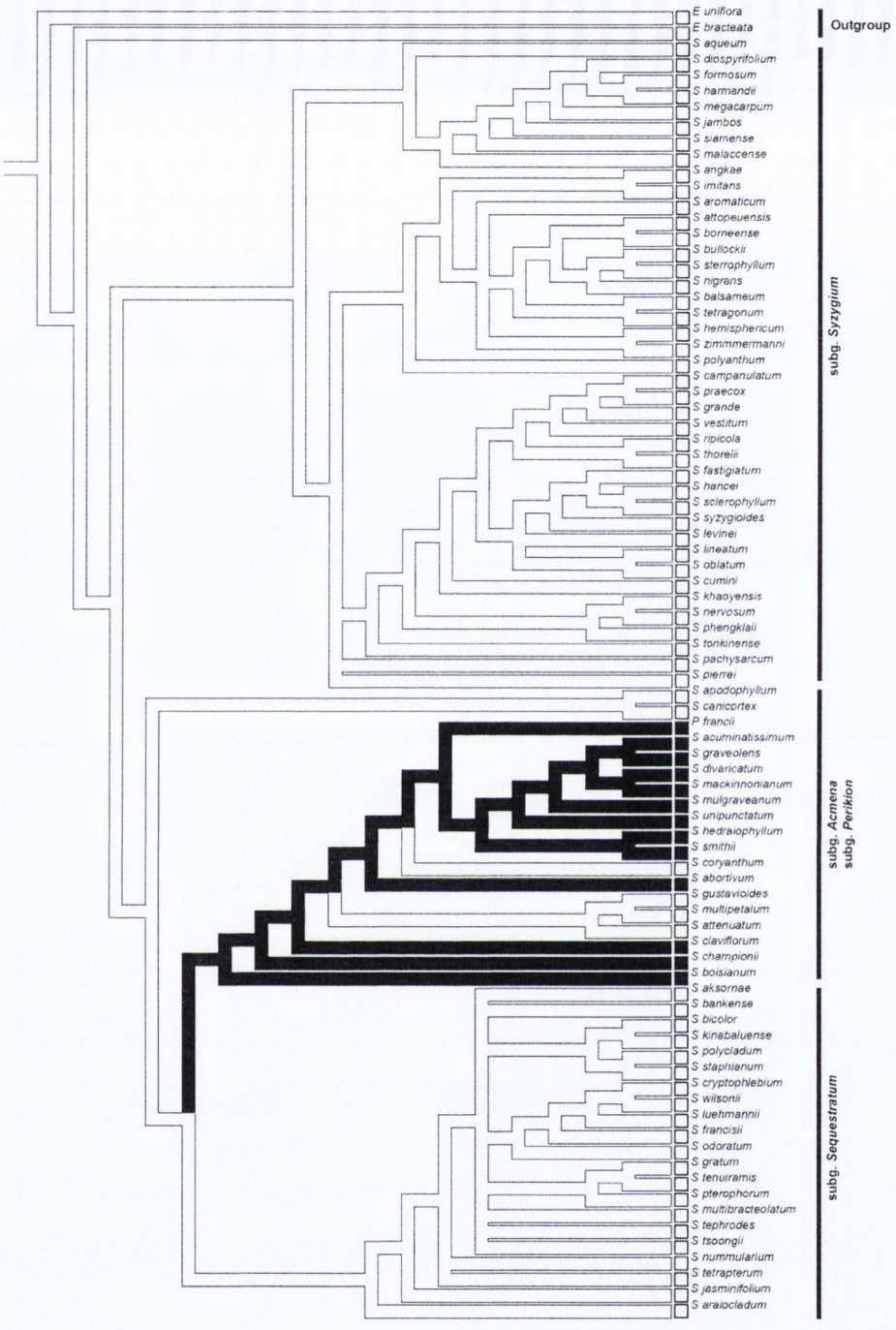


Figure 4.33. Character optimization of seed intercotyledonary intrusion on one of the 1,100 MPTs of qualitative morphology data. White = absent; black = present. Squares at ends of branches denote taxa whose character have been investigated.

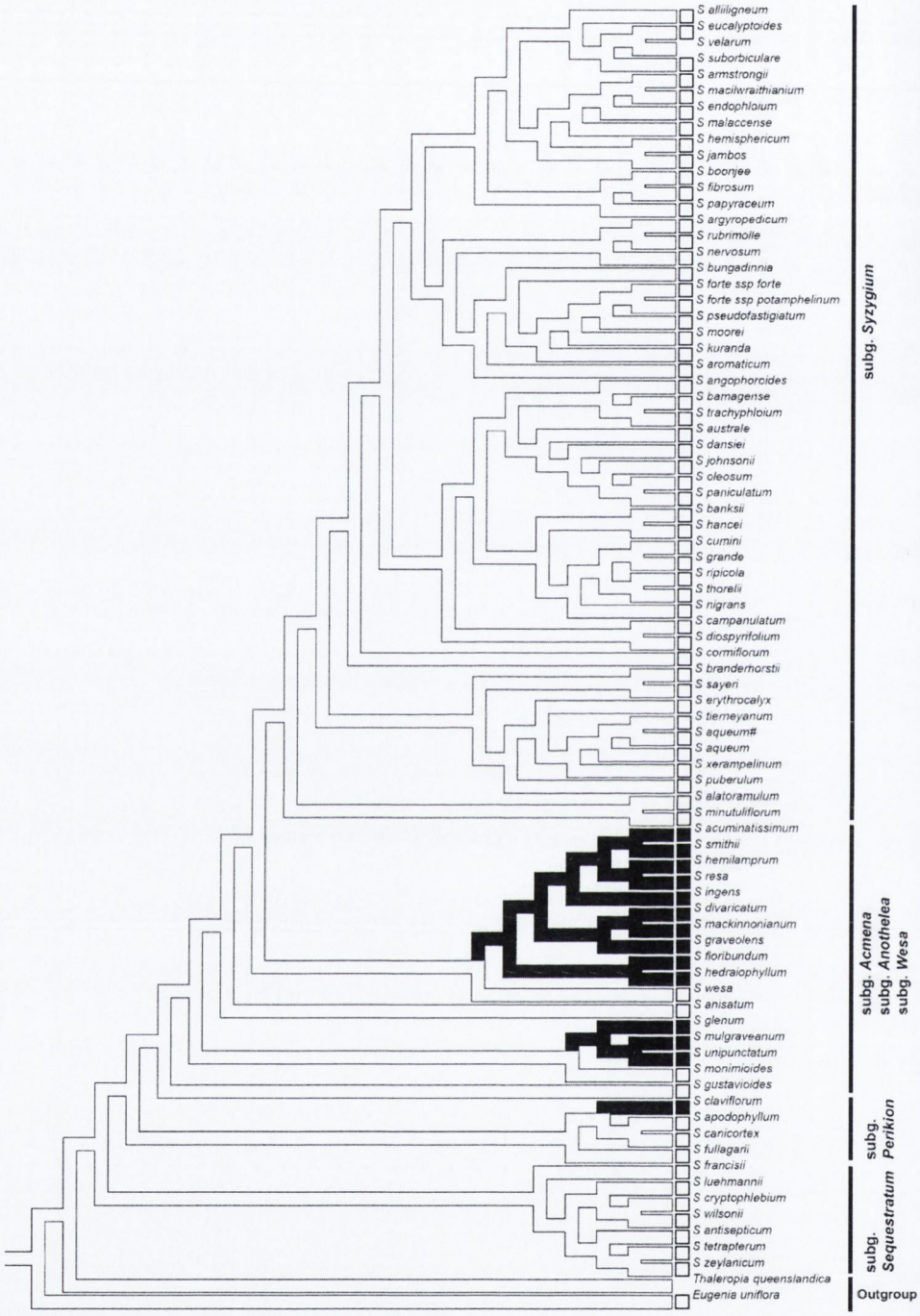


Figure 4.34. Character optimization of seed intercotyledonary intrusion on one of the 16,700 MPTs of combined ETS and ITS data. White = absent; black = present. Squares at ends of branches denote taxa whose character have been investigated.

4.4.3 Phenetic analysis

The result of the ordination in general followed that of phylogenetic analyses of the morphological (majority-rule consensus tree) and ETS-ITS datasets (see Figure 4.14 in Section 4.3). The grouping of points on the right side of the ordination diagram represents subg. *Syzygium*. This cluster formed a large group of 41 species and were broadly scattered with no apparent subgroups. Anatomically, the species within this grouping are distinctive from other groups in having a combination of predominantly paracytic and anisocytic stomatal types, and crystal types of druses and rarely prismatic crystals. In addition to this, the anatomical characters of subg. *Syzygium* as a whole are more elaborate than in other groups due to the presence of foliar sclereids, hairs and diverse midrib vasculature types (see table 3.2). The *Jambosa* group, which is associated with large flowered and fruited species (*S. aqueum*, *S. diospyrifolium*, *S. formosum*, *S. jambos*, *S. malaccense*, *S. megacarpum* and *S. siamense*) was not supported here by the ordination analysis. The same can be said of the calyptrate species from the Old World, formerly known as *Cleistocalyx* (*S. nervosum*, *S. nigrans*. *S. phengklaii* and *S. khaoyense*).

The subg. *Sequestratum* formed a well-defined cluster at the lower-left of the ordination diagram (20 species). This is in accordance with the results from morphological and DNA phylogeny, where it has received strong support. However, *S. apodophyllum* from the subg. *Perikion* was also circumscribed within this cluster. The leaf anatomy of the subg. *Sequestratum* is distinctive in having a combination of predominantly anisocytic and anomocytic stomata; crystal types that are predominantly prismatic crystals, rarely druses; vascular bundles with well to poorly develop adaxial phloem partition. Morphologically, this group is distinctive in having an elongated hypanthium (usually glaucous) though this is also found in other subgeneric groups. In the ordination diagram, *S. apodophyllum* was grouped together with subg. *Sequestratum* and not subg. *Perikion*, because it shared few similar anatomical characters with the earlier group in having a midrib vascular system with straight margins, anisocytic stomata, elongated hypanthium and seed without intercotyledonary intrusion. The ordination diagram showed that the subg. *Perikion* and *Acmena* formed a morphologically diverse group but

appeared somewhat separated. Although the species in the subg. *Perikion* and *Acmena* are morphologically variable, in relation to other subgenera, they are morphologically closely related; some species in both groups shared the same anatomical and macromorphological characters. Cyclocytic stomata, midrib vascular system with incurved margins and seed with intercotyledonary intrusion are frequently found in subg. *Acmena* but not in subg. *Perikion*. According to Craven and Biffin (2010), subg. *Perikion* and *Acmena* are separated by the presence of hypanthium bundle fibre in the former and absence in the latter. This character was not investigated and excluded from the analysis due to insufficient material.

4.5 Conclusions

The progress made in this chapter relative to previous studies on the phylogeny of *Syzygium* is three-fold: (1) leaf anatomical data was analysed with macromorphological data to infer phylogeny and produce ordinations; (2) ETS and ITS sequences of twelve *Syzygium* species from Southeast Asia (*S. antisepticum, aromaticum, S. campanulatum, S. cumini, S. diospyrifolium, S. grande, S. hancei, S. hemisphericum, S. jambos, S. nigrans, S. ripicol*a and *S. thoreli*) were incorporated in the established ETS-ITS data set ; (3) morphological characters were optimised on ETS-ITS phylogeny and hypotheses of character polarity were presented. The results indicated that morphologically derived phylogenetic groupings are congruent to a certain degree relative to the current nuclear and chloroplast DNA phylogeny in *Syzygium*, as far as subgeneric rank is concerned. The morphology phylogeny (majority-rule consensus tree) showed the same topology as the ETS-ITS phylogeny (strict consensus tree); in agreement are the clades of subg. *Sequestratum* and subg. *Syzygium*; however subg. *Acmena* and *Perikion* which were not separated and were grouped together in one clade. In the morphological phylogenetic tree (strict consensus tree), subg. *Sequestratum* was the only clade supported with DI value 2–3. The topologies within the clade of subg. *Syzygium* for the morphological and ETS-ITS analysis are different. Within subg. *Syzygium*, possible predictors for some clades may include geography and midrib vascular system. In the phenetic analysis, the result of the NMDS ordination is in accordance with the phylogenetic analysis in delimitating three groups: subg. *Syzygium*, subg. *Sequestratrum* and subg. *Perikion-Acmena*. In all

analyses, there are morphological characters that support the monophyletic groups, hence the subgeneric delimitations are based on: stomata, crystals, midrib vascular system, inflorescence type, hypanthium shape, anther locules, placentation and seed intercotyledonary intrusion. Diagnostic information for subgenera and hypothesized character polarity in *Syzygium* have been given in Table 4.8 and 4.6 respectively. The species placement in subgeneric groups is listed in Table 4.7.

Chapter 5 Taxonomic treatment

5.1 Introduction

Francois Gagnepain, who was the first botanist to revise the Indochinese *Syzygium* under *Eugenia* L. s.l., initially published all the 28 new species in *Notulae Systematicae* (Gagnepain, 1917) and later published the completed work in the *Flore Générale de l'Indochine* (Gagnepain, 1920). His work encompassed 55 species from French-Indochina, which corresponds to currently recognised political boundaries in Laos, Cambodia, Vietnam, Thailand (part of Mekong basin) and South China (Zhanjiang). Merrill and Perry (1938b) later updated the revision based on some original material supplied by Gagnepain and additional new material from Indochina, mainly collected by Petelot. In their synopsis (Merrill & Perry, 1938b), all the species were transferred from *Eugenia* L. s.l. to *Syzygium* Gaertn., the species nomenclature was updated, eight new species described and new records added.

Since Gagnepain's revision in 1920, the generic concept of *Eugenia-Syzygium* has changed and the current revisionary works of *Syzygium* in the neighbouring countries including Thailand (Chantaranothai & Parnell, 2002) and China (Chen & Craven, 2007) have suggested several new records for Indochina. This is not surprising, since the flora under *Flore Générale de l'Indochine* project was prematurely initiated considering that at the time many areas in Indochina were botanically unexplored. Since then, there have been many new botanical collections from previously inaccessible localities. This coupled with the resurgence of botanical work over the last three decades in Cambodia, Laos and Vietnam have generated a significant amount of new information. Therefore it seems now timely to revise *Syzygium* Gaertn. in Indochina (Cambodia, Laos and Vietnam), which is the main aim of this chapter.

5.2 Material and methods

The most recent taxonomic revisions (Gagnepain, 1920, Merrill & Perry, 1938; Chantaranothai & Parnell, 2002) and regional checklists (Nguyen, 2003; Newman et al., 2007a) of *Syzygium* in the mainland Southeast Asia were used as a starting point for this study. For this purpose, dried plant specimens acquired from different herbaria (**A**, **BKF**, **BM**, **E**, **GH**, **HN**, **K**, **KEP**, **L**, **NY**, **P**, **TCD**, **U** and **VFU**) were examined. In addition to this, images and references downloaded from online herbaria were also used (**A**, **GH**, **K**, **L**, **MO**, **NY** and **US**). In this study, over 4,000 specimens from Indochina and other regions have been studied; either on loan or *in situ* in the various herbaria. The study presented here deals with revisional work of a number of different species within *Syzygium*. In practice this means that herbarium specimens of the same phenotypic assemblage were sorted and grouped together. These groups were then either associated with an existing type specimen, which is linked to a particular taxon name or else described as a new species. After the herbarium specimens were sorted into groups, their morphological characters were examined. Dichotomous keys based on vegetative and fertile morphological characters were constructed.

Unless indicated, all macromorphological measurements and observations, including colour, texture and shape are recorded from herbarium specimens.

When no holotype or lectotype is available, then a lectotype is designated or a neotype selected by following the guidelines in the *International Code of Botanical Nomenclature* (ICBN) (McNeill et al., 2006). Discussion for each instance of this is found in the relevant species notes. Species synonyms were gathered from relevant publications, the *World Checklist of Myrtaceae* online database (Govaerts et. al., 2010) and personal observations from herbarium specimens. The synonyms listed in this account were verified by examining the types or voucher specimens, however when these were not available, then the synonyms are referred to the source publications. In some instances the synonyms were excluded when they were found not to conform with the species studied here. Generic synonyms were sourced from the *Index Nominum Genericorum* online database (Farr & Zijlstra, 1996) and from Craven and Biffin (2010).

All types that have been seen are indicated by '!' whereas those that were destroyed are indicated by '†' after the herbarium abbreviation.

Publication titles and author citation abbreviations follow those in the *International Plant Names Index* (IPNI) online database and *Taxonomic literature* series (Stafleu & Cowan, 1976-1988; Stafleu & Mennega, 1992, 1993, 1995, 1997, 1998, 2000; Dorr & Nicolson, 2008a, 2008b).

The conservation status for each species follows *IUCN Red List Categories and Criteria* ver. 3.1 (IUCN, 2001).

For documentation purposes, the specimens were databased using BRAHMS software (Botanical Research and Herbarium Management System). The species distributions were mapped using DIVA-GIS ver. 6 software. The coordinates were derived from herbarium labels, gazetteers, maps and *NGA Geonet Names Server* database (http://earth-info.nga.mil/gns/html/index.html). The names of major areas (provinces) follow the standard used in the *Flore du Cambodge du Laos et du Viêtnam* publication (see Appendix 5.1). Distributions outside of Indochina were obtained from herbarium specimens and relevant literature. All the studied specimens from Indochina were cited here under the heading *Specimens Examined.* These are arranged alphabetically in the following sequence: country, major area, minor area, collector and finally numerically by collecter's number. Selected specimens outside Indochina were listed optionally under the heading *Additional Specimens Examined.* The distributions of commercially cultivated species (*S. aqueum*, *S. aromaticum*, *S. malaccense* and *S. samarangense*) are not mapped.

5.3 Species concept, infrageneric and infraspecific classification

For practical reasons, the morphological species concept (Stuessy, 1990) was employed in this study. A species is defined here as a group of organisms that is readily recognisable by macro-morphological characters. In revisionary works, this is the best approach in order to make the output user-friendly. The justification for this is that the morphological delimitations do in fact reflect biological limits of isolation, commonality of interbreeding and genetic

divergence (Stuessy, 1990). The phylogenetic (molecular and morphology) based infrageneric classification of *Syzygium* proposed by Craven and Biffin (2010) was adopted and incorporated in the dichotomous key. This means that the genera *Acmena* and *Cleistocalyx* which were recognised in the previous Indochinese revision (Merrill & Perry, 1938) are now circumscribed in the genus *Syzygium* and within this, four out of a total of six subgenera are currently recognised in Indochina, namely *Acmena* (DC.) Craven & Biffin, *Perikion* Craven & Biffin, *Sequestratum* Craven & Biffin and *Syzygium* Craven & Biffin. Table 5.1 show the morphological delimitation of these subgenera. The other groups, subgenera *Anetholea* (Peter G. Wilson) Craven & Biffin and *Wesa* Craven & Biffin do not occur in Indochina but are confined to Australia.

Table 5.1. *Syzygium* subgenera in Indochina. The morphological descriptions were extracted from Craven and Biffin (2010).

Subgenus	Morphology	Indochinese species
Subg. *Syzygium*	Sepals persistent or deciduous, caducous when calyptrate, free or fused into a calyptra. Petals free, whether or not cohering into a pseudocalyptra, in calyptrate species obsolete and falling with the calyptra. Anther sacs parallel. Ovary apex below the hypanthium apex. Placentation axile-median or rarely axile-basal; ovules c. (3 –)8 – 60(– 90), arranged irregularly or rarely in 2 longitudinal rows, spreading to ascending. Seed without intrusive tissue interlocking the cotyledons, the cotyledons free and not obvolute (the opposing faces often undulate but the cotyledons not obvolute per se).	Most species (46 spp.) except for those listed below, in other subgenera.
Subg. *Acmena*	Sepals deciduous or persistent, caducous when calyptrate, free or fused into a calyptra. Petals free (not cohering into a pseudocalyptra), in calyptrate species obsolete and falling with the calyptra. Anther sacs divergent or sometimes parallel. Ovary apex below the hypanthium apex. Placentation axile-apical, or axile-basal or axile-median; ovules c. 2 – 22, in 1 transverse row or arranged irregularly or rarely in 2 longitudinal rows, pendulous. Seed usually with intrusive tissue interlocking the cotyledons, or sometimes the intrusive tissue lacking and the cotyledons then free.	*S. acuminatissimum*
Subg. *Sequestratum*	Leaves usually small, often glaucous (as are the flowers and fruits). Inflorescence often head-like. Flowers usually relatively small. Hypanthium funnel-shaped. Sepals free. Petals free (not cohering into a pseudocalyptra). Anther sacs parallel. Ovary apex below the hypanthium apex. Placentation axile-median; ovules c. 10 – 25 per locule, in 2 longitudinal rows, spreading to ascending. Seed	*S. antisepticum*, *S. araiocladum*, S. *tsoongii* and *S. odoratum*

	without intrusive tissue interlocking the cotyledons.	
Subg. *Perikion*	Hypanthium wall with numerous fibre bundles. Sepals deciduous or persistent. Petals 4 – 8. Anther sacs parallel. Ovary apex below the hypanthium apex. Placentation axile-median; ovules c. 8 – 22 per locule, in 2 (rarely 4) longitudinal rows or sometimes arranged irregularly, pendulous or sometimes ascending. Seed without intrusive tissue interlocking the cotyledons, or sometimes with ramifying interlocking tissue.	*S. abortivum*, *S. boisianum*, *S. championii* and *S. claviflorum*

Infraspecific rank is recognised if a taxon shows a clear geographical distinction or a small amount of overlap and where morphological distinction is minor (Stuessy, 1990). However, no infraspecific ranks are recognised here in Indochina for the following reasons: firstly, due to the paucity of the Indochinese collections and the lack of geographical and ecological information, it is difficult to ascribe allopatric or peripatric speciation with much confidence; secondly, there exists complex patterns of variation in some widespread species (for example *S. antisepticum*, *S. borneense*, *S. claviflorum*, *S. cumini* and *S. hancei*) that do not show clear morphological discontinuities, therefore making identification of infraspecific ranks difficult or impossible. In the latter case, a comprehensive study on the particular species is needed. This should include detailed phenotypic documentation, field observations and multivariate analysis. In the case of rheophytic species, they are maintained and treated as distinct species from their close allies. Morphological similarity among rheophytes is a result of convergent evolution, and allopatric (ecological or geographical) evolution is thought to be the main mechanism of speciation for rheophytes (Van Steenis, 1981; Mitsui et al., 2007). Because of this, ecological and geographical criteria are essential in deciding infraspecific rank. Unfortunately, as mentioned above, these two crucial pieces of information are often lacking for Indochina.

In *Syzygium*, many infraspecific ranks have been excluded in the current online *World Checklist of Myrtaceae* (Govaerts et. al., 2010). This approach is understandable because of the difficulty in recognising infraspecific variations in *Syzygium* and especially when the species are widespread and highly polymorphic. However, with sufficient evidence, it is important to formally

highlight the variation that exists within the respective species, which may be crucial in conservation at the level of species populations.

5.4 Nomenclature and lectotypification of Indochinese *Syzygium*

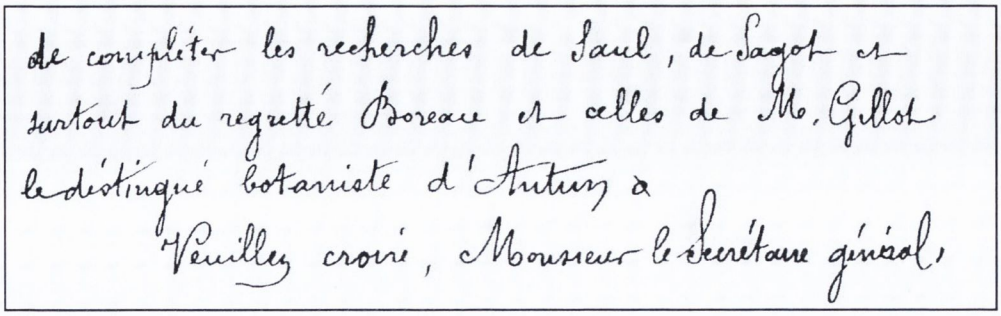
In his protologue, Gagnepain (1917) usually cited one or more gatherings (*i.e.* plants from particular localities) and he did not indicate any as type. These gatherings are usually in duplicates and are mostly kept in **P** (some duplicates are found in **BM**, **E**, **K**, **L** & **NY**). Under article 9.2 of ICBN (McNeill et al., 2006), all of these specimens are available for lectotypification. In the case where the species have been 'lectotypified' by later workers, there is often no annotation on the specimens of type and there are duplicates and undifferentiated sheets at **P.** Under article 9.15, second step lectotypification to narrow down to a single specimen is possible.

All the material deposited in **P** has been annotated by Gagnepain on the Herb. Museum Paris label (in addition to the Herb. Museum Paris label, the collector's label is sometimes present). The difficulty lies in locating the material that was cited in the protologue. The specimen numbers indicated in the protologue are in fact usually species numbers and rarely collection numbers. Therefore gatherings from different localities often have the same specimen number, as they are filed within the same species pile (pers. obs. in P; Sovanmoly Hul pers. comm., April 2009). This is very obviously the case in Pierre's and Thorel's collections. Furthermore, the labels on duplicates are often incomplete, sometimes without locality, dates, specimen number or notes. However, usually among a set of duplicates, there is one specimen with a complete and original label by the collector and it is therefore essential to be able to recognise the collector's handwriting (Figure 5.1a-d). I reproduce these samples herein because the problems I found in respect of *Syzygium* are duplicated for other groups and because samples of the collectors' handwritings are not readily available. Pierre's Herbarium has much of Harmand's collection and, as a result, there are sometimes two specimen numbers on one herbarium sheet – I cite such specimens as, for example, *Harmand 1172* in *Herb. Pierre 3290*. In some cases the developmental stage of the specimens coupled with the label information are good indicators as to whether or not they belong to the same gathering. A specimen is different if it

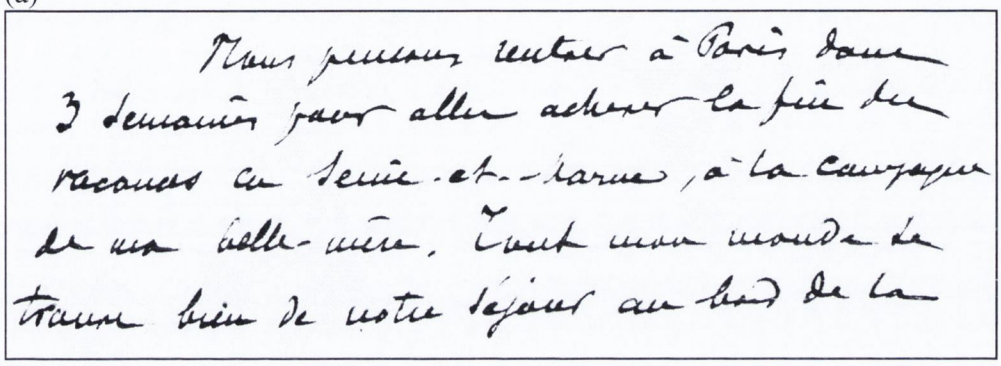
has a different collection date and/or locality (the number could be absent or similar).

The following are the materials used by Gagnepain (1917) in his protologue (collector, year collected, locality): Balansa, 1885-1891, Tonkin (Haiphong, the Black River and Mt. Bavi); Bois (D.) 1902-1903 Tonkin (Cai-kin), Annam (Lang-bian), Cochinchina; Bon (P.) 1883-1891 Tonkin (Hanoi, Ninh-binh, Lac-tho), Annam (North); Chevalier (Auguste), 1913-1919 Indochina; D' Alleizette, 1908 Tonkin; Hanh (D^r) (Philippe), 1881-1886 Cambodge; Harmand (Dr J.) 1875-1977 Laos (Attopue and along Mekong river), Annam; Julien, 1874 Cambodia; Lecomte (H.) and Finet (A.) 1911-1912 Indochina; Magnien, Gourgand & Châtillon, 1909 Cambodia; Pierre, 1865-1877 Cambodia, Cochinchina and South Thailand; Thorel (D^r), 1862-1866 Cochinchina, 1866-1868 Laos (along Mekong river); Vinot, c. 1912 Cochinchina (Bien-hoa). (ref.: Gagnepain (1944) & herbarium sheets)

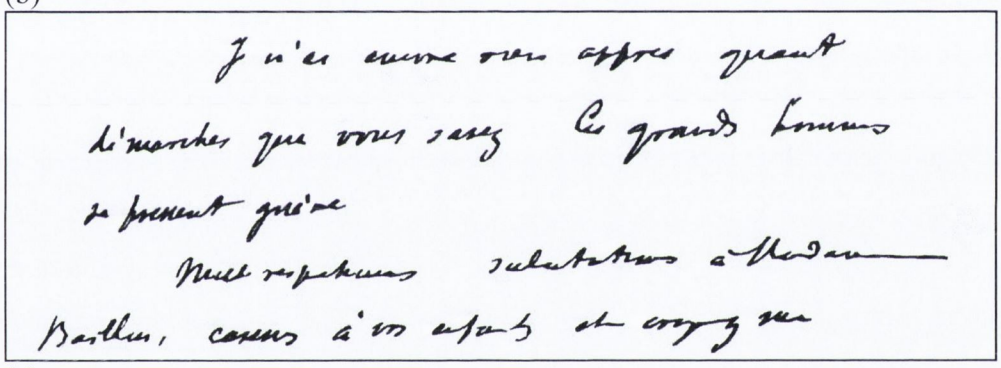
For Indochina, when lectotypification is required I have used two criteria to guide selection of the lectotype. Firstly, in general I have selected the material in best physical condition, but have also, when possible, selected herbarium specimens with Delpy's or Gagnepain's drawings attached, because the details in these drawings were used extensively by Gagnepain (1917) in his species descriptions. In the Myrtaceae collections in **P**, Delpy's drawings are generally attached to the respective herbarium specimens.



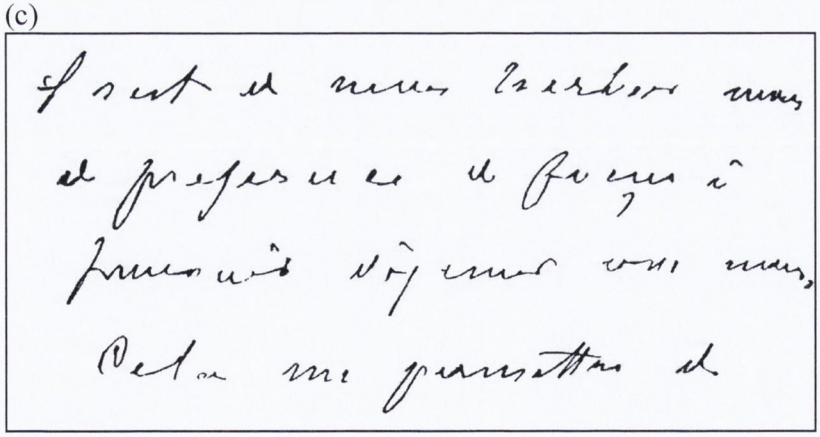
(a)



(b)



(c)



(d)

Figure 5.1 a-d. Autographs of selected plant collectors or botanists relevant to Indochina: (5.1a) Gagnepain, F.; (5.1b) Harmand, J.; (5.1c) Pierre, L.; (5.1d) Thorel, C. (with permission from Muséum National d'Histoire Naturelle)

5.5 Characters useful in identification and genera that can be confused with *Syzygium*

Generally *Syzygium* can be easily recognised by the simple, opposite, gland dotted (punctilate or pustulate) and exstipulate leaves with intramarginal veins. At species level, vegetative characters that are useful for identification include the nature and colour of the twig, leaf arrangement, petiole length and the shape, size, colour and venation of blade.

There are a few reproductive characters useful for identifying species. These are the inflorescence type and length, hypanthium shape and size, presence or absence of pedicel, calyptrate or free sepals and, to a limited extent, the fruit shape and size. At the infrageneric level, the hypanthium shape, ovule arrangement and placentation, the anther orientation and the presence or absence of seed intercotyledonary intrusion are useful for identifying subgeneric groups.

In having opposite leaves and intramarginal veins, herbarium specimen of *Syzygium* are often confused with other genera such as *Eugenia, Garcinia*, *Memecylon* and Rubiaceae. All the taxa mentioned above, except for *Eugenia,* do not have a punctilate or pustulate leaf surface (oil glands). *Garcinia* has leaves with petiole bases that clasp the twig while Rubiaceae has interpetiolar stipules. *Memecylon* usually has a shiny and wrinkled leaf, and the stamens are crescent-shaped. *Eugenia* has hairy vegetative shoots and inflorescences, and few flowers – from one to three per inflorescence.

5.6 Taxonomic treatment

Syzygium Gaertn.

(Greek, *Syzygos* = yoked together, referring to the the paired leaf arrangement)

de Fruct. 1: 166, t. 33 (1788), nom. cons. – *Eugenia* subg. *Syzygium* (Gaertn.) Wight, Ill. Ind. Bot. 2: 12, 15 (1841) – *Jambosa* sect. *EuSyzygium* Miq., Fl. Ind. Bat. 1: 447 (1855) – *Eugenia* sect. *Syzygium* (Gaertn.) M.R.Henderson, Gard. Bull. Sing. 12: 17 (1949). **Type**: *Syzygium caryophyllaeum* Gaertn.

Caryophyllus L., Sp. Pl. 515 (1753), nom. rej. **Type**: *Caryophyllus aromaticus* L. (*Syzygium aromaticum* (L.) Merr. & L.M.Perry).

Jambosa Adans., Fam. 2: 88, 564. (1763) ('*Jambos*'), nom. et orth. cons., nom. rej. – *Eugenia* subg. *Jambosa* Wight, Ill. Ind. Bot. 2: 12,15 (1841) – *Eugenia* sect. *Jambosa* Miq., Anal. Bot. Ind. 1: 17 (1850). **Type**: *Jambosa vulgaris* DC., nom. illeg. (*Eugenia jambos* L., *Jambosa jambos* (L.) C. F. Millspaugh, *Syzygium jambos* (L.) Alston) (typ. cons.)

Myrthoides Wolf, Gen. 73. 1776; Gen. Sp. 158 (1781). **Type**: *Myrtus caryophyllatus* L. (*Syzygium caryophyllatum* (L.) Alston) (Vide R. Ross, Acta Bot. Neerl. 15: 159. 1966.)

Acmena DC. Prodr. 3: 262 (1828) – *Lomastelma* Rafinesque, Sylva Tell. 107 (1838) – *Eugenia* subg. *Acmena* (DC.) Wight, Ill. Ind. Bot. 2: 12, 14 (1841) – *Eugenia* sect. *Acmena* (DC.) Miq., Anal. Bot. Ind. 1: 19 (1850). **Type**: *Acmena smithii* (Poir.) Merr. & L.M.Perry (*Eugenia elliptica* Sm., nom. illeg., non Lam. (1789) 206; *Eugenia smithii* Poir.; *Myrtus smithii* (Poir.) Spreng.; *Acmena floribunda β elliptica* DC.; *Lomastelma elliptica* (Sm.) Raf.; *Acmena elliptica* G. Don ex Steud.; *Syzygium brachynemum* F. Muell., nom. illeg.; *Eugenia brachynema* F. Muell., nom. illeg.; *Syzygium smithii* (Poir.) Nied.; *Lomastelma smithii* (Poir.) J.H. Willis).

Malidra Rafinesque, Sylva Tell. 107 (1838) – *Cerocarpus* Hassk. , Flora 25 (2, Beibl.): 36 (1842), nom. illeg. – *Jambosa* sect. *Cerocarpus* Blume (1850) 102 – **Type**: *Malidra aquea* (Burm.f.) Rafinesque (*Eugenia aquea* Burm.f., *Jambosa aquea* (Burm.f.) DC., *Cerocarpus aqueus* (Burm.f.) Hassk., *Syzygium aqueum* (Burm.f.) Alston).

Syllysium Meyen & J.C. Schauer in J. C. Schauer, Nov. Actorum Acad. Caes. Leop.-Carol. Nat. Cur. 19(Suppl. 1): 334 (1843) – **Type**: *Syllysium buxifolium* Meyen & J. C. Schauer.

Cleistocalyx Blume, Mus. Bot. 1: 84, t. 56 (1850) – *Cleistocalyx* sect. *Eucleistocalyx* Merr. & L.M.Perry, J. Arnold Arbor. 18: 325 (1937) – *Eugenia* sect. *Cleistocalyx* (Blume) M.R. Henderson Gard. Bull. Sing. 12: 17 (1949) – **Type**: *Cleistocalyx nitidus* Blume (*Eugenia cleistocalyx* Merr., *Syzygium cleistocalyx* (Merr.) P.S. Ashton). (fide Merr. & L.M.Perry, J. Arnold Arbor. 18: 333 (1937)

Clavimyrtus Blume Mus. Bot. 1: 113, t. 49 (1850) – *Jambosa* sect. *Clavimyrtus* (Blume) Miq., Fl. Ind. Bat. 1: 427 (1855) – **Type**: *Clavimyrtus glabrata* Blume (*Myrtus glabrata* Blume (1826), nom. illeg., non *M. glabrata* O. Swartz (1788). (fide Merrill & Perry, Mem. Amer. Acad. Arts 18: 141 (1939)

Gelpkea Blume, Mus. Bot. 1: 88 (1850). **Type**: *Gelpkea stipularis* Blume (*Syzygium stipulare* (Blume) Craven & Hartley) lectotype designated by L.Craven & E.Biffin, Blumea 55: 96 (2010).

Strongylocalyx Blume, Mus. Bot. 1: 89, t. 54 (1850) – **Type**: *Strongylocarpus leptostemon* (Korthals) Blume (*Jambosa leptostemon* Korthals, *Eugenia leptostemon* (Korthals) Blume, *Syzygium leptostemon* (Korthals) Merr. & L.M.Perry). (fide Merr. & L.M., Perry, Mem. Amer. Acad. Arts 18: 141 (1939))

Microjambosa Blume Mus. Bot. 1: 117 (1850) – **Type**: *Microjambosa conferta* (Korthals) Blume (*Jambosa conferta* Korthals, *Syzygium confertum* (Korthals) Merr. & L.M.Perry). (fide Merr. & L.M., Perry, Mem. Amer. Acad. Arts 18: 141 (1939))

Acicalyptus A. Gray, Proc. Amer. Acad. Arts 3: 127 (1854) – *Cleistocalyx* sect. *Acicalyptus* Merr. & L.M.Perry, J. Arnold Arbor. 18: 325 (1937) – **Type**: *Acicalyptus myrtoides* A. Gray (*Calyptranthes myrtoides* (A. Gray) Seemann, *Cleistocalyx myrtoides* (A. Gray) Merr. & L.M.Perry, *Syzygium myrtoides* (A. Gray) R. Schmid).

Jambosa sect. *Leptomyrtus* Miq., Fl. Ind. Bat. 1: 436 (1855) – *Leptomyrtus* (Miq.) O.C. Berg., in C. F. P. Martius, Fl. Brasil. 14(1): 635 (1859). **Type**: not designated.

Jambosa sect. *Bostrychode* Miq., Fl. Ind. Bat. 1: 438 (1855) – *Bostrychode* (Miq.) O.C. Berg. in C. F. P. Martius, Fl. Brasil. 14(1): 634 (1859). **Type**: not designated.

Macromyrtus Miq., Fl. Ind. Bat. 1: 439 (1855) – **Type**: *Macromyrtus javanica* Miq. (*Eugenia macromyrtus* Koord. & Valeton, *Syzygium macromyrtus* (Koord. & Valeton) Merr. & L.M.Perry).

Aphanomyrtus Miq., Fl. Ind. Bat. 1: 480 (1855) – **Type**: *Aphanomyrtus rostrata* Miq.

Piliocalyx Brongn. & Gris, Bull. Soc. Bot. France 12: 185 (1865), nom. cons – **Type**: *Piliocalyx robustus* Brongn. & Gris, non *Syzygium robustum* Miq. (1858) (*Syzygium viriosum* Craven & J.W. Dawson). (fide R.Mansfeld, Bull. Misc. Inform. Kew 1935: 449 (1935).

Cupheanthus Seem. Fl. Vitiensis 76 (1865) – **Type**: *Cupheanthus neocaledonicus* Seem. (*Syzygium neocaledonicum* (Seem.) J.W. Dawson).

Eugenia sect. *Erythronema* F. Muell. Fragm. 5: 12 (1865) – **Type**: *Syzygium wilsonii* (F. Muell.) B. Hyland (*Eugenia wilsonii* F. Muell.).

Gaslondia Vieill., Bull. Soc. Linn. Normandie 10: 96 (1866) – **Type**: *Gaslondia amphoricarpa* Vieill. (Myrtaceae?: vide Van Tieghem, Ann. Sci. Nat. Bot. ser. 8. 19: 349. 1904)

Pseudoeugenia Scortechini, J. Bot. 23: 153 (1885) – **Type**: *Pseudoeugenia perakiana* Scortechini.

Xenodendron Lauterb. & K. Schum. Fl. Deutsch. Südsee 461. t. 16. (1900) – **Type**: *Xenodendron polyanthum* Lauterb. & K. Schum. (*Acmena polyantha* (Lauterb. & K. Schum.) Merr. & L.M.Perry).

Pareugenia Turrill, Hooker's Icon. Pl. 31: ad t. 3004 (1915) – **Type**: *Pareugenia imthurnii* Turrill (*Syzygium imthurnii* (Turrill) Merr. & L.M.Perry).

Tetraeugenia Merrill, J. Straits Branch Roy. Asiat. Soc. 77: 230 (1917) – **Type**: *Tetraeugenia caudata* Merr.

Eugenia sect. *Fissicalyx* M.R. Hend. Gard. Bull. Sing. 11: 333 (1947) – **Type**: *Eugenia symingtoniana* M.R. Hendenderson, lectotype designated by L.Craven & E.Biffin, Blumea 55: 98 (2010) (*Stereocaryum symingtonianum* (M.R. Hend.) A.J. Scott, *Syzygium symingtonianum* (M.R. Hend.) I.M. Turner).

Acmenosperma Kausel, Ark. Bot. Ser. 2. 3: 609 (1957) – **Type**: *Acmenosperma claviflorum* (Roxb.) Kausel (*Eugenia claviflora* Roxb., *Acmena claviflora* (Roxb.) Walp., *Syzygium claviflorum* (Roxb.) Wall. ex Steud.).

Waterhousea B. Hyland, Austral. J. Bot., Suppl. Ser. 9: 138 (1983) – **Type**: *Waterhousea floribunda* (F. Muell.) B. Hyland (*Syzygium floribundum* F. Muell.).

Anetholea Peter G. Wilson, Austral. Syst. Bot. 13: 434 (2000) – **Type**: *Syzygium anisatum* (Vickery) Craven & Biffin (*Backhousia anisata* Vickery, *Anetholea anisata* (Vickery) Peter G. Wilson).

Tree to 35 m tall or shrub 1 – 3 m tall. Indumentum mostly absent, rarely present. Oil glands present in almost all organs, punctilate or pustulate on surface. **Twig** terete, subangular, angular (3 or 4 angled) or winged, terete when becoming old, 2 – 5 mm diameter, stout or slender, surface usually smooth, sometimes flaky or fissured, colour whitish, greyish, pale brownish to dark brownish, contrasting or not to leaf or petiole colour. **Leaves** usually opposite (decussate) or subopposite, rarely alternate or verticillate in whorls of three, petiolate or subsessile, 2.5–50 × 2 – 9 cm, 1.5 to 12 times as long as wide, elliptic, ovate, obovate, lanceolate to

oblong, base attenuate, cuneate, rounded to cordate, 15 – 60 degrees from midrib, margin flat or recurved inward, apex usually acute or acuminate, sometimes rounded, rarely cuspidate or mucronate, acumen absent or present, 0.3 – 2 cm long, sometimes deflexed, blade chartaceous, subcoriaceous to coriaceous, upper surface usually punctilate, rarely pustulate, lower surface always pustulate, cork wart (black dots) always present, leaf yellowish brown, pale to dark brownish or greenish, always paler below, sometimes shiny on both sides or just the lower surface; midrib often sunken above, rarely flat, mostly smoothly raised below, rarely angled (only in *S. fastigiatum*); secondary veins 7 – 45 per side per blade, 0.5 – 20 mm apart, 30 – 60 degrees from midrib, prominent or faint, raised or sunken above, always raised below, narrowly (Type A.I) or broadly (Type A.II or A.III) spaced and connecting to the prominent inner intramarginal veins, sometimes 1 – 3 basal secondary veins (acrodromous veins) arcuate (Type B) and not connecting but often extending to form outer intramarginal veins, sometimes intramarginal veins absent and all secondary veins arcuate or looped to form pinnate-like venation (Type C)[6]; intermediate secondaries present or absent, one to two in between secondaries, prominent or faint; tertiary veins prominent or faint, reticulate, subscalariform or scalariform; inner intramarginal veins frequently present and always prominent, 0.5 – 5 mm from leaf margin, straight or scalloped, outer intramarginal veins prominent, faint or absent; petiole 0.1 – 3 cm, 1/4 – 1/140 of blade length, 0.5 – 5 mm diameter, slender or stout, brownish to dark brownish, to blackish, constrasting or not to blade colour. **Inflorescence** terminal, axillary on leafy twig near the twig-end or lateral-axillary in axil of fallen leaf, 1–17 cm long, solitary, racemose or paniculate (first to fourth order branching), flowers few to many, one to 300, usually in triplets, sometimes in pairs, spreading or in compact heads; axes angular or terete, usually smooth, rarely flaky; bracts and bracteoles persistent or caducous, 0.3 – 2 × 0.3 – 2 mm, triangular, elliptic or lanceolate. **Flower** sessile or pedicellate, pedicel 0.05 – 2 cm long, hypanthium 1–20 × 0.3 – 20 mm, obconic, pyriform, elongate or clavate, usually smooth, sometimes glaucous, corrugate or warty, pseudostalk distinct or indistinct, 1–13 mm long; sepals 4 – 5, free or calyptrate (dome-shaped), triangular, ovate, semiorbicular or orbicular, 0.3 – 10 × 0.6 – 18 mm, equal or

[6] For details on leaf venation types, see Chapter 2.

unequal in size, if unequal outer lobes smaller than inner lobes; petals 4 – 6, rarely 8, free or coherent, 1 – 17 × 1 – 17, semiorbicular to orbicular; stamens many, outer stamens 1 – 30 mm long; anther 0.2 – 2 mm, mostly oblong and sacs parallel, dehiscence by longitudinal slits or wider than long and sacs divaricate, dehiscence by apical slits (only in Subg. *Acmena*), connective gland conspicuous or inconspicuous; style 0.8 – 40 mm; ovary inferior, 2 locules, rarely 3, all fertile, placenta mostly axile-median, rarely axile-apical (only in Subg. *Acmena*), ovules 5 – 35 per locules, arrange in two longitudinal rows or radiating. **Fruit** a berry, 0.5 – 7 cm long, pyriform, globose, depressed globose, ellipsoid to obloid, surface smooth to rugose; with apical cavity, deep or shallow, surrounded by calyx ring, with crown-like persistent sepal lobes or undulating rim (formed from base of caducous sepal lobes or small sepals ring); seed 1 – 2, subglobose or ellipsoid, 0.35 – 3 cm, testa loosely or closely adhering to pericarp, cotyledons free or undivided, intercotyledonary intrusion present or absent, if present ramify from the side or apex.

Key to Indochinese species

This key is based on vegetative and flowering characters. Unless indicated, all observed characters are based on dried herbarium specimens. The species positions in the key are arranged to reflect their phenetic and hypothesized phylogenetic affinity.

1. Anther sacs divergent; placentation axile-apical.....2. *S. acuminatissimum* (Subg. *Acmena*)
   Anther sacs parallel; placentation axile-median.....2

2. Hypanthium clavate or elongate with long pseudostalk, ovules in two longitudinal rows.....3
   Hypanthium obconic or pyriform, ovules irregularly arranged, radiating.....12 (Subg. *Syzygium*)

3. Hypanthium glaucous; petiole dark brownish to blackish, contrasting to blade colour..... 4 (Subg. *Sequestratum*)
   Hypanthium not glaucous; petiole brownish, not contrasting to blade colour...7

4. Inflorescence racemose, short (2 – 2.5 cm long), few flowered (2 – 4).....6. *S. araiocladum*
   Inflorescence paniculate, first to second order branching, long (3–7 cm long), many flowered (30 – 100).....5

5. Hypanthium elongate, abruptly constricting to pseudostalk; leaf with distinct acumen.....40. *S. odoratum*
   Hypanthium clavate, gradually narrowing to pseudostalk; leaf without distinct acumen.....6

6. Leaf blade elliptic to ovate, 1 to 3.5 times as long as wide.....*4. S. antisepticum*
   Leaf blade lanceolate, 3.5 to 5 times as long as wide.....54. *S. tsoongii*

7. Seed without intercotyledonary intrusion; hypanthium not fibrous.....8
   Seed with intercotyledonary intrusion; hypanthium fibrous* .....9 (Subg. *Perikion*)

8. Flower sessile.....8. *S. attenuatum* (Subg. *Perikion*)
   Flower pedicellate.....7. *S. aromaticum* (Subg. *Syzygium*)

9. Leaf blade subsessile, petiole very short (0.05–0.1 cm); leaf base cordate, sometimes rounded.....11. *S. boisianum*
   Leaf blade petiolate, petiole long (0.3–0.6 cm); leaf base cuneate or attenuate.....10

10. Leaf nearly always lanceolate.....1. *S. abortivum*
    Leaf always elliptic, oblong-elliptic, ovate to obovate.....11

11. Leaf blade small (4 – 8.5 × 1 – 4 cm); petiole short (0.15 – 0.2 cm.....16. *S. championii*
    Leaf blade large (6 – 22 × 1.5 – 7.5) cm; petiole long (0.3 – 0.6 cm).....18. *S. claviflorum*

12. Hypanthium large (≥ 1 cm long); inflorescence racemose.....13 (Jambos group)
    Hypanthium small (< 1 cm long); inflorescence paniculate.....24

13. Leaves nearly always verticillate, arranged in whorls of three.....14
    Leaves always in pairs, opposite or subopposite.....16

14. Inflorescence terminal, rarely axillary on leafy twig..... 23. *S. diospyrifolium*
    Inflorescence lateral-axillary at axils of fallen leaf.....15

15. Leaf blade large, 15 – 35 × 6 – 18 cm .....25. *S. formosum*
    Leaf blade small, 11 – 18 × 1.5 – 2.5 cm.....29. *S. harmandii*

16. Inflorescence lateral-axillary at axils of fallen leaf.... 35. *S. malaccense*
    Inflorescence terminal or axillary on leafy twig.....17

17. Leaf blade more than 20 cm long.....18

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* This can be determined by dissecting fresh or boiled dried flowers: the fibres reside in the hypanthium wall and are visible with a hand lens.

Leaf blade less than 20 cm long.....19

18. Tertiary venation ladder-like (scalariform); leaf blade oblong elliptic, 3 to 4 times as long as wide.....36. *S. megacarpum*
Tertiary venation net-like (reticulate); leaf blade lanceolate, 5 to 9 times as long as wide.....20. *S. crassiflorum*

19. Basal secondary veins arcuate, not connecting to each other.....20
Basal secondary veins connecting to each other.....21

20. Leaf subsessile, petiole ≤ 2 mm long; leaf base cordate; hypanthium apex abruptly constricted to pseudostalk; fruit turbinate.....*5. S. aqueum*
Leaf petiolate, petiole > 2 mm long; leaf base cuneate, rounded or slightly cordate; hypanthium gradually constricted to pseudostalk; fruit pyriform to subglobose.....46. *S. samarangense*

21. Petiole < 3 mm long.....22
Petiole ≥ 3 mm long.....23

22. Leaf base cuneate; tertiary veins reticulate.....42. *S. pierrei*
Leaf base cordate; tertiary scalariform to subscalariform.....17. *S. chantaranothaianum*

23. Leaf apex gradually narrowing without distinct acumen; hypanthium greenish (in vivo).....32. *S. jambos*
Leaf apex with distinct acumen; hypanthium reddish-green (in vivo).....47. *S. siamense*

24. Inflorescence lateral-axillary on axile of fallen leaves.....25
Inflorescence terminal or axillary on leafy twig.....29

25. Sepals calyptrate; intramarginal veins absent, all secondary veins arcuate ..... 37. *S. nervosum*
Sepals free; intramarginal veins present.....26

26. Basal secondary veins connect to adjacent secondary veins to form intraginal veins.....27
Basal secondary veins arcuate and not connecting to adjacent secondary veins to form intramarginal veins.....28

27. Twig terete; secondary veins ≥ 20 pairs per side per blade, narrowly spaced (2–5 mm).....22. *S. cumini*
Twig angular (4-angled) and winged; secondary veins < 20 pairs per side per blade, broadly spaced (5 − 15 mm)....50. *S. tetragonum*

28. Petals free; leaf base slightly unequal; leaf blade brownish.....43. *S. polyanthum*
Petals coherent; leaf base equal; leaf blade greenish.....10. *S. balsameum*

29. Inflorescence hairy.....30

Inflorescence glabrous.....31

30. Leaf hairy; twig brownish not contrasting leaf colour; secondary veins broadly spaced, ; tertiary veins subscalariform.....55. *S. vestitum*
Leaf glabrous; twig whitish contrasting to leaf colour; secondary veins narrowly spaced (1 – 3 mm); tertiary veins reticulate.....33. *S. levinei*

31. Sepals calyptrate ..... 38. *S. nigrans*
Sepals free.....32

32. Inflorescence short (≤ 3 cm long).....33
Inflorescence long (> 3 mm long).....35

33. Leaf blade lanceolate, 5 to 8 times as long as wide.....48. *S. sterrophyllum*
Leaf blade elliptic to obovate, 1.5 to 3 times as long as wide.....34

34. Leaf blade larger (usually > 3 cm long); leaf dark greenish brown.....28. *S. hancei*
Leaf blade smaller (≤ 3 cm long); leaf light brownish.....15. *S. buxifolium*

35. Flower pedicellate.....36
Flower sessile.....41

36. Inflorescence unbranched.....3. *S. angkae*
Inflorescence branch at least once.....37

37. Basal secondary veins arcuate, not connecting to adjacent secondary veins.....38
Basal secondary veins connecting to adjacent secondary veins.....40

38. Twig whitish, contrasting to leaf colour; leaf blade 3 to 4 times as long as wide.....56. *S. zimmermannii*
Twig brownish, not contrasting to leaf colour; leaf blade 2 to 3 times as long as wide.....39

39. Tertiary veins reticulate; secondary veins 7 – 15 mm apart; peduncle surface flaky;.....30. *S. hemisphericum*
Tertiary vein subscalariform; secondary veins 15 – 20 mm apart; peduncle smooth.....31. *S. imitans*

40. Leaf blade small (< 10 cm long), elliptic, oblong-elliptic or ovate, base cuneate and slightly attenuate; midrib smoothly raised below.....34. *S. lineatum*
Leaf blade large (≥ 10 cm long), obovate, base strongly attenuate; midrib angled below.....24. *S. fastigiatum*

41. Inflorescence with flowers clustering at branch-end, compact, in 7 – 13 flowers.....42
Inflorescence not compact at branch-ends, in 3 flowers.....49

42. Intramarginal veins absent, all secondary veins arcuate.....26. *S. glomerulatum*
Intramarginal veins present.....43

43. Secondary veins sunken above.....13. *S. borneense*
Secondary veins raised above.....44

44. Hypanthium large (> 5 mm long); sepals unequal, inner sepals larger than outer sepals.....45
Hypanthium small (≤ 5 mm long); sepals equal.....46

45. Secondary veins 8 – 12 per side per blade, 8 – 10 mm apart.....27. *S. grande*
Secondary veins 20 – 25 per side per blade, 2 – 5 mm apart.....41. *S. pachysarcum*

46. Twig whitish, contrasting to leaf colour.....47
Twig brownish, not contrasting leaf colour.....48

47. Leaf blade elliptic or obovate, one to two times as long as wide .....22. *S. cumini*
Leaf blade lanceolate, 2.5 to six times as long as wide.....44. *S. ripicola*

48. Leaf apex mucronate.....21. *S. cucphuongense*
Leaf apex blunt , acute or acuminate.....49

49. Secondary veins narrowly spaced (2 – 3 mm); leaf apex without acumen.....51. *S. thorelli*
Secondary veins broadly spaced (5 – 8 mm); leaf apex with distinct acumen.....53. *S. tonkinense*

50. Leaf subsessile, petiole very short (≤ 2 mm long), 1/25 – 1/60 of blade length; base cordate.....51
Leaf petiolate, petiole long (≥ 3 mm), 1/7 – 1/22 of blade length; base cuneate or attenuate.....52

51. Twig whitish, contrasting to leaf colour..... 14. *S. bullockii*
Twig dark brownish, not constrasting to leaf colour.....12. *S. bokorense*

52. Leaf blade lanceolate, 5 to 8 times as long as wide.....9. *S. attopeuense*
Leaf blade elliptic, ovate, obovate to oblong, 1.5 to 4 times as long as wide.....53

53. Twig strongly angular (4-angled) and winged.....44. *S. praecox*
Twig terete and compressed.....54

54. Secondary veins narrowly spaced (≤ 2 mm).....49. *S. syzygioides*
Secondary veins broadly spaced (≥ 4 mm).....55

55. Hypantium small (≤ 2.5 mm long.....19. *S. corticosum*
Hypanthium large (> 3 mm long).....56

57. Leaf blade dark dark brown to blackish.....*52. S. thumra*
Leaf blade yellowish brown.....39. *S. oblatum*

1. *Syzygium abortivum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 101 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 45, fig. 3722 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 32 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 826 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 900 (2003); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 244 (2007) − *Eugenia abortiva* Ganep. Notul. Syst. 3: 316 (1917); in Lecomte, Fl. Gén. Indo-Chine 2: 802, f. 86 (1920); Craib, Fl. Siam. Enum. 1: 631 (1931). **Type**: Laos, Vien-chang, fl., *Thorel s.n.* [*2245*] (lectotype **P**! [barcode P00589305] here designated; isolectotype **P**! [barcode P00589306]). Remaining former syntypes: Thailand, Lakhon Nakhon Panom, fl., *Thorel s.n.* [2245] (**P**! [barcode P00589304]); between Xieng-kuoang and Pak-lay, fl., *Thorel s.n.* [2245] (**P**!). (see note 1)

Tree small. Glabrous on all parts. **Twig** angular when young, terete when old, c. 2 mm diameter, stout, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, (4 −)5 − 7 × 0.7 − 1(− 1.5), 3 to 6 times as long as wide, lanceolate or elliptic, base strongly attenuate, c. 20 degrees from midrib, margin slightly recurved inward, apex acute, blunt or pointed, few rounded, acumen absent, subcoriaceous, greenish; midrib sunken above, raised below; secondary veins (Type A.I) 20 − 25 per side per blade, narrowly spaced, c. 2.5 mm apart, c. 45 degrees from midrib, faint and raised above, prominent below; tertiaries prominent, of tertiaries or secondary strength, reticulate; inner intramarginal veins c. 0.5 mm from leaf margin, straight, outer intramarginal veins absent or faint; petiole, 0.3 − 0.4 cm, 1/13 − 1/24 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal and axillary on leafy twig, 1.3–1.7 cm long, solitary pr racemose, flowers few, one to five, not compact; axes 3–7 mm long, angular; bracts and bracteoles persistent, bracteoles 1 − 1.5 × 1 mm, lanceolate to elliptic. **Flower** white, sessile, hypanthium not glaucous, not fibrous, 10–12 × 3 mm, clavate, pseudostalk distinct, 5–7 mm long; sepals 4, free, c. 1 × 1 mm, triangular; petals 4, coherent, 2–5 × 2–4 mm,

orbicular; stamens 10 – 12 mm long; anther c. 0.5 mm, sacs parallel, connective gland inconspicuous; style c. 10 mm, ovules c. 10 per locule, arrange in two longitudinal rows. **Fruit** (immature) ellipsoid, 1 × 0.5 cm, surface smooth, calyx ring with smooth to undulating rim; seed 1, ellipsoid, 0.8 × 0.3 cm, cotyledons free, intercotyledonary intrusion present, ramify from side.

DISTRIBUTION: Myanmar, Thailand, Laos and Vietnam.

ECOLOGY OR HABITAT. Primary forest, near waterfall.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: July, September. Fruiting: not documented.

VERNACULAR NAME. Vietnam: Ruri (Thua Thien-Hue), Tram lac thai.

USES. Not documented.

NOTES.

1. Although in the protologue *Thorel 2245*, which is a species number, was cited for three different localities (Vien-chang, Lakhon and Xieng-kuoang-Pak-Lay), in **P** the specimens are unnumbered.

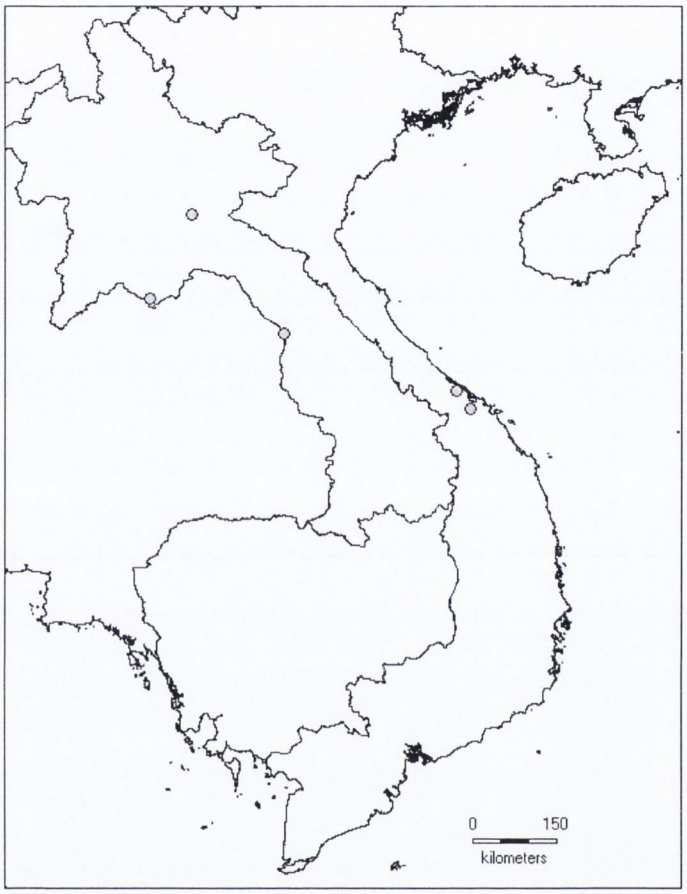
2. Contrary to what Gagnepain (1920) had reported, dissection of mature flowers from specimens cited by Gagnepain (*Thorel s.n.* [2245]) and other collected materials (*Squire 106* & *Vidal 795A*) showed that the ovary has two fertile locules instead of one. The flowers examined by Gagnepain were probably abberant.

3. This species is morphologically and anatomically close to *S. claviflorum*. Morphologically it is similar to *S. claviflorum* in having a clavate hypanthium, racemose inflorescence and seed intercotyledonary intrusion. Anatomically, it is similar to *S. claviflorum* in having anisocytic and cyclo-staurocytic stomatal types and arc midrib vascular system with adaxial phloem partition and prismatic crystals. The narrow lanceolate leaves of this species resemble the rheophytic form of *S. claviflorum*, *i.e.* var. *riparia*. *Vidal 795A* is the only collection that could possibly indicating a rheophytic habitat at the waterfall. More ecological and geographical information is needed to determine the real status of this species.

SPECIMENS EXAMINED.

LAOS. Viangchan: 1866-1868, *Thorel s.n.* [*2245*] (**P**); *d'Alleizette s.n.* (**L**) – between Xieng Khouang and Pak: 1866-1868, *Thorel s.n.* [*2245*] (**P**).

THAILAND. Nakhon Phanom: Lakhon, 1866-1868, *Thorel s.n.* [*2245*] (**P**).
VIETNAM. *s. loc.*, *Anon. HLF 1606* (**HN**) − Thua Thien-Hue: Mt. Bach Ma, 27 July 1943, *Vidal 795A* (**L**, **P**); Huong Phu, 4 September 1980, *Thai Thuan 735* (**HN**); Hue, 1927, Jan-May, *Squires 106* (**A**, **K**).



Map 1. Distribution of *Syzygium abortivum* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

2. *Syzygium acuminatissimum* (Blume) DC., Prodr. 3: 261 (1828); J. Chen & Craven, Fl. China 13: 343 (2007) − *Myrtus acuminatissima* Blume, Bijdr.: 1088 (1826) − *Jambosa acuminatissima* (Blume) Hassk., Cat. Hort. Bot. Bogor.: 362 (1844); Miq., Fl. Ind. Bat. 1: 438 (1855) − *Eugenia acuminatissima* (Blume) Kurz, Prelim. Rep. Forest Pegu, App. A: lxiii (1875), nom. illeg., non Miq. (1846); Kurz, J. Asiat. Soc. Bengal 46: 67 (1877); Duthie in Hook.f., Fl. Br. Ind. 2: 483 (1878); Koord. & Valeton, Meded. Lds. PlTuin. 40: 155 (1900), [excl. in syn. *Jambosa saligna*]; King, J. Asiat. Soc. Bengal 70: 126 (1901), Mater. Fl.

Mal. Pen. 12: 556 (1901); Ridl. J. Fed. Mal. Str. Mus. 10: 91 (1920), Fl. Mal. Pen. 1: 747 (1922), J. Bot. 68: 34 (1930); M.R.Henderson, Gard. Bull. Sing. 12: 260 (1949); Kochummen in Ng, Tr. Fl. Mal. 3: 188 (1978) – *Acmena acuminatissima* (Blume) Merr. & L.M.Perry, J. Arnold Arbor. 19: 12 (1938); Merr. Philip. J. Sci. 79: 361 91950); N.P. Balakr., Fl. Jowai 1: 201; Harid. & R.R.Rao, Forest Fl. Meghalaya: 387 (1985); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 43, fig. 3715 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 15 (1994); M.C.Le & T.H.Le Forest Plants (Thực vật rừng): 320, fig. 271 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 782 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 311 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 891 (2003); M.F.Newman et al., Checkl. Vas. Pl. Laos: 242 (2007). **Type**: loc. sin. [Java], *Blume s.n.*, (holotype **L**! [barcode L0484157]).

– *Syzygium subdecurrens* Miq., Fl. Ind. Bat. 1: 449 (1855) – *Eugenia subdecurrens* (Miq.) Merr. & Chun, Sunyat. 2: 289 (1935). **Type**: Indonesia, Java, Ungarang, *Junghuhn s.n.* (holotype **U**! [barcode U0004930]; isotype **L**! [barcode L0329868]).

– *Eugenia cumingiana* D. Vidal, Phan. Cuming.: 173 (1885); Craib, Fl. Siam. En. 1: 636 (1931); Corner, Ways Trees. 1: 496 (1940) – *Syzygium cumingianum* (D.Vidal) Gibbs, J. Linn. Soc. Bot. 42: 76 (1914). **Type**: The Philippines , Albay Province, *Cuming 925* (holotype **PNH**†; isotypes **K**!, **L**! [2 sheets]).

– *Xenodendron polyanthum* K.Schum. & Lauterb., Fl. Schutzgeb. Südsee: 461 (1900), t. 16 – *Acmena polyantha* (K.Schum. & Lauterb.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 11 (1938). **Type**: New Guinea, Sattelburg, *Bamler 5* (holotype **B**†). (fide Goveart et. al. (2010))

– *Eugenia cuspidate-obovata* Hayata, Icon. Pl. Formosan. 3: 116 (1913) – *Syzygium cuspidate-obovatum* (Hayata) Mori, Trans. Nat. Hist. Soc. Taiwan 28: 439 (1938). **Type**: n.v. (fide J. Chen & L.A. Craven, Fl. China 13: 343 (2007))

– *Eugenia laevifolia* Ridl., Trans. Linn. Soc. London, Bot. 9: 48 (1916) – *Acmena laevifolia* (Ridl.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 18 (1938). **Type:** New Guinea, *Kloss s.n.* (holotype **K**!; isotype **BM**!).

– *Eugenia attenuatifolia* Merr., Philipp. J. Sci. 18: 299 (1921). **Type**: Philipines, Canta duanes, Mt. Mariguidon, 26th Nov 1917, *Ramos, Bur. Sci. 30314*, (holotype **PNH** †; isotypes **A** n.v. [barcode 69614], **K**!).

– *Acmena dielsii* Merr. & L.M.Perry, J. Arnold Arbor. 19: 18 (1938). **Type**: New Guinea, Gawaree, 22 Nov 1925, *Brass 675* (**A** n.v. [barcode 68803 & 68804], BRI n.v.). (fide T.G.Hartley & L.A Craven, J. Arnold Arbor. 58: 331 (1977))

– [*Syzygium altissimum* Wall., *Wallich Numer. List 2588* (1831) (**K-W**!), nom. nud.]

– [*Eugenia eucaudata* Elmer in Merr., Enum. Philipp. Fl. Pl. 3: 176 (1923), nom. nud.]

– [*Eugenia saligna* auct. non Miq, Fl. Ind. Bat. 1: 432 (1855) (*Jambosa saligna*): C.B.Rob. Philipp. J. Sci. 4: 392 (1909). **Vouchers**: The Philippines, Albay, *Cuming 925* (**L**!); The Philippines, Province of Benguet, Mt. Tonglon, *For. Bur. 5044* (Curran) (**L**!)]. (fide type of *Jambosa saligna* Miq: Indonesia, Java, *Junghuhn 77* (holotype **L**! [barcode L898203370]) (see note 2)

Tree to 35 m tall. Glabrous on all parts. **Twig** terete and compressed or subangular, 2 – 3 mm diameter, slender, smooth, brownish, not contrasting to leaf colour. **Leaves** opposite to subopposite, 8 – 9 × 2.5 – 3 cm, 3 times as long as wide, elliptic, ovate, base, cuneate, slightly attenuate, 30 – 40 degrees from midrib, margin flattish, apex acute, acuminate, mostly with distinct acumen, acumen 0.5 – 1 cm, 1/5 of blade length, blade chartaceous, pale brownish; midrib sunken above, raised below; secondary veins (Type A.II and B) 10 to 15 per side on blade, narrowly spaced, 2 – 3 mm apart, ascending c. 60 degrees from midrib, faint above, prominent or faint below, very slender; tertiaries prominent or faint, reticulate, slender; inner intramarginal c. 1 mm from margin, slightly looped, outer intramarginal veins faint, sometimes first pairs of basal secondary veins (acrodromous veins) arcuate, extend from base to half way or near leaf apex (forming outer intramarginal veins); petiole 0.5 cm, 1/16 – 1/18 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal, to 5 cm long, paniculate, usually third order branching, sometimes fourth order, flowers many, 30 – 45; axes to 5 cm long, angular, smooth; bract and bracteoles caducous. **Flowers** small, sessile, hypanthium not glacous, not fibrous, 3.5 – 4.0 × 2.5 – 3.0 cm, obconic, pseudostalk distinct, 1.5 – 2.0 mm

long; sepals 4, free, triangular, undulate on rim and inconspicuous; petals 4, coherent, 1×1 mm, orbicular; stamens c. 1 mm long, anthers 0.2 mm long, sacs divergent, connective gland conspicuous; style 1 – 1.3 mm, ovules 8 per locule, axile-apical, radiating horizontally in single array surrounding placenta. **Fruit** depressed globose, 1.5×1.2 cm, surface smooth, dark purple when ripe, calyx ring with smooth rim; seed 1, depressed globose, large, 1.1×1.4 mm, cotyledons free, intercotyledonary intrusion present, ramifying from seed apex.

DISTRIBUTION: Widespread from South China to the Solomon Islands. In Indochina, this species is undercollected and only documented so far in Laos and Vietnam but possibly occur also in Cambodia.

ECOLOGY OR HABITAT. In primary or secondary forest to 1450 m on sandy or clayey soil.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Not documented.

VERNACULAR NAME(S). Thoa (Vietnam).

USES. Timber used for furniture and boat (Le & Le, 2000).

NOTES.

1. *Syzygium acuminatissimum* is a very polymorphic species. Its morphological variations were extensively discussed in Merrill & Perry (1938) and Hartley and Craven (1977). Merrill & Perry (1938) observed morphological variations in the frequency of gland dots, the branchlet texture, leaf venation, leaf shape and leaf arrangement. However, they found these morphological variations intergrading and no distinct form was recognised. Hartley & Craven (1977) recognised three entities in Papuasian species: Entity I is pubescent while the Entity II and Entity III are glabrous. Entity III differs from Entity II in having larger fruit width (3 – 4.5 cm versus 1 – 2 cm) and pedicel width (5 – 10 mm versus 1 mm), otherwise both cannot be differentiated on the basis of sterile or flowering specimens. The Indochinese and Thai specimens seem to fall into Entity II; they are glabrous and have small fruit (1.4 mm wide).

2. Koorders & Valeton (1900) sunk *Jambosa saligna* Miq into *Eugenia acuminatissima* (Blume) Kurz by mistake. Later, Robinson (1909) upon realizing that *E. acuminatissima* (Blume) Kurz is illegitimate decided to choose the second

oldest name, *Jambosa saligna* Miq, from Koorders & Valeton's list of synonyms as a valid name without checking the actual type.

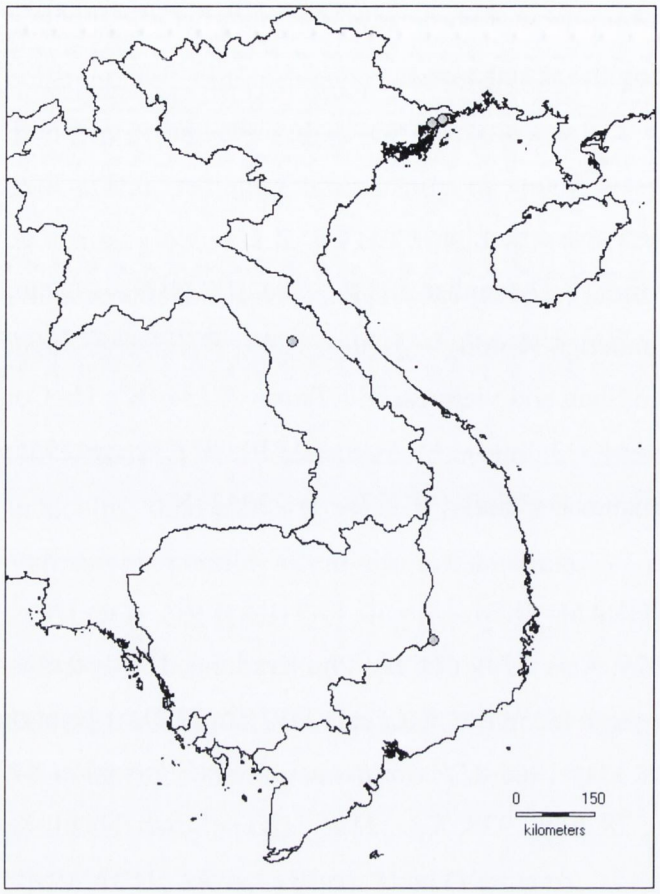
SPECIMENS EXAMINED.

LAOS. Khammouan: Nakai, M.F. Newman Lao 850 (**E**).

VIETNAM. Dac Lak: Duc Minh, 9 December 1979, , *Tue 300* (**HN**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, 18 May - 5 July, 1940, *W.T.Tsang 30088* (**BKF**); Ha Coi, Tsai Wong Mo Shan and vicinity, *W.T.Tsang 27134* (**K**); Ha Coi, Tsai Wong Mo Shan and vicinity, 23 June - 31 August 1939, *W.T.Tsang 29366* (**K**); Ha Coi, Tsai Wong Mo Shan and vicinity, *W.T.Tsang 27062* (**K**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND. Loei: March 1929, *Kerr 8749* (**TCD**); Phu Kradung, 13 September 1990, *P.Chantaranothai D.Simpson; K.Sridit, & J.Parn. 90/192* (**TCD**) – Nakhon Si Thammarat: Khao Luang, 18 May 1968, *C.F.van Beusekom & C.Phengklai 842* (**L**, **P**) – Songkla: Khao Khao, 28 July 1928, *Kerr 15964* (**K**) – Surah Thani: Ko Samui, 1927, *Put 1294* (**TCD**).



Map 2. Distribution of *Syzygium acuminatissimum* DC. in Cambodia, Laos and Vietnam.

3. *Syzygium angkae* (Craib) P.Chantaranothai & J.Parn., Kew Bull. 48: 592 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 35 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 830 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003); M.F.Newman et al., Checkl. Vas. Pl. Laos: 244 (2007) – *Eugenia angkae* Craib, Bull. Misc. Kew 1929: 115 (1929); in Fl. Siam. Enum. 1: 633 (1931). **Type**: Thailand, Doi Inthanon [Doi Angkae], 30 April 1921, *Kerr 5287* (lectotype **BK**!, designated by P.Chantaranothai & J.Parn. op cit. (1993: 592); isolectotypes **BM**!, **K**!, **TCD**!).

– *Eugenia spissa* Craib, Bull. Misc. Inform., Kew 1930: 169 (1930) – *Syzygium angkae* subsp. *spissum* (Craib) P.Chantaranothai & J.Parn., Kew Bull. 48: 592 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 36 (1994); P.Chantaranothai & J.Parn., Flora of Thailand 7: 831 (2002). **Type**: Thailand,

Chumphon, Tasan, 28 January 1927, *Kerr 11666* (lectotype **BK**! designated by P.Chantaranothai & J.Parn. op cit. (1993: 592); isolectotypes **ABD** n.v., **BM**!, **K**!).

– [*Eugenia ngawunensis* Parkins in P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 36 (1994), nom. nud. **Vouchers**: Burma, Tenassirim, Htahpe Chaung, Ngawun reserve, *C.E. Parkinson 1614* (**K**!); Burma, Mergui, Ngawun reserve, *R.N. Parker 2595* (**K**!)]

Tree to 15 m tall. Glabrous on all parts. **Twig** terete, c. 2 mm diameter, slender, smooth, whitish to pale brownish, contrasting to leaf colour. **Leaves** opposite, 6 – 8.5 cm×3.5 – 4.5 cm, 1.5 to 2 times as long as wide, elliptic, base cuneate, c. 45 degrees from midrib, margin flat, apex mostly cuspidate, sometimes acuminate, acumen 0.5 – 1.5, 1/5 – 1/10 of blade length, blade chartaceous, greenish; midrib sunken above, raised below; secondary veins (Type A.I) 25 – 30, narrowly spaced, 1 – 2 mm apart, spreading, 75 degrees ascending from midrib, faint and raised above, prominent to faint below, slender; tertiaries faint, reticulate; inner intramarginal veins prominent, c. 1 mm from leaf margin, straight, secondary intramarginal veins absent; petiole c. 0.8 cm, 1/7 – 1/10 of balde length, c. 1 mm diameter, slender, dark brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary on leafy twig, short, 0.6 – 0.8 cm long, racemose inflorescence, few flowers, 5 to 7; axes, 0.6 – 0.8 cm long, angular, smooth; bract and bracteoles persistent, bract triangular, 1×1 mm, bracteoles triangular, 0.5×0.5 mm. **Flowers** whitish or greenish white (in vivo), not glacous, not fibrous, pedicellate, pedicel c. 0.1 cm long, hypanthium 5×3 mm, obconic, pseudostalk indistinct, to 1.5 mm; sepals 4, free, c. 1×2 mm, semiorbicular, distinct; petals 4, free, 5×4.7 mm, orbicular; outer stamens 5 mm, anthers c. 0.6 mm long, sacs parallel, connective gland inconspicuous; style c. 6 mm long, ovules c. 9 per locule, irregularly arranged, radiating. **Fruit** (Thailand) depressed globose, 1.5×1.8 cm, surface smooth, calyx ring with prominent and persistent with sepal lobes; seed 1, subglobose, 1×1 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Myanmar, Thailand, Laos and Vietnam.

ECOLOGY OR HABITAT. In primary forest to 1450 m altitude.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: April, May, July, August, November. Fruiting (Thailand): March, May, September.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

NOTES.

1. *Syzygium angkae* is a new record for Vietnam. Chantaranothai and Parnell (2002) recognised two subspecies: subspecies *angkae* (sepal > 1mm, longer petiole, shorter peduncle, occurring at 800 – 1950 m altitude) and subspecies *spissum* (sepal < 1mm, shorter petiole, longer peduncle, occurring at 50 – 700 m altitude). However, there is overlap in the length of petiole and peduncle for both of these subspecies.

SPECIMENS EXAMINED.

LAOS. Xieng Khouang: Phou Bia, 15 April 1932, *Kerr 21064* (**L**); Phou Bia, *Kerr 21066* (**L**).

VIETNAM. Dong Nai: Trang Bom, 13 May 1965, *M.A.Martin 936* (**P**) – Kon Tum: Dak Glei, 22 November 1995, *Ayeryanov et. al. VH 1895* (**HN**); Mang Canh, 23 November 1988, *T.D.Dai 249* (**HN**) – Son La: Xuan Nha, November 2003, *Phuong 7134* (**HN**) – Thanh Hoa: Dau Be, 21 August 2002, *Anon. s.n.* (**HN**) – Thua Thien-Hue: , Mt. Bach Ma, 5 August 1942, *Vidal 794A* (**P**) – Vinh Phuc: Mt. Tam Dao, 26 July 1976, *Anon. LX-VN 189* (**HN**).

ADDITIONAL SPECIMENS EXAMINED.

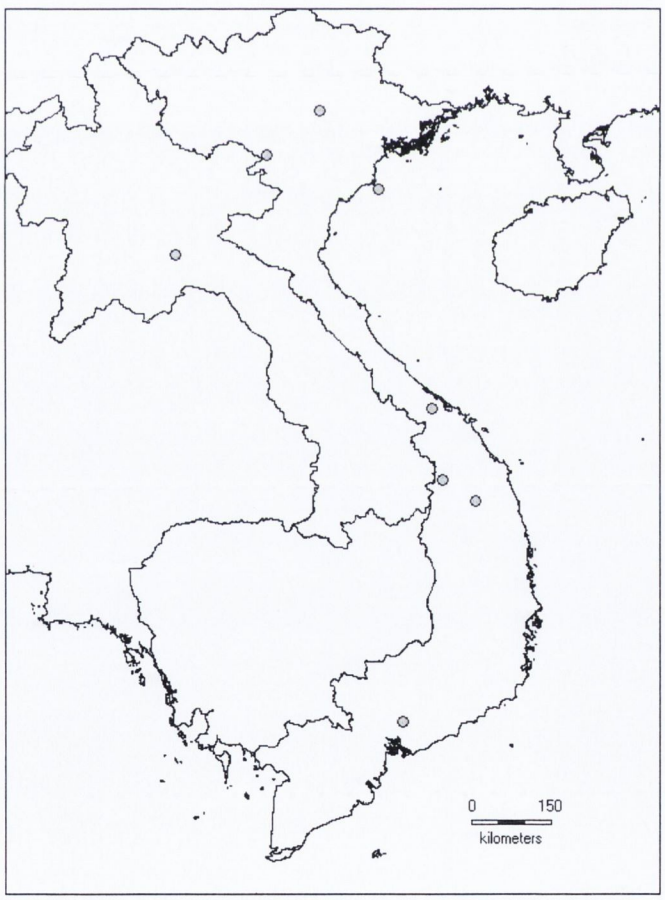
Syzygium angkae subsp. *angkae*:

THAILAND. Chiang Mai: Amphoe Mae Taeng, 23 October 1979, *T.Shimizu et. al. BKF 78041* (**BKF**); Amphoe Mae Taeng, 23 October 1979, *T.Shimizu* et al. *BKF 78041* (**BKF**); Doi Angkha, 8 April 1935, *Garret, H.B.G. 938* (**L**, **TCD**); Doi Angkha, 9 May 1939, *H.B.G.Garret 1120* (**L**, **TCD**); Doi Angkha, , 8 April 1935, , *H.B.G.Garret 938* (**TCD**); Doi Angkha, 9 May 1939, *H.B.G.Garret. 1120* (**TCD**); Doi Intanon, 7 October 1990, *P.Chantaranothai, R.Pooma, D.Simpson & J.Parnell 90/657* (**TCD**); Doi Intanon, 7 October 1990, *P.Chantaranothai, R.Pooma, D.Simpson & J.Parnell 90/657* (**TCD**) – Chiang mai: Doi Chiang, 27 September 1971, *G.Murata, C.Phengkhlai & K.Iwatsuki 15168* (**L**) – Loei: Phu

Luang, 11 September 2003, *R.Fennelly 7* (**TCD**); Phu Luang, 11 September 2003, *R.Fennelly 7* (**TCD**) – Nan: Phu Kha, 16 August 1995, *J.Parnell, C.Pendry & Pooma 95/109* (**TCD**); Phu Kha, 16 August 1995, *J.Parnell., C.Pendry & Pooma 95/109* (**TCD**) – Payap: Doi Chiengdao, 7 December 1965, *Heinnepman 3261* (**L**).

Syzygium angkae subsp. *spissum* (Craib) P.Chantaranothai & J.Parn.:

THAILAND. sin. loc., 19 February 1989, *Kerr 17150* (**L**, **TCD**) Kanchanaburi: Khao Yai, 6 April 1968, *C.F.van Beusekom 366* (**BKF**) – Loei: Phu Luang, 26 October 1996, *J.Parnell 98/16* (**TCD**) – Kamphaeng Phet: 7 June 1922, *Kerr 6089* (**TCD**) – Kanchanaburi: Khao Yai, 6 April 1968, *C.F.van Beusekom BKF 49891* (**BKF**) – Loei: Phu Luang, 26 October 1996, *J.Parnell 98/16* (**TCD**) – 19 February 1989, *Kerr 17150* (**TCD**) – Kamphaeng Phet: 7 June 1922, *Kerr 6089* (**TCD**).



Map 3. Distribution of *Syzygium angkae* (Craib) P.Chantaranothai & J.Parn. in Cambodia, Laos and Vietnam.

4. *Syzygium antisepticum* (Blume) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 159 (1939); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 245 (2007) – *Calyptranthes aromatica* Blume, Bijdr.: 1092 (1826), nom. illeg., non A.St.-Hil. (1824) – *Caryophyllus antisepticus* Blume in DC, Prodr. 3: 262 (1828), nom. nov. – *Jambosa aromatica* Miq., Fl. Ned. Ind. 1(1): 436 (1855) – *Eugenia antiseptica* (Blume) Kuntze, Revis. Gen. Pl. 1: 238 (1891). **Type:** Indonesia, Java, loc. sin. (Mt. Pantjar in protologue), *Blume s.n.* (lectotype **NY**! [barcode 00386778] here designated; isolectotype **U**! [barcode 0258717]). (see note 1)

– *Eugenia grata* Wight, Ill. Ind. Bot. 2: 15 (1841); Kurz, J. Asiat. Soc. Bengal 46: 65 (1877); Kurz, Forest Fl. Burma 1: 480 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 486 (1878); King, J. Asiat. Soc. Bengal 70: 109 (1901); King, in Mater. Fl. Malay Penins. 12: 539 (1901); Brandis, Ind. Trees: 322 (1906); Ridl., Fl. Malay. Penins. 1: 739 (1922); Craib, Fl. Siam. Enum. 1: 644 (1931); Corner, Wayside Trees Mal. 1: 498 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 233, fig.44g (1949) – [*Syzygium gratum* Wallich, *Wallich Numer. List 3586* (1831) (**K-W**!), nom. nud] – *Acmena grata* (Wight) Walp., Repert. Bot. Syst. 2: 181 (1843) – *Syzygium gratum* Wallich ex S.N.Mitra, Indian Forester 99: 100 (1973); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 70 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 861, fig. 18 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003). **Type**: Myanmar, Moulmyne, 1827, *Wallich Numer. List* 3586 (lectotype **K**! ['914 Hb. Mergui', *Herb. Hooker*] here designated; isolectotype **K**! [3 sheets: 'Mergui, *Griffith s.n.*', *Herb. Hooker*; 'Mergui, *Griffith s.n.*', *Herb. Hooker*; *Herb. Bentham*]). (fide Noltie (2005: 358))

– *Myrtus quadrangularis* Buch.-Ham. ex Duthie in J.D.Hooker, Fl. Brit. India 2: 486 (1878). **Voucher**: n.v. (fide Goveart et. al. (2010))

– *Eugenia cuprea* Koord. & Valeton, Bull. Inst. Bot. Buitenzorg 2: 6 (1899), nom. illeg, non (O.Berg) Nied. (1893). **Type**: Indonesia, Java, Tjibodas, Preanger, *Herb. Koorderss* (lectotype **L**! [*KDS 5478β*, barcode L0420061] here designated; isolectotype **L**! [*KDS 5631β*, barcode L0420062]).

– *Eugenia glaucicalyx* Merr., Publ. Bur. Sci. Gov. Lab. 35: 50 (1905) – *Syzygium glaucicalyx* (Merr.) Merr., Philipp. J. Sci. 79: 391 (1951). **Type**: The Phillipines,

Borden 2748 (lectotype **A** n.v. [frag., barcode 69701] designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 71 (1994)).

– *Eugenia collinsae* Craib, Bull. Misc. Inform. Kew 1928: 237 (1928). **Type**: Thailand, Chonburi, Sriracha, 4 April 1922, *Collins 782* (lectotype **BK**! designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 71 (1994); isolectotypes **ABD** n.v., **E**!, **K**!, **TCD**!).

– *Eugenia grata* Wight var. *nervosum* Craib, Fl. Siam. Enum. 1: 646 (1931). **Type**: Thailand, Nakhon Si Thammareat, Sichon, 12 May 1928, *Kerr 15690* (lectotype **BK**! designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 71 (1994); isolectotype **ABD** n.v.).

– *Syzygium ovatifolium* Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 161 (1939). **Type**: Malaysia, Sabah, Mt. Kinabalu, Tenompok, September 1932, *J & M.S. Clemens 28748* (holotype **A** n.v. [barcode 71377]; isotypes **BM**!, **NY**!, **K**!, **L**!).

– *Syzygium gratum* var. *confertum* P.Chantaranothai & J.Parn., Kew Bull. 48: 599 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 70 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 861 (2002). **Type**: Thailand, Ranong, Kraburi, Nikom Pak Chom, Pawta Luang Keow, *S.Pengnaren & S.S. 534* (holotype **BKF**!).

– [*Eugenia scabrida* Wallich, *Wallich Numer. List 3564D* (1831) (**K-W**!), nom. nud.]

– [*Eugenia zeylanica* auct. non (L.) Wight: Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 804 (1920) [incl. forma *angustifolia*, forma *parvifolia* and forma *laxiflora*] – *Syzygium zeylanicum* auct. non (L.) DC: Merr. & L.M.Perry, J. Arnold Arbor. 19: 101 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 62, fig. 3771 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 910 (2003).] (see note 2)

Shrub (2 – 3 m) or tree to 20 m tall. Glabrous on all parts. **Twig** angular and slightly winged when young, terete when old, fissured or fibrous on surface, 1 – 2 mm diameter, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, (2.5 –)3 – 8(– 13.5) × 1.5 – 5 cm, 1 to 3.5 times as long as wide, elliptic to ovate, base rounded to cuneate, c. 40 – 50 degrees from midrib, margin

flat, apex acute or obtuse, acumen indistinct, subcoriaceous to coriaceous, yellowish brown; midrib sunken above, raised below; secondary veins (Type A.II) slender, 10 – 15 per side per blade, broadly spaced, 2 – 7 mm apart, c. 45 degrees ascending from midrib, prominent and raised above, prominent below; tertiaries prominent or faint, reticulate; inner intramarginal veins 0.5 – 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.2 – 0.6 cm, 1/12 – 1/30 of blade length, c. 1 – 1.5 mm diameter, stout, dark brownish to blackish, contrasting to blade colour. **Inflorescence** terminal and axillary near leafy twig apex, 3 – 7 cm long, paniculate, first to second order branching, flowers many, to 39, in clusters of 3 to 6 flowers at lateral branches, 9 at terminal of main axes, lateral branches can be long or very short (c. 1 mm); axes 2.5 – 6.5 cm, angular, stout; bract and bracteoles caducous, ovate, c. 1.5 × 1 mm. **Flower** whitish (in vivo), sessile, hypanthium corrugated, glaucous, not fibrous, c. 5 – 7 × 2 – 2.5 mm, clavate, pseudostalk distinct, 0.5 – 2 mm; sepals 4 – 5, free, c. 0.5 × 1 mm, triangular; petals 4 – 5, coherent, 2 – 3 × 2 – 3 mm, orbicular; outer stamens 0.5 – 0.8 cm, anthers c. 0.4 mm, sacs parallel, connective gland conspicuous; style 5 – 8 mm, ovules 10 – 12 per locule, in 2 longitudinal rows. **Fruit** whitish (in vivo), globose, 0.5 × 0.5 cm, surface smooth, calyx ring with persistent sepal lobes; seed subglobose, 0.4 × 0.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread from India to Southeast Asia. In Indochina, found in Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. Occurs in wide range of habitat, in primary and secondary forest, dwarf forest, bush, savanna, along roadsides, marshes and by the sea shore, to 1300 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: January to October. Fruiting: February to May.

VERNACULAR NAME(S). Cambodia: Pring lies (Kampot), Renh (Kampong Chhang), Smach (Pursat, Kampong Chhang & Kampong Thum), Smach daom (Kampot, Kampong Spoe & Koh Kong), Sme (Siem Reap). Laos: Phak Sa Mek (Viangchan). Vietnam: Chen (Quang Tri), Tram tich lan (Vietnam), Tram sang (Tay ninh), Tram vo do (Vietnam).

USES. The fruit and young leaves edible, the bark is used for making torches and as red dye for fabrics and fishing nets. The plant is also used as traditional medicine against syphilis and dysentery (Dy Phon, 2000). The wood is used as timber for building houses (Lemmens et al., 1995).

NOTES.

1. Blume (1826) initially described this species under *Calyptranthes aromatica* but later under *Caryophyllus* using a new epithet *antisepticus* because the earlier epithet is pre-empted by *Caryophyllus aromatica* L. Miquel (1855) decided that this species belong to *Jambosa* and changed the name by using the oldest epithet, that is to *Jambosa aromatica*. This species is currently grouped under *Syzygium* and hence the name *Syzygium antisepticus* (Blume) Merr. & L.M.Perry is accepted. The specimens used by Blume to describe *Calyptranthes aromatica*, in **U** and **NY**, are flowering specimens collected from Mt. Pantjar in Java. The duplicate in **NY** is annotated by Blume as '*Calyptranthes aromatica*'. The duplicate in **U**, annotated by Miquel as '*Jambosa aromatica*, Java, monte', is possibly from Junghuhn's collection (fruiting specimens on upper-side of sheet) and Blume's collection (flowering specimen on lower-side of sheet) mounted on the same sheet. Because of the ambiguity of the specimen in **U**, the duplicate in **NY** was chosen as the preferred lectotype.

2. *Syzygium zeylanicum* and *S. antisepticum* are considered by most authors as closely related with the same geographical distribution, polymorphic and vegetatively inseparable, but can be differentiated by their hypanthium surface texture: warty in *S. zeylanicum* while smooth or wrinkled *S. antisepticum*. Until a comprehensive study is undertaken to resolve this complex species, I tentatively accept this division. Indochinese specimens all showed wrinkled or smooth hypanthium, therefore I grouped them into *S. antisepticum*. Throughout its range and also in Indochina, this species is very polymorphic and therefore I do not accept Gagnepain's formal recognition of the narrow leaf form (forma *angustifolia*), small leaf form (forma *parviflora*) and lax inflorescence form (forma *laxiflora*).

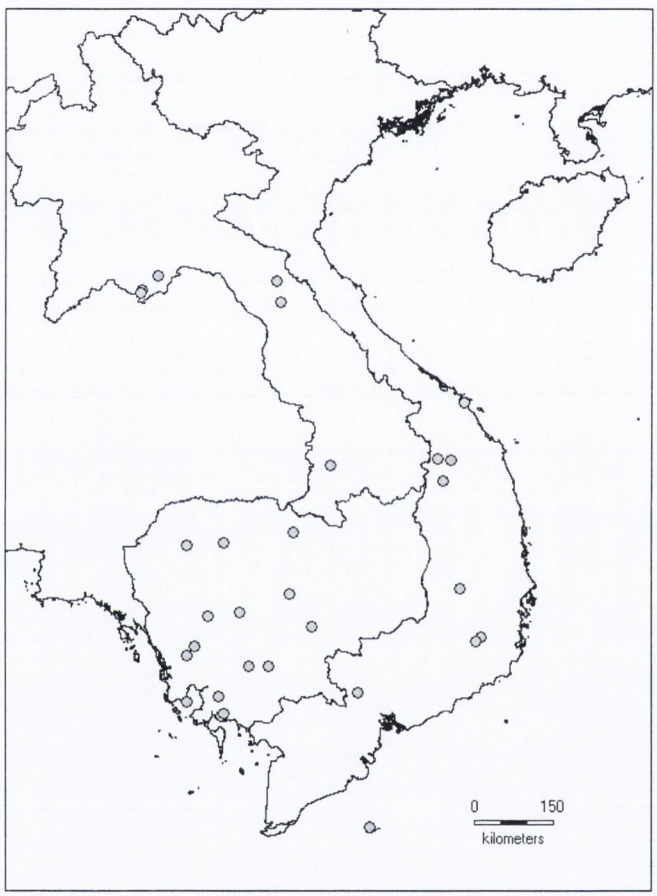
SPECIMENS EXAMINED.

CAMBODIA. loc. sin. Aubriville 29; loc. sin., *Collard 54* (**P**); loc. sin., *Guinet 108* (**P**) – Kampong Chhnang: Kralanh forest reserve, 12 February 1918, *Chevalier 36889* (**P**); Kralanh forest reserve, 12 February 1918, *Chevalier 36974* (**P**); 13 March 1914, *Chevalier 31945* (**P**) – Kampong Speu: Samroang Tong, Phnum Chreav [Mt. Cherev], April 1870, *Pierre 979* (**P**) – Kampong Spoe: Kirirom, 27 February 1966, *Dy Phon 95* (**P**) – Kampong Thum: *ecomte, H. Finet s.n.* (**P**) – Kampot: 26 March 1904, *Geoffray 372* (**P**); 24 February 1896, *Hanh s.n.* (**P**); Mt. Bokor, 20 December 1965, *Vidal 4773* (**P**); Mt. Bokor, 20 February 1960, *T.Smitinand & E.C.Abbe 6489* (**K**); Mt. Bokor, 4 February 1999, *Bansok 26* (**K**); Mt. Bokor, 10 March 2001, *D.Middleton & M.Monyrak 669* (**A**, **P**); Mt. Bokor, Popok Vil waterfall, 17 March 1970, *Stone, B.C. 9216* (**P**); Phnom Kamchay, 8 February 1896, *Hanh 97* (**P**) – Kandal: Phnom Penh, June 1909, *d'Alleizette s.n.* (**L**) – Koh Kong: Che Ko, 24 February 1965, *T.Kira, K.Hozumi, K.Yoda & S.Kokawa 952* (**BKF**); Thma Bang, 3 May 2000, *K.Eanghourt 64* (**K**) – Preah Vihear: Mlu Prey, January 1876, *Pierre 3195* (*Harmand 252)* (**P**); – Pursat: 26 February 1960, *T.Smithinand L.B., E.C. Abbe & B.Rollet 9662* (**K**); Kol Totung, July 1965, *M.A.Martin 164* (**P**) – Siem Reap: June 1909, *d'Alleizette s.n.* (**L**); Kralanh, Prey Kralanh, 18 April 1909, *Magnen, Gourgand & Chatillion 3* (**P**); Kralanh, Prey Kralanh, *Magnen, Gourgand & Chatillion 2* (**P**).

LAOS. Semoun basin, 1875-1877, *Harmand s.n.* (**K**) – Attapeu: Bolaven plateau [Attopeu plateau], March 1877, *Pierre 3197 (Harman1333)* (**P**) – Bolikhamxai: Khamkeuth, Temple Garden, 2 km southeast of town, 23 April 2000, *D.D.Soejarto, S.Bouamanivong, S.Vorasing & M.Sensavang 11419* (**GH**) – Khammouan: Nakai, 24 May 2006, *K.Nanthavong & C.E.Ridsdale BT 512* (**E**) – Viangchan: Ban Saphang Meuk, 5 February 1950, *Vidal 1169B* (**P**); Pha That Luang, 6 April 1949, *Vidal 1107B* (**P**); Phou Khaokhoay, 29 October 1971, *Vidal 5626* (**P**) – between Ubon and Kemmarath: 1866-1868, *Thorel s.n.* (**BM**, **P**).

VIETNAM. Ho Chi Minh-Cay Cong, April 1866, *Pierre 6253* (**P**) – Annam: *Pierre s.n.* (**P**) – Cochinchina: 1862-1866, *Thorel s.n.* (**K**); *Pierre s.n.* (**BM**, **P**); Thuoc Thau?, 1862-1866, *Thorel s.n.* (**K**) – Da Nang: Tourane and vicinity, May 1927, *J. & M.S. Clemens 3778* (A, **BM**); Tourane and vicinity, May 1927, *J. & M.S. Clemens 4215* (**A**, **K**); Tourane and vicinity, 5-9 September 1927, *J. & M.S. Clemens 4490* (**P**) – Dac Lak: 11 March 1953, *Schmid s.n.* (**P**) – Dac lak: Ban Trang, *Schmid 1001* (**P**) – Khanh Hoa: Poulo-Condor, *Germain 56* (**P**) – Kon

Tum: Dak Poko river, 20 km from Dak Glei village, 30 March 1995, *Ayeryanov* et al. *VH 1000* (**P**); Dak Glei, 18 March 1978, *Bien 483* (**HN**); Dak To, 4 April 1978, *Phuong 464* (**HN**); Ngoc Linh, NW slope of Mt. Ngoc Linh, 15 April 1995, *Averyanov* et al. *VH 1412* (**P**) – Lam Dong: Dalat, 22 April 1955, *Schmid s.n.* (**P**); Dalat, 29 April 1955, *Schmid s.n.* (**P**) – Quang Tri: *Chevalier 40207 (de Pirey 21)* (**P**); 1919, *Chevalier 41215 (de Pirey 20)* (**P**) – Tay Ninh: Cai Cong, 23 April 1866, *Pierre 106* (**BM**).



Map 4. Distribution of *Syzygium antisepticum* (Blume) Merr. & L.M.Perry. in Cambodia, Laos and Vietnam.

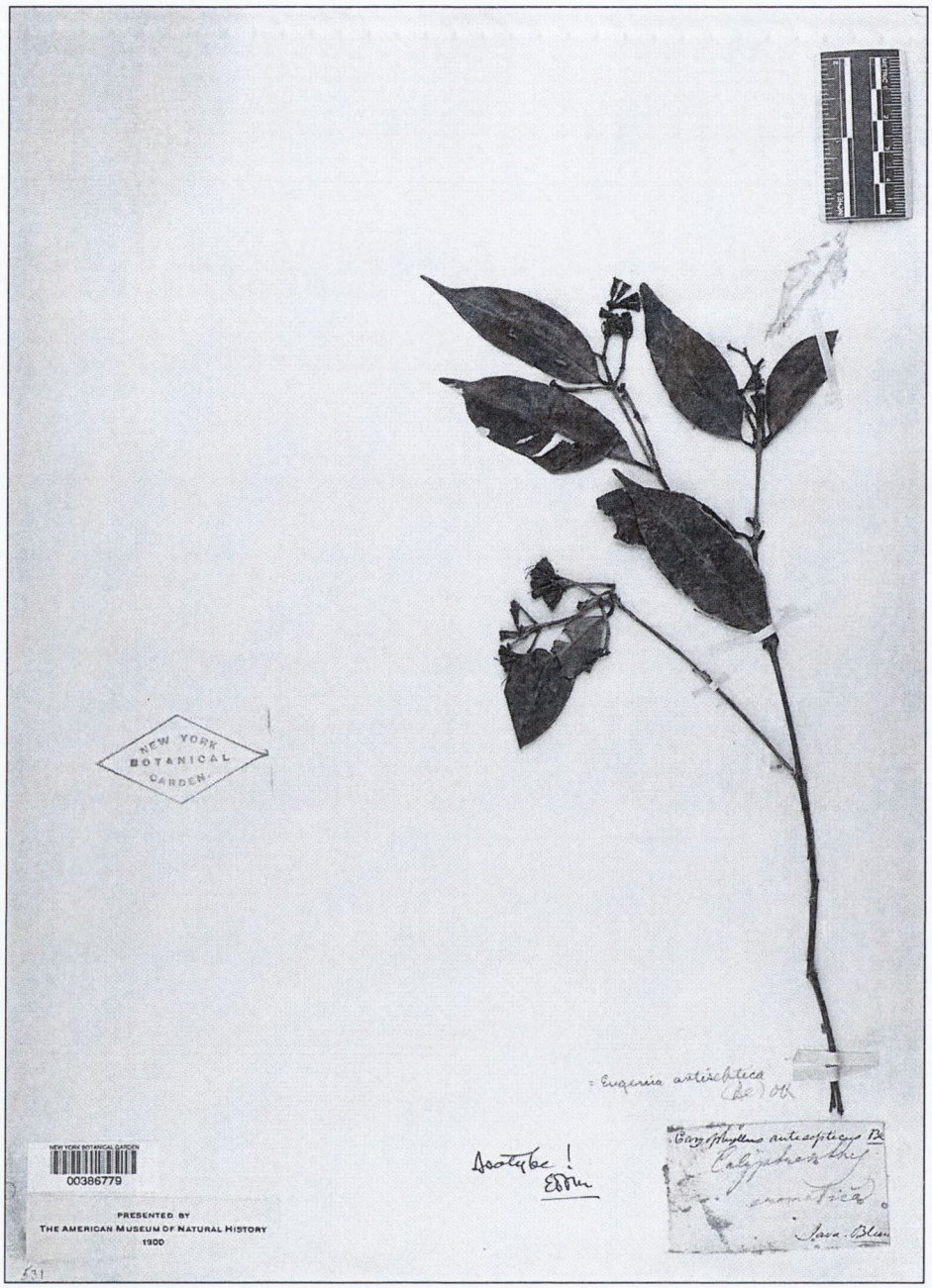


Plate 5.1. Lecotype of *Syzygium antisepticum* (Blume) Merr. & L.M.Perry. Image courtesy of The New York Botanical Garden.



Plate 5.2. Young infructescence of *Syzygium antisepticum* (Blume) Merr. & L.M.Perry. Photo courtesy of Nguyen Van Dung and John Tan.

5. *Syzygium aqueum* (Burm. f.) Alston, Ann. Roy. Bot. Gard., Peradeniya 11: 204 (1929); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 244 (2007) – [*Jambosa aquea* Rumph., Herb. Amboin. 1: 126, t. 38, f. 2, 1741, nom. inval.] – *Eugenia aquea* Burm. f., Fl. Ind.: 114 (1768) – *Jambosa ? aquea* (Burm. f.) DC., Prodr. 3: 288 (1828) – *Malidra aquea* (Burm. f.) Raf., Sylva Tellur.: 107 (1838) – *Cerocarpus aqueus* (Burm. f..) Hassk., Flora 25, Beibl.: 36 (1842). **Type**: Icon, Ambon. Rumphius Herb. Amboin. 1: t. 38, f. 2, 1741 – Epitype: Ambon. *Robinson Pl. Rumph. Amboin. 192* (**US** n.v.; duplicates in **A** n.v., **BM** n.v., **BO**

n.v., **F** n.v., **K** n.v., **L**!, **MO** n.v., **NSW** n.v., **N.Y** n.v.), suggested by Merrill (1917b), designated by N. Snow & J.F. Veldkamp, Blumea XX: XX (2010).

– *Eugenia javanica* Lam., Encycl. 3: 200 (1789) – *Jambosa javanica* (Lam.) Lam. ex K. Schum. & Lauterb., Fl. Deutsch. Schutzgeb. Sudsee: 470 (1900) – *Myrtus javanica* (Lam.) Spreng., Syst. Veg. 2: 484 (1825); Blume, Bijdr.: 1084 (1826) – *Syzygium javanicum* (Lam.) Miq. ex Masam., Enum. Phan. Born.: 530 (1942), non *Syzygium javanicum* Miq. (1855) – **Type:** Java, *Commerson s.n.* (holotype **P-LA**! [barcode P00297990]).

– *Eugenia obversa* Miq., Anal. Bot. Ind. 1: 18 (1850). *Syzygium obversum* (Miq.) Masam., Enum. Phan. Born.: 535 (1942). **Type**: Borneo, *Korthal s.n.* (holotype **L**! [barcode L0329634])

– *Jambosa madagascariensis* Blume, Mus. Bot. 1: 103 (1850). **Type**: Madagascar, *Chapelier s.n.* (holotype **L**! [sheet no. 898203-25]; isotype **P** n.v.)

Tree to 5 m tall. Bark smooth, pale brownish. Glabrous on all parts. **Twig** terete, 2.5 – 4 mm diameter, stout, surface smooth, pale brownish, not contrasting to leaf colour. **Leaves** opposite, 10 – 15 × 5 – 7 cm, 2 times as long as wide, elliptic, oblong-elliptic to ovate, base cordate, c. 35-45 degrees from midrib, margin flat, acute, broadly acute or obtuse, blade chartaceous, brownish to greenish; midrib sunken above, raised below; secondary veins (Type A.III or B) 10 – 12 per side per blade, broadly distanced, 10 – 20 mm apart, c. 45 degrees ascending from midrib, prominent and raised above, prominent below, sometimes a pairs of basal secondary veins (acrodromous veins) arcuate and extending to form outer intramarginal veins; tertiaries prominent, reticulate; inner intramarginal 3 – 6 mm from leaf margin, straightly or slightly looped, outer intramarginal veins prominent; leaf blade subsessile, petiole 0.1 – 0.2 cm, 1/75 – 1/100 of blade length, 1.5 – 2 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary on leafy twig or axil of fallen leaves, to 6 cm long, racemose, flowers few, 3 to 7; axes to 5 cm, terete to subangular; bract and bracteoles caducous. **Flower** whitish to yellowish, big, pedicellate, pedicel 1 – 2 cm, hypanthium greenish (in vivo), not glacous, not fibrous, 10 – 22 × 10 – 15 mm, pyriform, apex tapering abruptly into distinct pseudostalk, c. 5 mm; sepals greenish, 4, free, semiorbicular, 2.5 – 3 × 3 – 4 mm; petals 4, free, ovate to orbicular, 5 – 6 × 5 – 7 mm; outer stamens 12 – 13 mm, anthers, c. 1.5 – 2 mm,

sacs parallel, connective gland conspicuous; style c. 15 – 16 mm, ovules c. 30 per locule, irregularly radiating. **Fruit** turbinate, top flattened, pinkish to reddish, 4 – 5 × 3 – 4 cm, surface smooth, shiny, calyx ring with inflexed, fleshy sepal lobes; seed 1 to 2, subglobose, c. 1 – 1.5 × 1 – 1.5 cm, cotyledons free, intercotyledonary intrusion absent.

(The description here is based on herbarium specimens and field observations)

DISTRIBUTION: Widely cultivated in the tropics, including Cambodia, Laos and Vietnam. Possibly native to Malesia.

ECOLOGY OR HABITAT. Cultivated at lowland.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

VERNACULAR NAME(S). Water apple (general).

USES. Fruit edible.

NOTES.

1. *Syzygium samarangense* and *S. aqueum* are widely cultivated species in the tropics ranging from India through Southeast Asia to the Pacific Islands. In the field both species are distinct and easily recognised, with *S. aqueum* having almost sessile leaves and a cordate leaf base, the flower is smaller and the hypanthium and fruit are abruptly constricted at the pseudostalk. In *S. samarangense*, the leaves are petiolate, the base is rounded or slightly cordate, the flower is larger, the hypanthium broader and gradually constricting to the pseudostalk and the fruit is pyriform to subglobose. In the dried state, these characters are difficult to see. This is further complicated by some overlapping characters between the two species. In addition to this, the fleshy and watery fruit, being the most striking character in distinguishing the two species, do not preserve well in herbarium. Lamark (1789) hesitantly associated *Eugenia javanica* with *Jambosa aquea* Rumph. and hence many authors had interpreted and used the name in part 'pro parte'. However, Blume (1926), who was the first to describe *S. samarangense*, considered *Myrtus javanica* (= *E. javanica*) and *Jambosa aquea* as conspecific but different from *S. samarangense*. The name *Eugenia javanica* Lam had been associated by some authors with specimens belonging to *S. samarangense* but the type (*Commerson s.n.*) which I have examined, belongs to *S. aqueum*. Due to the confusion and complexity of this

problem, I have presented here floristic references pertaining to Indochina and not from other regions. In general there is an agreement among botanists that *S. samarangense* and *S. aqueum* are two distinct species but the problem is the misapplied name of *E. javanica* Lam. In herbarium collections, many specimens are misidentified under the names *S. aqueum* and *S. samarangense*.

2. After having seen the type specimens, the following names, which are included as the synonyms for *S. aqueum* in the *World Checklist of Myrtaceae* (Govaerts et. al., 2010) were omitted here and transferred to *S. samarangense*: *Eugenia alba* Roxb., *Eugenia mindanaensis* C.B.Rob, *Jambosa ambigua* Blume, *Myrtus obtusissima* Blume = *Jambosa obtusissima* (Blume) DC., *Myrtus timorensis* Zipp. ex Span. = *Jambosa timorensis* (Zipp. ex Span.) Blume. The status of the following *S. aqueum* synonyms cannot be confirmed because their types were not found in **L** or **U**: *Gelpkea stipularis* Blume = *Eugenia stipularis* (Blume) Miq. and *Jambosa calophylla* Miq. = *Eugenia callophylla* (miq.) Reinw. ex de Vriese.

SPECIMENS EXAMINED.

CAMBODIA. Phnom Penh, June 1909, *d'Alleizette s.n.* (**L**).

VIETNAM. Hanoi City: 25 May 1886, *Balansa 2866* (**P**).



Plate 5.3. Icon of *Syzygium aqueum* (Burm. f.) Alston from Rumphius' *Herbarium amboinense* (1741) showing the flowers and fruits on *Fig. 2*. Image courtesy Missouri Bortanical Garden - Botanicus Digital Library.



Plate 5.4. Holotype of *Eugenia javanica* Lam. Image courtesy of Pietro Corsi.

6. *Syzygium araiocladum* Merr. & L. M. Perry, J. Arnold Arbor. 19: 225 (1938); J. Chen & Craven, Fl. China 13: 356 (2007). **Type**: China, Kwangsi, Shap Man Taai Shan, near Hoh Lung Village, Shang-sze District, June 1933, *W.T.Tsang 22482* (lectotype **BM**! here designated; isolectotype **A** n.v. [barcode 711302]).

Shrub to 3 m tall. Glabrous on all parts. **Twig** angular and winged when young, terete when old, 0.5 – 1 mm diameter, slender, surface smooth, brownish, contrasting or not to leaf colour. **Leaves** opposite, 3 – 5 × 0.8 – 1.7 cm, 3 times as long as wide, elliptic, ovate , base cuneate, c. 45 degrees from midrib, margin flat, apex acuminate, acumen prominent, 1 – 2 cm, 1/4 – 1/3 times of blade length, chartaceous, silky below, yellowish brown; midrib sunken above, raised below; secondary veins (Type A.II) slender, c. 12 per side per blade, broadly spaced, 1 – 2 mm apart, c. 60 degrees ascending from midrib, faint on both surfaces; tertiaries faint, reticulate; inner intramarginal veins 0.5 – 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.2 – 0.3 cm, 1/15 – 1/25 of blade length, c. 0.5 mm diameter, slender, blackish, contrasting to blade colour. **Inflorescence** terminal and axillary near leafy twig apex, 2 – 2.5 cm long, racemose, flowers few, 2 to 4; axes c. 1 cm, angular, slender; bract and bracteoles caducous. **Flower** whitish, sessile, hypanthium corrugated, glaucous, not fibrous, c. 10 × *2.5 mm*, clavate, pseudostalk distinct, c. 4 mm; sepals 4 – 5, free, c. 0.5 × 1 mm, triangular; petals 4 – 5, coherent, 2 × 2 mm, orbicular; outer stamens c. 0.5 cm, anthers c. 0.4 mm, sacs parallel, connective gland conspicuous; style c. 5 mm, ovules 10 to 12 per locule, in 2 longitudinal rows. **Fruit** (immature) globose, 0.5 × 0.5 cm, surface smooth, calyx ring with persistent sepal lobes; seed subglobose, 0.4 × 0.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: South China (Guangxi and Hainan) and North Vietnam (Quang Ninh).

ECOLOGY OR HABITAT. In primary forest, to 270 m altitude.

CONSERVATION STATUS. IUCN Global Status: Data Deficient (DD); IUCN Regional (Indochina) Status: Data Deficient (DD)

PHENOLOGY. Flowering: May - September. Fruiting: February.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

NOTES.

1. *Syzygium araiocladum* belongs to the subg. *Sequestratum* because of its glaucous clavate hypanthium (see table 5.1). *S. araiocladum* is vegetatively similar to *S. jasminifolium* in Thailand and Peninsular Malaysia, but differs in the

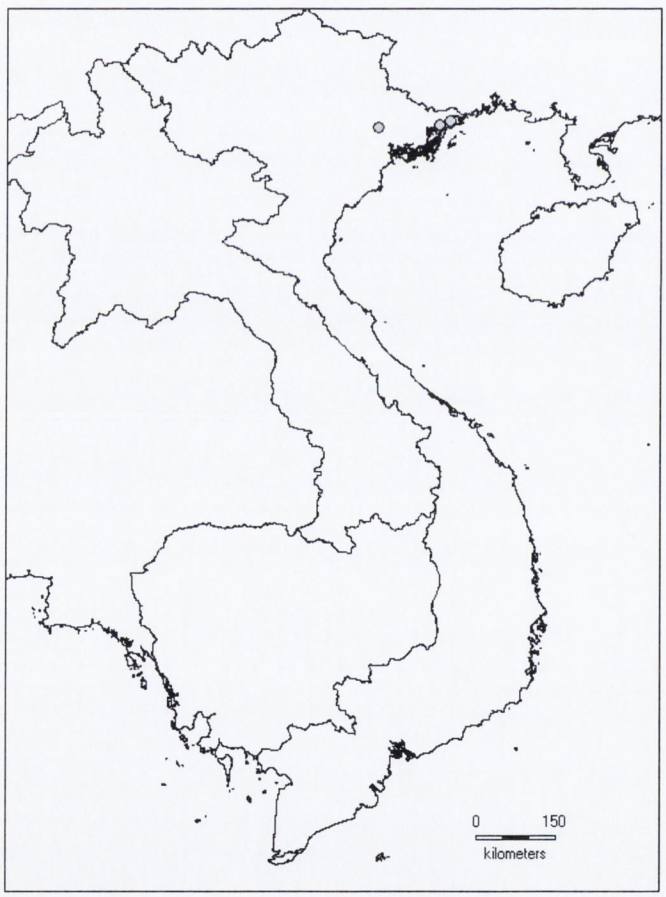
inflorescence type, which is not clustered and with caducous bract in *S. araiocladum* but clustered with persistent bracts in *S. jasminifolium*.

SPECIMENS EXAMINED.

VIETNAM. Quang Ninh: Dam Ha, Sai Vong Mo Leng, July-September 1940, *W.T.Tsang 30349* (**E**, **K**, **P**); Dong Bong, 12 February 1977, *V.N.Trinh 51* (**VFU**); Ha Coi, Tsai Wong Mo Shan and vicinity, 3 May – 22 June 1939, *W.T.Tsang 29081* (**A**, **E**, **K**, **P**).

ADDITIONAL SPECIMENS EXAMINED.

CHINA. Guangxi: Shang-sze district, Shap Man Taai Shan, near Hoh Lung Village, June 1933, *W.T.Tsang 22482* (**BM**), *W.T.Tsang 22559* (**BM**).



Map 5. Distribution of *Syzygium araiocladum* Merrill & L. M. Perry. in Cambodia, Laos and Vietnam.

7. *Syzygium aromaticum* (L.) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 196 (1939); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 45, fig. 3720 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 38 (1994); P.Dy Phon, Plants used in Cambodia: 376 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 832, fig. 10 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 900 (2003); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 244 (2007). **Type**. Lectotype *Herb. Clifford: 207, Caryophyllus 1* ! [barcode BM000628747] designated by McVaugh in Howard, Fl. Lesser Antilles 5: 528 (1989). (For synonyms see Goveart et. al., 2010)

Tree to 20 m tall. Glabrous on all parts. **Twig** terete, c. 2 mm diameter, stout, surface smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 8 – 12 × 3.5 – 5 cm, 2 to 3 times as long as wide, lanceolate or obovate, base strongly attenuate, c. 25 degrees from midrib, margin flat, apex acute, blunt, acumen absent, blade subcoriaceous, pale greenish; midrib sunken above, raised below; secondary veins (Type A.I) 20 – 30 per side per blade, narrowly spaced, 2 – 3 mm apart, 60 – 70 degrees from midrib, faint and raised above, prominent below; tertiaries faint, reticulate; inner intramarginal veins 1 – 1.5 mm from leaf margin, straight, outer intramarginal veins absent or faint; petiole, 1.5 – 2.5 cm, 1/5 – 1/6 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal, 3 – 5 cm long, paniculate, first order branching, flowers few, c. 15, not compact; axes 2.5–3 mm long, subangular; bracts and bracteoles caducous, 2 – 3 mm long, triangular. **Flower** pale yellowish (in vivo), pedicellate, pedicel thick, stout, 3 – 7 mm long, hypanthium not glacous, not fibrous, 11–12 × 3 mm, clavate, pseudostalk distinct; sepals 4, free, 3.5 – 4 × 3 – 3.5, ovate; petals 4, free, 7–8.5 × 7×8 mm, orbicular; outer stamens 7 – 7.5 mm long; anther c. 0.5 mm, sac paralle, connective gland inconspicuous; style c. 4 mm, ovules c. 16 per locule, arrange in two longitudinal rows. **Fruit** reddish, 2 – 2.5 cm, obovoid, calyx ring with undulating rim; seed 1, intercotyledonary intrusion absent.

(Due to paucity of collection from Indochina, the description presented here is also based on P.Chantaranothai & J.Parn., Fl. Thailand 7: 832 (2002))

DISTRIBUTION: Native to Moluccas Is. but widely cultivated in the tropics for clove production. Introduced and cultivated in Indochina.

ECOLOGY OR HABITAT. Cultivated, to 900 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

VERNACULAR NAME(S). Cambodia: Khan phluu, Khlam puu. Laos: Dok chan, Kanz phu. Vietnam: Dinh huong.

USES. The flower bud which is the clove is used for cooking. In addition to this, the flower together with other parts of the plants such as fruit, flower stalk and leaves are used to produce clove oil. (for detail on usage see de Guzman & Siemonsma, 1999).

SPECIMEN EXAMINED.

VIETNAM. Dong Nai, Bien Hoa, July 1909, *D'Alleizette s.n.* (**L**).

8. *Syzygium attenuatum* (Miq.) Merr. & L.M.Perry, in Mem. Amer. Acad. Arts 18: 185 (1939); Airy Shaw, Bull. Misc. Inform. Kew 1949: 121 (1949); Merr., Philipp. J. Sci. 79: 376 (1950); Backer & Bakh.f., Fl. Java 1; 338 (1963); T.G. Hartley & L.M.Perry. J. Arnold Arbor. 54: 100 (1973); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 39 (1994); I.M.Turner, Gard. Bull. Singapore 47: 371 (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: 834 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003) – *Jambosa attenuata* Miq. Fl. Ind. Bat. 1: 437 (1885) – *Eugenia attenuata* (Miq.) Koord. & Valeton, Meded. Lds. PlTuin. 40: 121 (1900); Ridl., in J. Bot. 68: 33 (1930); M.R. Henderson, Gard. Bull. Singapore 12: 238, fig. 45a (1949); Kochummen in Ng, Tree Fl. Mal. 3: 183 (1978) – [*Syzygium attenuatum* (Miq.) Masam. Enum. Phan. Born.: 523 (1942), nom. illeg.]. **Type**: Indonesia, W. Java, Uangaram, *Junghun s.n.*, (holotype **L**! [barcode U0005205]).

– *Eugenia penangiana* Duthie in Hook.f., Fl. Brit. Ind. 2: 486 (1878); Corner, Ways. Trees. 1: 501 (1940). **Type**: Malaysia, Penang, Government Hill, *Maingay 744* (holotype **K**!).

– *Eugenia purpuricarpa* Elmer, Leafl. Philipp. Bot. 4: 1435 (1912). **Type**: Philippines, Palawan, Puerto Princesa (Mt. Pulgar), March 1911, *Elmer 12818* (holotype **PNH**†; isotype **A** n.v. [barcode 69768 & 69769], **K**!, **BM**!).

– *Eugenia attenuata* var. *montana* M.R. Henderson, Gard. Bull. Singapore 12: 242 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 183 (1978) – *Syzygium attenuatum var. montanum* (M.R. Henderson) P.Chantaranothai & J. Parn., Kew Bull. 48: 593 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 40 (1994); I.M.Turner, Gard. Bull. Singapore 47: 371 (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: 835 (2002). **Type**: Peninsular Malaysia, Pahang, Cameron Highlands, *Henderson SFN 23559*, (holotype **SING!**; isotype **K**!).

– *Eugenia attenuata* var. *ophirensis* M.R. Hend. (1949: 241); Kochummen in Ng, Tree Fl. Mal. 3: 183 (1978). *Syzygium attenuatum* var. *ophirense* (M.R.Hend.); I.M.Turner, Gard. Bull. Singapore 47: 371 (1995). **Type**: Peninsular Malaysia, Johor, Mt. Ophir, *Ridley 3298* (holotype **SING!**; isotype **K**!).

– *Eugenia circumscissa* Gagnep. in Lecomte, Notul. Syst. (Paris) 3: 321 (1918), in Fl. Gén. Indo – Chine 2: 841 (1920); Craib, Fl. Siam. Enum. 1: 635 (1931) – *Cleistocalyx circumscissa* (Gagnep.) P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 63, fig. 3774 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 892 (2003) – *Syzygium attenuatum* subsp. *circumscissum* (Gagnep.) P.Chantaranothai & J.Parn., Kew Bull. 48: 593 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 41 (1994); I.M.Turner, Gard. Bull. Singapore 47:372 (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: 835 (2002) – [*Syzygium circumscissum* (Gagnep.) Craven et al., Blumea 51: 136 (2006), sphalm.]. **Type**: Vietnam, Bien Hoa, Chiao-xham, *Herb. Pierre 6279*, (lectotype **P**! [barcode P00589289] designated by P.Chantaranothai & J.Parn. op. cit. (1993: 593); isolectotype **K**! [barcode K000276203])

– *Eugenia rhamphiphylla* Craib Bull. Misc. Inform. Kew 1930: 168 (1930), in Fl. Siam. Enum. 1: 635 (1931); M.R. Henderson, Gard. Bull. Singapore 12: 242 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 214 (1978) – *Syzygium rhamphiphyllum* (Craib) C.E.C. Fisch., Bull. Misc. Inform. Kew 1937: 438 (1937). **Type**: Thailand, Satul, Klawng Ton, 10 March 1928, *Kerr 14444* (lectotype **BK**! designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 41 (1994): isolectotypes **ABD** n.v., **BM**!, **K**!).

– *Eugenia barringtonii* Hole ex Chalk & Chattaway, Trop. Woods 41: 24 (1935), nom. nud; C.E.C. Fisch., Bull. Misc. Inform. Kew 1937: 438 (1937) [as syn. of *S. rhamphiphyllum*]. (fide P.Chantaranothai & J.Parn. Thai Forest Bull. (Bot.) 21: 41 (1994))

Tree to 15 m tall. Glabrous on all parts. **Twig** terete, c. 2 mm diameter, slender, surface smooth, pale brownish, contrasting to leaf colour. **Leaves** opposite, 4 – 7 × 1.7 – 2.5 cm, 2.5 to 3 times as long as wide, elliptic, base strongly attenuate , c. 20 degrees from midrib, margin flat, apex, acuminate, acumen c. 0.5 cm, distinct, 1/8 – 1/10 of blade length, blade chartaceous to subcoriaceous, pale brownish to yellowish; midrib sunken above, raised below; secondary veins (Type A.I) 20 – 30 per side per blade, 1 – 2 mm apart, 45 – 50 degrees from midrib, prominent and raised on both leaf surfaces prominent; tertiaries faint, reticulate; inner intramarginal veins c. 0.5 mm from leaf margin, straight, outer secondary intramarginal faint; petiole 0.5 – 0.8 cm, 1/8 – 1/10 of blade length, diameter c. 0.5 mm, slender, pale brownish, not contrasting to blade colour. **Inflorescence** terminal or near apex of leafy twig, 4 – 4.5 cm long, paniculate, to first order branching, flowers 9 to 15; axes 2.5 – 3 cm long, angular; bract and bracteoles caducous. **Flowers** sessile, hypanthium not glaucous, not fibrous, 8 – 15 × 4 – 5 mm, clavate, flower bud globose at apex, narrowing into long distinct pseudostalk, 10 – 13 mm long; sepals 4, free, 0.4 × 0.6 mm, triangular; petals 4, coherent, 2 × 2 mm, orbicular; outer stamens to 1.5 mm long, anthers 0.45 mm, sacs parallel, connective gland inconspicuous; style 1 – 1.5, stout and thick, locules 2 to 3, ovules 10 to 12 per locule, in two longitudinal row. **Fruit** obloid – obovoid, 7 – 8 × 4 – 6 mm, surface smooth, calyx ring with smooth rim; seed 1, ovoid, cotyledons free, intercotyledonary intrusion absent.

(Due to the paucity of collections from Indochina, the description presented here is also based on specimens from Thailand)

DISTRIBUTION: Widespread from Southeast Asia to New Guinea. Recorded in Myanmar, Thailand, Vietnam, Philippines, Peninsular Malaysia, Borneo, Jawa and New Guinea.

ECOLOGY OR HABITAT. Primary lowland to montane forest, to 1,100 m (in Thailand)

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Not documented.

VERNACULAR NAME(S). Vietnam: Tram o, Tram voi o.

USES. Not documented.

NOTES.

1. This species is widespread and highly variable in its hypanthium size, leaf size and venation. In Indochina and Thailand the subsp. *circumscissum* (Gagnep.) P.Chantaranothai & J.Parn. is recognised and differs from the typical form in having a longer hypanthium cup (> 10 mm long). However, I have observed variability in the length of the hypanthium cup and I have not seen any disjunct pattern in this character for this species. For Indochina, there is only one collection. For this reason and the above mentioned, I am hesitant to recognise the subsp. *circumscissum* (Gagnep.) P.Chantaranothai & J.Parn..

SPECIMENS EXAMINED.

VIETNAM. Bien Hoa, Chiao-xham, *Herb. Pierre 6279* (**K**, **P**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND. Chanthaburi: Kao Petchakut, April 1925, *Noe 88*; Nakhon Si Thammarat: Khao Luang, *Ploenchit 291* (**BKF**); Ranong: Kao Talu, February 1927, *Kerr 11785* (**BKF**); Satun: Adang, 12 January 1938, *Kerr 14014* (**BKF**); Khuan Kalong, 11 February 1961, *T.Smitinand 7168* (**BKF**).Trang: Khao Chong, 2 May 1969, *S.Phusomsaeng 245* (**BKF**).



Map 6. Distribution map of *Syzygium attenuatum* (Miq.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

9. *Syzygium attopeuense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor 19: 107 (1938); P.H.Hô, Fl. Ill. Viêtnam (Cây co Viêtnam) 2: 46, fig. 3723 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 901 (2003); M.F.Newman et al., Checkl. Vas. Pl. Laos: 244 (2007) – *Eugenia attopeuensis* Gagnep. Not. Syst. 3: 322 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 816 (1920). **Type**: Laos , plateau of Attopeu, river Semoun, March 1877, *Harmand 1172* in *Pierre 3290* (lectotype **P**! [barcode P00589301; Delpy's drawing dated Jan. 1900 attached] here designated; isolectotypes **P**! [4 sheets: barcodes P00589302 & P00589303; two others without barcodes – one sheet with label from Herb. Mus. Paris indicating Dr. Harmand expedition at Bassin d'Attopeu, the other sheet with ticket bearing Dr. Harmand's signature and handwriting '200-500 m altitude').

Shrub or tree 3 – 8 m tall, to 45 cm dbh. Glabrous on all parts. **Twig** subangular, 2 – 2.5 mm diameter, slender, surface smooth, whitish, contrasting to leaf colour. **Leaves** subopposite, sometimes verticillate in whorls of three, 5 – 11.5(– 17) × 1 – 2 cm, 5 to 8 times as long as wide, usually lanceolate, sometimes oblong-elliptic, base strongly attenuate, c. 10 degrees from midrib, margin recurved, apex acute or rounded with no distinct acumen, blade subcoriaceous, pale brownish; midrib sunken above, raised below; secondary veins (Type A.II) 15 – 20 per side per blade, narrowly or broadly spaced, 2 – 4 mm apart, accending steeply to 35 degrees from midrib, slender, faint and sunken above, prominent and raised below; tertiaries faint, reticulate; iiner intramarginal c. 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole c. 0.5 cm, 1/10 – 1/15 of blade length, 1 – 1.5 mm diameter, slender, dark brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, 7 – 17 cm long, paniculate, third order branching, spreading, flowers many, 45 to 153; axes 8 – 15 cm, angular; bract and bracteoles persistent, triangular, bract 0.5 × 0.5 mm, bracteoles 0.3 × 0.3 mm. **Flower** small, sessile, hypanthium not glacous, not fibrous, 2 – 3 × 1 – 1.5 mm, obconic, pseudostalk indistinct, to 1 mm if present; sepals 4, free, 0.3 × 1 mm, semiorbicular; petals 4, coherent, 2 × 2 mm, orbicular; outer stamens c. 1.5 mm, anthers, c. 0.8 mm, sacs parallel, connective gland conspicuous; style c. 1.5 mm, ovules 9 – 12 per locule, irregularly radiating. **Fruit** depressed globose, 0.6 × 0.75 cm, surface smooth, calyx ring with undulating rim; seed 1, globose, 0.4 × 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Thailand, Laos and Vietnam.

ECOLOGY OR HABITAT. Secondary or primary forest, along rivers on rocky terrain, 300 to 1500 m altitude.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Vulnerable (VU B1ab(i, iii)).

PHENOLOGY. Flowering: January, March, April, October, November, December. Fruiting: April.

VERNACULAR NAME(S): Laos: Khai Noun, Mak Va Nam (Viangchan), Va Nam (Viangchan). Vietnam: Jomau ia (Gia Lai), Riri la-lon.

USES. Fruit edible and soaking of roots is used as medicine.

NOTES.

1. This is a new record for Thailand and Vietnam which was previously only known from laos. In having lanceolate leaves, subangular twig, and being constantly recorded along rivers, this is possibly a rheophytic or riparian rheophytic shrub.

2. Gagnepain (1917) made reference to the *Harmand 1172* collection, which therefore should be the type. However there are five potential type sheets at **P** from the same gathering and lecotypification is required here. Although the labels vary slightly, I believe that all the five sheets came from the same gathering because the specimens are very consistent in morphology and developmental stage.

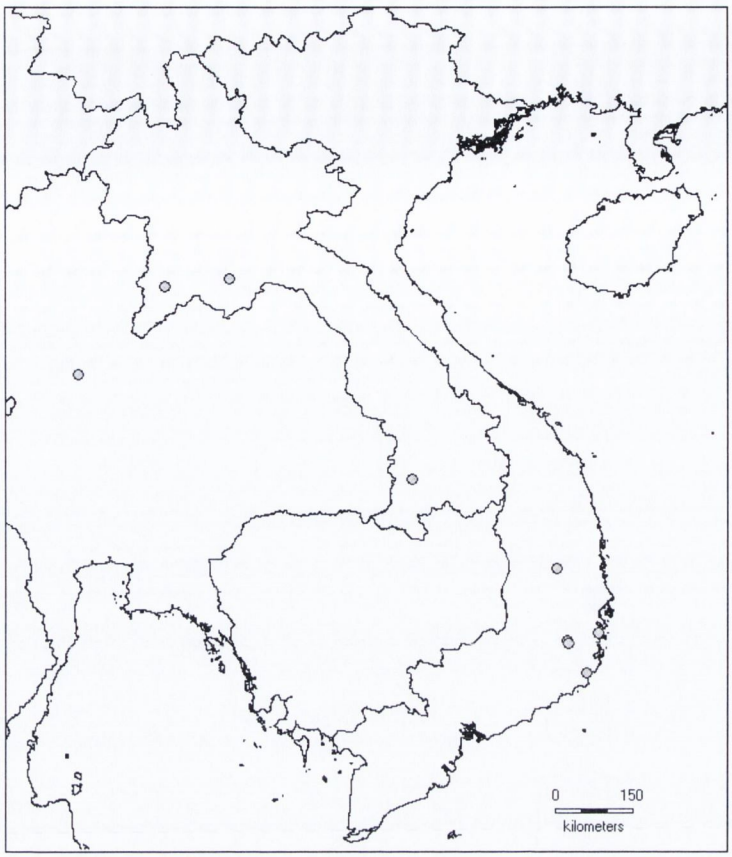
SPECIMENS EXAMINED.

LAOS. Attapeu basin, March 1877, *Harmand 1172* (**P**) – Viangchan: Nam Ngum reservoir, 19 October 1974, *Vidal 5959* (**P**) – Xaignabouli: Nam Phoun, January 1953, *Vidal 2102* (**P**).

VIETNAM. 1922 , *Anon. s.n.* (**P**) – Gia Lai: Cheo Reo, March, *Schmid s.n.* (**P**) – Lam Dong: Bi Doup, Mt. Bi Doup, 20 April 1997, *Averyanov, N.Q.Binh & N.T.Hiep VH 4118* (**HN**); Bi Doup, Mt. Bi Doup, 16 April 1997, *Averyanov, N.Q.Binh & N.T.Hiep VH 4003* (**HN**) – Ninh Thuan: Ninh Hai, Vinh Hai, 20 March 2003, *Anon. QB 267* (**HN**); Phan Rang, 19 April 1982, *Rejmanek s.n.* (**P**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND. Phitsanulok: Tung Salaeng Luang NP, *S.Phengnaren 95* (**BKF**, **L**); 12 December 1965 , *M.Tagawa & N.Fukuoka 2121* (**BKF**, **L**); *Vidal 4558* (**P**).



Map 7. Distribution of *Syzygium attopeuense* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos, Thailand and Vietnam.


H. F. N° 3290
Eugenia (Syzygium)
Hab. ad flum. Se mun prope Attopeu. Cochinch. Coll. Dr Harmand 3/77.
fl. 38-40
fruit
fruit
fruit



Plate 5.6. Lectotype of *Syzygium attopeuense* (Gagnep.) Merr. & L.M.Perry

10. *Syzygium balsameum* Walp., Repert. Bot. Syst. 2: 179 (1843); D.G. Long & Rae in Grierson & D.G. Long, Fl. Bhutan 2: 285 (1911); Merr. & L.M.Perry, J. Arnold Arbor. 19: 108 (1938); Harid. & R.R.Rao, Forest Fl. Meghalaya: 394 (1985); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 46, fig. 3724 (1992) [as

Syzygium balsamineum (Wight) Walper]; P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 42 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 835 (2002); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 901 (2003) – [*Syzygium balsameum* Wallich, *Wallich Numer. List 3592* (1831) (**K-W**!, **E**!) nom. nud] – *Eugenia* balsamea Wight, Ill. Ind. Bot. 2: 16 (1841); Kurz, J. Asiat. Soc. Bengal 46: 66 (1877); Kurz, Forest Fl. Burma 1: 485 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 499 (1879); Brandis, Ind. Trees: 323 (1906); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 819 (1920); Ridl., Fl. Malay. Penins. 1: 754 (1922); Craib, Fl. Siam. Enum. 1: 633 (1931) – *Syzygium balsameum* Wallich ex A.M. & J.M.Cowan, Trees N. Bengal, 68 (1929), nom. superfl. **Type**: Calcutta Botanical Garden introduced from Sillet, *Anon. s.n.* (possibly *Griffith*), with the annotation '*Syzygium* balsameum Wall. herb. Cat. 3592... H[ortus] B[otanicus] C[alcuttensis], Intr. e Silhet', in *Herb. Hooker* (lectotype **K**! here designated). (fide Noltie (2005: 347)) (see note 1)

– *Eugenia balsamea* var. *angustifolia* Duthie in Hook.f., Fl. Brit. Ind. 2: 499 (1879). **Type**: India, Assam, Mt. Khasia, 2000 ft., *J.D.H. & T.T. 10* in *Herb. Hooker* (holotype **K**!).

– [*Memycylon floribundun* Wallich, *Wall. Numer. List 4113* (1831) (**K-W**!, **BM**!), nom. nud.]

Tree to 6 m tall. Glabrous on all parts. **Twig** terete, 2 – 3 mm diameter, stout, smooth, whitish, contrasting to leaf colour**. Leaves** opposite, 11.5 – 12.5 × 3 – 6 cm, 2 to 3 times as long as wide, elliptic, obovate, base strongly attenuate, c. 20 degrees from midrib, margin flat, apex rounded or obtuse, sometimes mucronate, acumen if present, very short, c. 0.5 cm long, c. 1/25 of blade length, blade chartaceous to subcoriaceous, greenish; midrib sunken above, raised below; secondary veins (Type B) 12 – 15 per side per blade, broadly spaced, 5 – 10 mm apart, ascending 45 degrees from midrib, prominent to faint above, prominent below, 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate and extending to form outer intramarginal veins; tertiaries prominent or faint, reticulate; inner intramarginal veins 1 – 2 mm from margin, looped, outer intramarginal veins prominent; petiole 1 – 1.5 cm, 1/7 – 1/12 of blade length, 1 – 1.5 mm diameter, slender, not contrasting to blade colour**. Inflorescence** lateral-axillary on axil of fallen leaves, 4 – 5 cm long, paniculate, second to third order

branching, flowers many, 30 to 45; axes c. 4 – 5 cm, terete and compressed; bract and bracteoles, persistent, triangular, bract 0.5 × 0.3 mm, bracteoles 0.3 × 0.3 mm. **Flowers** sessile, hypanthium not glaucous, not fibrous, 2.5 – 3 × 2 – 2.5 mm, obconic, flattish, pseudostalk distinct, c. 1 mm; sepals 4, free, 1 × 1 mm, roundish, inconspicuous, undulate on rim, erect; petals 4, whitish (in vivo), coherent, 1.5 × 1.5 mm, orbicular; outer stamens c. 1 mm long, anthers 0.4 mm, sacs parallel, connective gland conspicuous; style c. 1.5 mm long, ovules 4 – 8 per locule, irregular radiating. **Fruit** globose, 0.5 × 0.5 cm, surface smooth, calyx ring with smooth rim; seed 1, globose, 0.48 × 0.48, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION. India, Bangladesh, South China (Yunnan), Myanmar, Thailand, Vietnam and Peninsular Malaysia. Possibly not yet collected in Cambodia and Laos.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: November, January.

VERNACULAR NAME(S). Tram dau (Vietnam).

USES. Not documented.

NOTES.

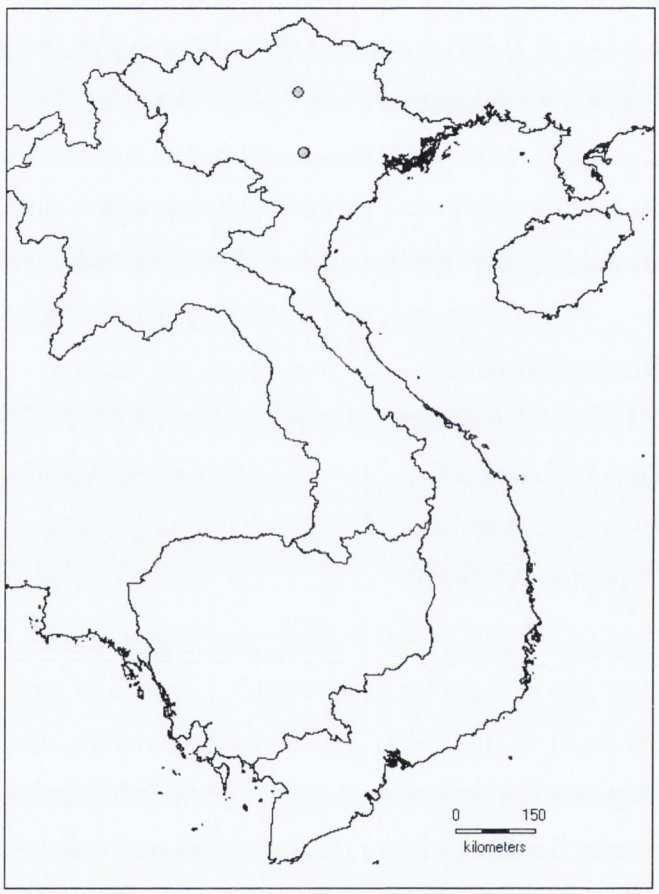
1. Wight (1841) described *Eugenia balsamea* based on the specimen supplied by Wallich from Calcutta Botanic Garden and the Jenkins' specimen collected from Assam. Jenkins' specimens are not in **K**, **E** or **BM**. Therefore Wallich's specimen with the ticket bearing 'HBC intr. e Silhet' and with the stamp herbarium hookerianum is selected as the lectotype. A specimen from Wallich's herbarium (**K-W**) is not selected as the lectotype as these specimens were probably not examined by Wight. (Noltie, 2005).

2. *Syzygium balsameum* is distinctive and is closely related to *S. tetragonum* both morphologically and anatomically. It is similar to *S. tetragonum* morphologically in having a lateral-axillary inflorescence and basal secondary veins that are arcuate instead of connecting to the adjacent veins but differs in having a flattish hypanthial cup. Anatomically, both of these species share the

same midrib vascular system, which is a complex open system. In India, a narrow leaf form was formally recognised as var. *angustifolia* Duthie.

SPECIMENS EXAMINED.

VIETNAM. Ha Tay: Mt. Ba Vi, Muongs village, 26 November 1887, *Balansa 2878* (**K**, **P**); Thu Phap, 22 November 1888, , *Balansa 2896* (**K**, **L**, **P**); Tuyen Quang: January 1931, *Anon. 7* (**P**).



Map 8. Distribution map of *Syzygium balsameum* Walp. in Cambodia, Laos and Vietnam.

11. *Syzygium boisianum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 115 (1938); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 43 (1994); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 47, fig. 3726 (1992);l P.Chantaranothai & J.Parn., Fl. Thailand 7: 836 (2002); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 901 (2003); J. Chen & Craven, Fl. China 13: 347 (2007) − *Eugenia boisiana Gagnep*. Not. Syst. 3: 318 (1917), et in Lecomte, Fl.

Gén. Indo-Chine 2: 840, f. 87 (1921). **Type**: Tonkin [Vietnam], Yen The, around De-tham village, fl., 13 Oct. 1902, *Bois 236* (lectotype **P**! [barcode P00589298] here designated; isolectotype **P**!)

– *Syzygium boisianum* subsp. *longifolium* P.Chantaranothai & J.Parn., Kew Bull. 48: 593 (1993). **Type**: Thailand, Narathiwat, Bukit Pattani, 25 Jan 1931, *Put 3625* (holotype **K**!; isotypes **BM**!, **BK**!).

Shrub to 1.6 m tall. Glabrous on all parts. **Twig** angular (4-angled) and winged when young, terete when old, 2 – 2.5 mm diameter, stout, whitish to greyish brown, contrasting or not to leaf colour. **Leaves** opposite, subsessile, (6 –)8 – 14 × (2.5 –)3 – 5.5 cm, 2 to 3 times as long as wide, elliptic, oblong or ovate, base mostly cordate, sometimes rounded, margin flat, apex mostly acuminate, sometimes acute, acumen usually present, 1 – 2 cm long, 1/6 – 1/8 of blade length, subcoriaceous, pale greenish, midrib sunken above, raised below; secondary veins (A.II) 25 – 30 per side per blade, broadly spaced, 2 – 5 mm apart, spreading, 70 – 80 degrees ascending from midrib, prominent or faint, raised above, prominent and raised below; tertiaries prominent or faint below, reticulate; inner intramarginal veins prominent to 0.5 – 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.05 – 0.1 cm, very short, 1/80 – 1/140 of blade length, c. 1 diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** axillary or terminal on leafy twig. 1.5 – 2.5 cm long, racemose, few flowers , c. 7, fascicle, compact or spreding; axes, 0.2 – 1.5 cm, 4-angled, axes varies from very short to long; bract and bracteoles persistent and elliptic, bract 1 × 0.4 mm, bracteoles 0.6 × 0.2 mm. **Flowers** whitish, sessile, hypanthium not glacuous, fibrous, 1 – 1.5 × 3.5 mm, clavate, pseudostalk distinct, c. 2 cm; sepals 4, not prominent, 0.5 × 2 – 2.5 mm, triangular, erect; petals 6 – 8, coherent, 1.5 × 1.5 mm, orbicular; outer stamens 4 – 6 mm long, anthers 0.5 mm long, sacs parallel, connective gland conspicuous; style 0.8 – 1 cm, ovules 7 – 10 per locule, in two longitudinal row. **Fruit** ellipsoid to obovoid, 1 – 1.3 × 0.5 – 0.7 cm, surface smooth, calyx ring with smooth to undulating rim; seed 1, ellipsoid, 0.5 × 0.6 cm, cotyledons free, intercotyledonary intrusion present, ramifying from the side.

DISTRIBUTION: China (Hainan), Thailand and Vietnam.

ECOLOGY OR HABITAT. In primary or secondary forest.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: February, October, December. Fruiting:March.

VERNACULAR NAME(S): Not documented.

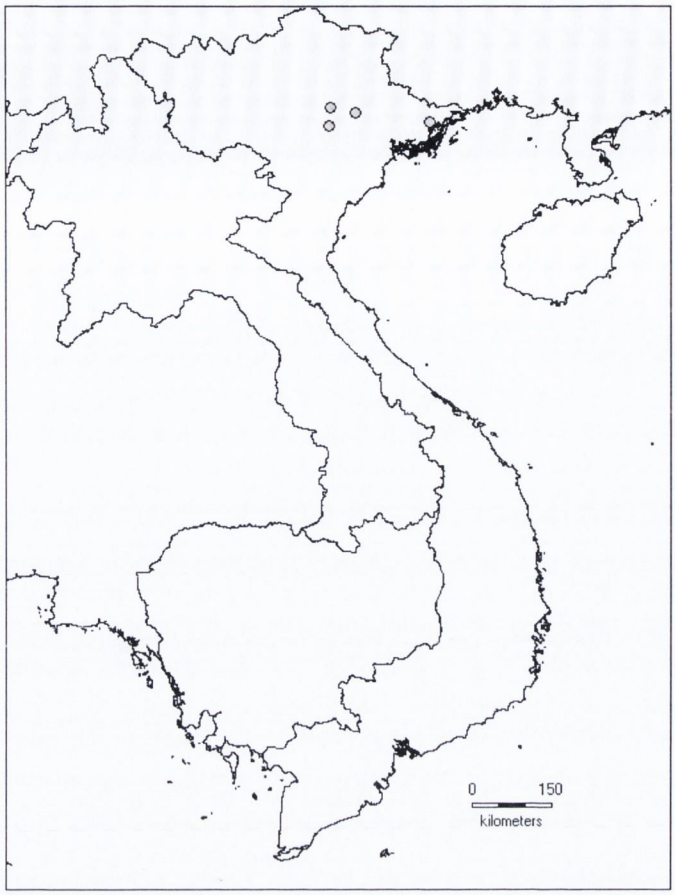
USES. Not documented.

NOTES.

1. The fruit of *S. boisianum* is described here for the first time (*Anon. 32MB-0064*). The discovery of the fruit is important for deciding the affinity of this species in relation to *S. claviflorum*. In having a clavate hypanthium, racemose inflorescence and seed with intercotyledonary intrusion, this species is closely associated with *S. claviflorum* and falls into the subg. *Perikion*. The longer leaf form (subsp. *longiflorum*) is confined to Thailand. Gagnepain (1920) reported 10 petals for this species and he used this character in his species key but in this study, I found six to eight petals. I do not find the number of petal taxonomically useful in sectional or species delimitation because of its variability.

SPECIMENS EXAMINED:

VIETNAM. sin. loc., 6 March 1961, *Anon. 32MB-0064* (**VFU**) – Bac Giang: Yen The, De Tham village, 13 December 1902, *Bois 236* (**P**) – Ha Tay: Huong Canh, 1909, *d'Alleizette 336* (**P**) – Quang Ninh: Tien Yen, Ho Yung Shan and vicinity, October 1940, *W.T.Tsang 30728* (**E**, **K**, **P**); Tien Yen, Kau Nga Shan and vicinity, December 1936, *W.T.Tsang 27341* (**A**, **E**, **K**, **P**) – Thai Nguyen: October 1937, *Petelot 6202* (**A**); Son Bot, December 1937, *Petelot 6218* (**A**); Tan Duong, February 1938, Jan to february, *Petelot 6274* (**A**, **P**).



Map 9. Distribution of *Syzygium boisianum* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

12. *Syzygium bokorense* W.K.Soh & J.Parn. sp. nov. **Type**: Cambodia, Kampot, Mt. Bokor, 20 December 1965, *J.E.Vidal 4798* (holotype **P**! [barcode P00557353]; isotype **P**! [barcode P P00589386])

Syzygio sclerophyllo et S. wrayi similis in folii basi rotundata ad cordata, consistentia coriacea ad subcoriacea, venis secundariis approximatis. A S. sclerophyllo habitu fruticoso (non arboreo) ad 1 m alto, ramulis teretis, folii lamina maiore (2.5 – 5.5 × 2 – 4 cm contra 1.1 – 2 × 1.5 – 2.5 cm), inflorescentia longiore (3 – 5 cm longa contra ad 2 cm longa), et laxiore, altitudine inferiore reperta differt. A S. wrayi ramulis teretis, inflorescentia longiore (3 – 5 cm longa contra ad 2 cm longa), et laxiore, venis tertiariis minus prominentibus, altitudine inferiore reperta differt.

Shrub 0.6 – 1 m tall. Glabrous on all parts. **Twig** terete, 2 – 3 mm diameter, stout, slightly flaky, brownish, not contrasting to leaf colour. **Leaves** opposite, 2.5 – 5.5 × 2 – 4 cm, 1 to 1.5 times as long as wide, rounded to broadly elliptic, base strongly cordate to rounded, margin recurved downward, apex obtuse, acute or sometimes acuminate, acumen if present, 0.2 – 0.3 cm, 1/10 – 1/18 of blade length, blade coriaceous, brownish; midrib sunken above, raised below; secondary veins thick, 18 – 22 per side per blade, narrowly spaced, 1 – 2 mm apart, c. 60 degrees ascending from midrib, prominent and raised on both surfaces; tertiaries faint, reticulate; outer intramarginal veins c. 1 mm from leaf margin, straight, outer intramarginal veins prominent or faint; petiole very short, subssile, 0.1 – 0.2 cm, 1/25 – 1/50 of blade length, 1 – 2 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, 3 – 5 cm long, paniculate, second degrees branching, spreading, flowers to 27; axes stout, 2.5 – 4.5 cm long, angular; bract and bracteoles persistent, triangular, bract 1 × 0.5 mm, bracteoles 0.5 ×0.2 mm. **Flower** sessile, hypanthium greenish (in vivo), not glaucous, not fibrous, 3 × 2 mm, obconic, pseudostalk distinct, very short, 1 – 1.5 mm; sepals, 4, free, triangular, 1.3 – 1.5 × 3 mm; petals whitish with tinged red (in vivo), 4, free, orbicular, c. 2.5 × 2.5 mm; outer stamens c. 10 mm, anthers, c. 0.4 mm, sacs parallel, connective gland conspicuous; style 4.5 – 5 mm; ovary 2 loculars, ovules c. 10 per locule, irregularly radiating. **Fruit** reddish to purplish (in vivo), depressed globose, 0.6 × 0.5 cm, surface smooth, calyx ring with smooth rim; seed 1, globose, c. 0.4 × 0.4 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Endemic to Cambodia, only known from the type locality in the Bokor National Park.

ECOLOGY OR HABITAT. In scrubby forest, along river, flooded area and waterfall, on sandy soil or podzol, between 800-1050 m.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Near Threatened (NT).

PHENOLOGY. Flowering: April, November, December. Fruiting: March, December.

ETYMOLOGY. The specific epithet is derived from the locality of Bokor, in the Kampot province in Cambodia.

VERNACULAR NAME(S). Phlong kaaep (Cambodia: Kampot)

USES. Used as firewood.

NOTES.

1. *Syzygium bokorense* is morphologically close to S. *sclerophyllum* from Sri Lanka and *S. wrayii* from Peninsular Malaysia in having a rounded to cordate leaf base, a coriaceous to subcoriaceous leaf texture and secondary veins that are narrowly spaced. Both of these species are different from *S. bokorense* in having 4-angled twigs, stout and short inflorescences (to 2 cm) and are found at altitudes above 1500 m. In addition to this, *S. sclerophyllum* is a tree to 10 m tall and the leaf is smaller (1.5 – 2.5 × 1.1 – 2 cm). The tertiary veins of *S. wrayi* are more prominent than *S. bokorense.*

SPECIMENS EXAMINED.

CAMBODIA. Kampot, Mt. Bokor: 9 March 2001, *D.Middleton & M.Monyrak 630* (A); 8 December 1968, *M.A.Martin 1216* (**P**); 20 December 1965, *Vidal 4798* (**P**); March 1967, *Dy Phon 1141* (**P**); 7 December 1968, *M.A.Martin 157* (**P**); December 1965, *M.A.Martin 806* (**P**); 20 November 1999, *S.Hul et, a.l. 737* (**P**); 11 December 2000 , *S.Hul et, a.l. 927* (**P**); Popok Vil waterfall, April 1967, *Dy Phon 1148* (**P**); Popok Vil waterfall, 17 March 1970, *Stone, B.C. 9264* (**P**); 4 December 1964, *T.Kira, K.Hozumi, K.Yoda & S.Kokawa 278* (**BKF**); 11 December 2000, *S.Hul et, a.l. 946* (**P**); 4 December 1964, *T.Kira, K.Hozumi, K.Yoda & S.Kokawa 276* (**BKF**).

ADDITINAL SPECIMENS EXAMINED.

Syzygium sclerophyllum Thwaites: Sri Lanka, Pidurutalaga, Feb 1846, *C.P.274* (isotype **BM**!, **P**!).

Syzygium wrayi (King) I.M.Turner: Peninsular Malaysia. Perak: Gunung Batu Puteh, *Wray 321* (**BM**); Ulu Batang Padang, *Wray 1504* (**K**); Gunung Bubu, March 1890, *Wray 3859* (**P**) – Selangor: Genting Highlands, 11 December 1974, *FRI 021958* (*Francis Putz*) (**KEP**); Gunung Mengkuang, 3 February 1913, *Robinson s.n.* (**BM**).

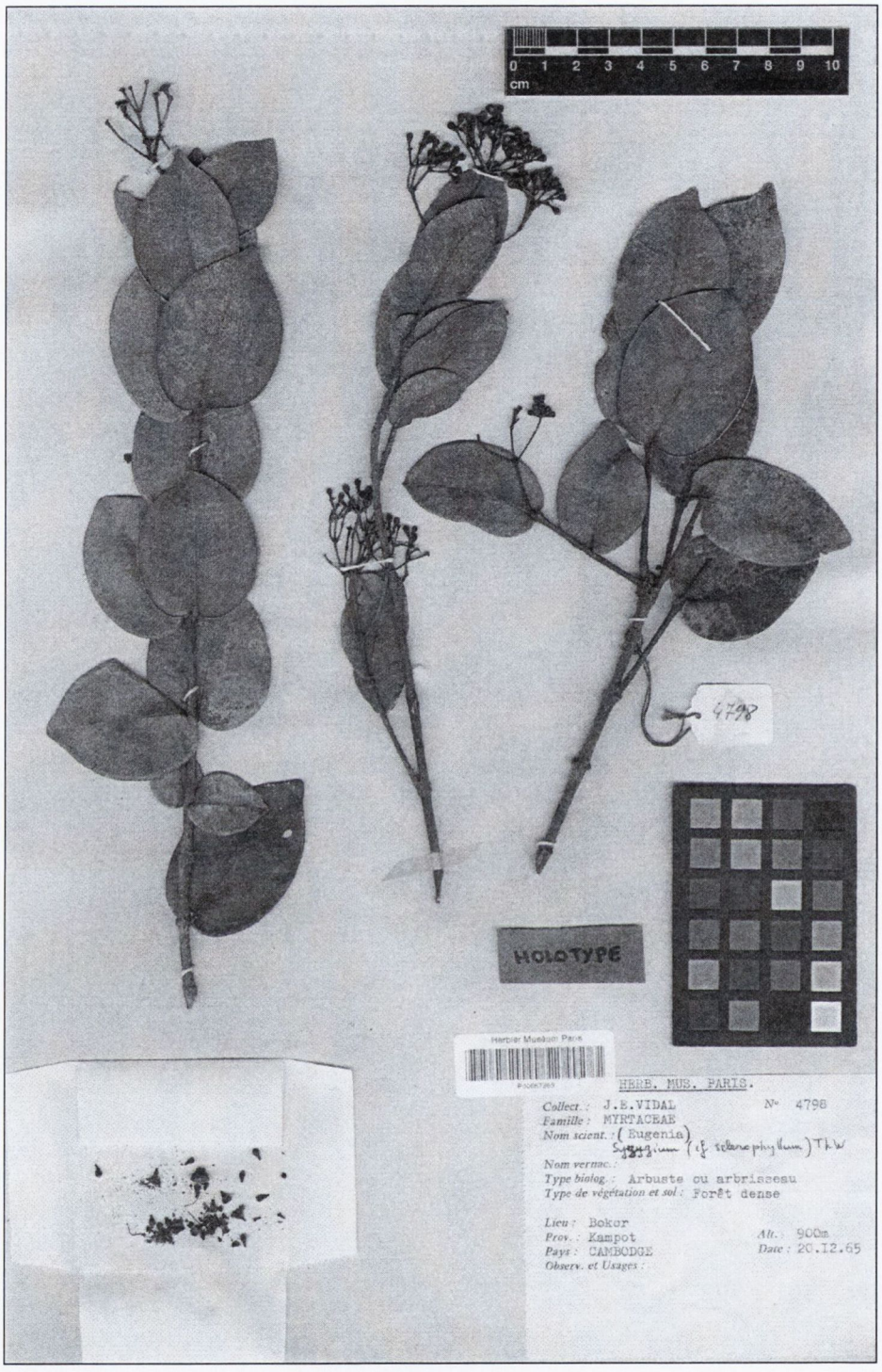


Plate 5.7. Holotype of *Syzygium bokorense* W.K.Soh & J.Parn.

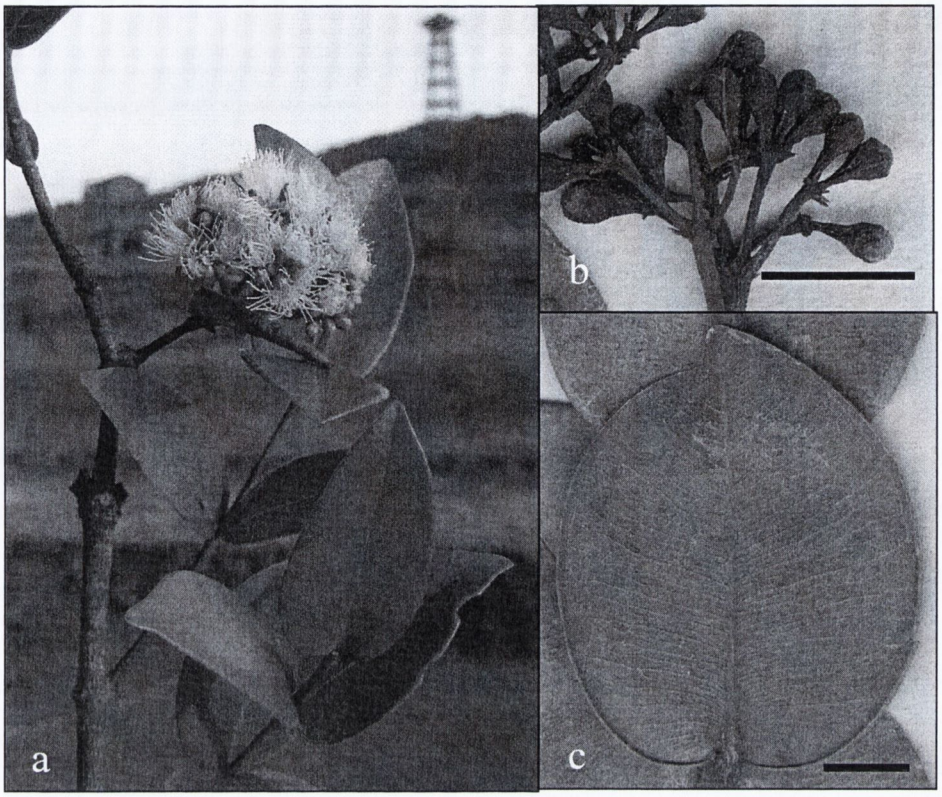
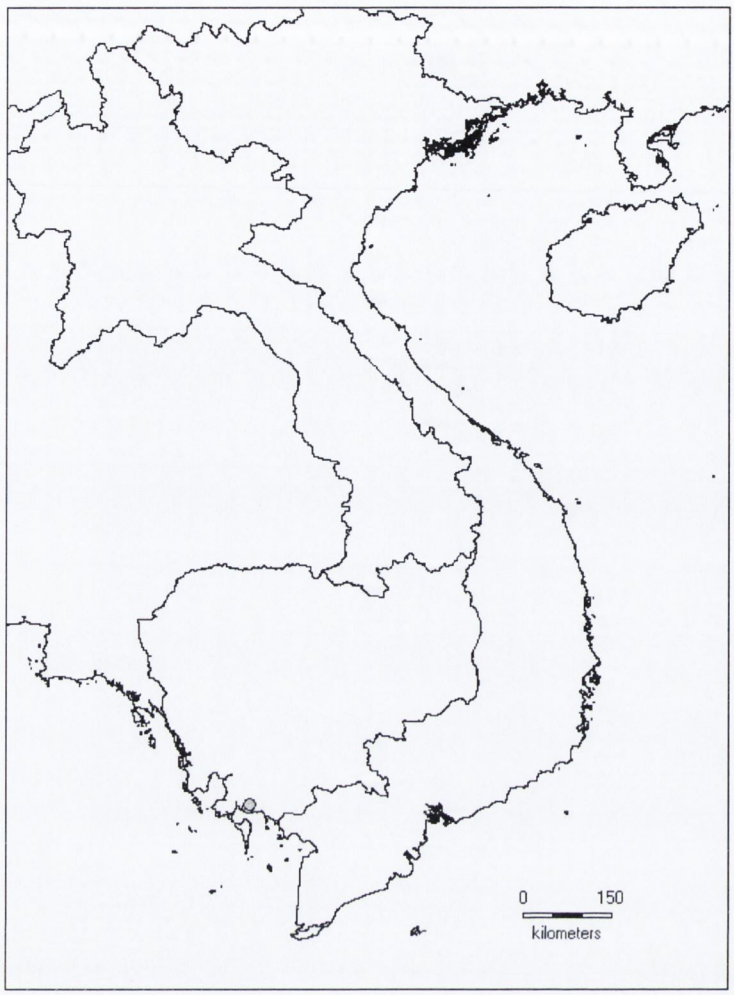


Plate 5.8. *Syzygium bokorense* W.K.Soh & J.Parn. – a. Inflorescence (Photo courtesy of Nguyen Van Du and John Tan); b. Inflorescence (dried state); c. Leaf blade (dried state). Bar = 1 cm.



Map 10. Distribution of *Syzygium bokorense* W.K.Soh & J.Parn. in Cambodia, Laos and Vietnam.

13. *Syzygium borneense* (Miq.) Miq., Fl. Ind. Bat. 1: 453 (1855); Walp., Ann. Bot. Syst. 4: 835 (1857); Merr. & L.M.Perry in Mem. Amer. Acad. Arts 18: 190 (1939); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 44 (1994), Fl. Thailand 7: 838 (2002) [excl. var. *myrtillus*]; I.M.Turner, Gard. Bull. Singapore 47: 372 (1995) – *Eugenia borneensis* Miq., Anal. Bot. Ind. 1 24 (1850), tab. 7; Merr. Enum. Born.: 426 (1921). **Type**: Indonesia, Borneo, Gunung Pamatton, *Korthals s.n.* (holotype **L**! [barcode L0009408]). (see note 1)

– *Eugenia cinerea* Kurz, Prelim. Rep. Forest Pegu, App. A: 64, App. B: 50 (1875), For. Fl. Brit. Burma 1: 483 (1877), J. Asiat. Soc. Bengal 46: 66 (1877); Ridl., Fl. Mal. Pen. 1: 744 (1922); Craib, Fl. Siam. En. 1: 634 (1931) – [*Syzygium cinereum* Wallich, *Wallich Numer. List 3576* (1831) (**K-W**!), nom. nud.; Merr. &

L.M.Perry, J. Arnold Arbor. 19: 107 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 49, fig. 3734 (1992)] – [*Eugenia pseudosubtilis* var. *platyphylla* King, J. Asiat. Soc. Bengal 70: 124 (1901), nom. illeg., nom. superfl.] – *Syzygium cinereum* (Kurz) P.Chantaranothai & J.Parn., Kew Bull. 48: 596 (1993); P. Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 51 (1994); I.M.Turner, Gard. Bull. Singapore 47: 373 (1995); P.Dy Phon, Plants used in Cambodia: 377 (2000); P.Chantaranothai & Parn.J., Fl. Thailand 7: 843 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 902 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 434 (2004) [as *S. tonkinense*]; M.F.Newman et al., Checkl. Vas. Pl. Laos: 245 (2007); J. Chen & Craven, Fl. China 13: 348 (2007). **Type**: Peninsular Malaysia, Penang, *Wallich Numer. List 3576* (lectotype **K-W**! designated by P.Chantaranothai & J.Parn. op. cit. (1993: 596); isolectotypes **E**!, OXF n.v., **L**!), **syn. nov.** (see note 1)

– *Syzygium glaucescens* Bl. ex Miq. Anal. Bot. Ind. 1 24 (1850), in syn (voucher n.v.).

– *Eugenia microcalyx* Duthie in Hook.f., Fl. Brit. Ind. 2: 493 (1878). **Type**: Malaysia, Malacca, *Maingay 727* (lectotype **K**!, designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 45 (1994)).

– *Eugenia pseudosubtilis* King, J. Asiat. Soc. Bengal 70: 123 (1901); Brandis, Ind. Trees: 324 (1906); Ridl., Fl. Mal. Pen. 1: 746 (1922); Corner, Ways Trees. 1: 502 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 202 (1949), fig. 39c; Kochummen in Ng, Tree Fl. Mal. 3: 163 (1978). **Type**: Peninsular Malaysia, Perak, Dec 1884, *King's Collector 6946* (lectotype **BM**!, designated by P.Chantaranothai & J.Parn,. Thai Forest Bull. (Bot.) 21: 52 (1994); isolectotype **K**!).

– *Eugenia pseudosubtilis* var. *subacuminata* King, J. Asiat. Soc. Bengal 70: 124 (1901). **Type**: Peninsular Malaysia, Penang, May 1881, *King's collector 1793* (holotype **K**!).

– *Eugenia ixoroides* Elmer, Leafl. Philipp. Bot. 4: 1426 (1912. **Type**: Philippines, Palawan, Puerto Princesa, Mt. Pulgar, May 1911, *Elmer 13165* (holotypes **PNH**†; isotypes **A** n.v. [barcode 69716], **GH** n.v. [barcode 69717], **K**!).

– *Eugenia litseifolia* Merr. J. Straits Branch Roy. Asiat. Soc. 77: 215 (1917) – *Syzygium litseifolium* (Merr.) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18:

191 (1939). Holotype: Malaysia, Sarawak, *Native Collector 260* (Bur. Sci.) (holotype **PNH** †; isotypes **K**!).

– *Eugenia irregularis* Craib Bull. Misc. Inform. Kew 1930: 167 (1930), Fl. Siam. Enum. 1: 646 (1931) – *Syzygium irregulare* (Craib) Merr. & L.M.Perry, J. Arnold Arbor. 19: 107 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 52, fig. 3742 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 905 (2003) – *E. microcalyx* Duthie *var. irregularis* (Craib) M.R.Henderson, Gard. Bull. Sing. 12: 207 (1949). **Type**: Thailand, Phangnga, takuapa, Kapong, Feb 1929, *Kerr 17128* (lectotype **BK**!, designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 45 (1994); isolectotypes ABD, **BM**!, **K**!, **TCD**!).

– *Eugenia operculata* Roxb. var. *avicennifolia* Craib Craib, Fl. Siam. Enum. 1: 654 (1931). **Type**: *Kerr 12646*, Thailand, Surat, Koh Samui, April 1927 (lectotype **ABD** n.v. designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 52 (1994); isolectotypes **BK**!, **K**!).

– *Eugenia pseudosubtilis* King var. *orientalis* Craib (1931: 657). **Type**: Kerr 16240, Thaialnd, Chumphorn, Siepyuan, Dec 1928 (lectotype **BK**!, designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 52 (1994); isolectotype **ABD** n.v., **BM** n.v., **K**!, **TCD**!).

– [*Syzygium ribesoides* Wallich, *Wallich Numer. List 3553A* (1831) (**K-W**!), nom. nud.]

– [*Eugenia brachiata* auct. non Roxb.: Duthie in Hook.f., Fl. Brit. Ind. 2: 496 (1878) pro parte; Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 811 (1920).] (see note 2)

Shrub or tree, 4 – 25 m tall, to 30 cm dbh. Bark pale whitish to brownish; slash bark light brown. Glabrous on all parts. **Twig** terete, c. 2 – 3 mm diameter, stout, surface smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 6 – 12 × 3 – 6.5 cm, 2 to 2.5 times as long as wide, elliptic or obovate, base attenuate, 30 – 45 degrees from midrib, margin slightly recurved inward, apex mostly acute, sometimes obtuse or cleft, acumen absent, blade coriaceous to subcoriaceous, brownish, sometimes dark brownish; midrib sunken above, raised below; secondary veins (Type A.II & B) 7 – 10 per side per blade, broadly spaced, 5 – 10 mm apart, c. 45 degrees from midrib, prominent, sunken above, raised below, sometimes 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate;

tertiaries obscure, reticulate; inner intramarginal veins 1 – 2 mm from margin, slightly looped, secondary intramarginal veins faint; petiole, 0.7 – 1 cm, c. 1/10 of blade length, 1 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary on leafy twig, 4–7 cm long, paniculate, to second order branching, first order branch spreading, flowers 51 – 63, the second degrees branch very short, forming flower head of 7–9 flowers in triplets, compact; axes c. 4–7 mm long, angular; bracts and bracteoles persistent, triangular, bract 1 × 0.5 mm, bracteoles 0.5 x 0.5 mm. **Flower** white to pale yellow, sessile, hypanthium not glaucous, not fibrous, 1.5–2 × 1.5 mm, obconic, pseudostalk indistinct; sepals 4, free, 0.5–0.7 × 1 mm, semiorbicular; petals 4, coherent, 1.5–2 × 1.5–2 mm, orbicular; stamens 1.5 – 2 mm long; anther c. 0.5 mm, sacs parallel, connective gland conspicuous; style 1 – 1.5 mm, ovules 10–14 per locule, irregularly radiating. **Fruit** reddish (in vivo), globose, 1 × 1 cm, surface smooth, calyx ring with smooth rim; seed 1, globose, 0.5 × 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widely distributed from India to the Philippines and from South China to Borneo.

ECOLOGY OR HABITAT. Primary or secondary forest, road side, swamp, lowland to hill forest to 800 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: February-August. Fruiting: February, May, July, August, October.

VERNACULAR NAME(S): Cambodia: Pring bai (Kampong Chhnang), Pring chanloh. Vietnam: Cham (Thua Thien-Hue), Tram ba vo (Annam), Tram dong (Dong Nai), Tram khoai (Thua Thien-Hue), Tram se, Tram trang (Dong Nai).

USES. Fruit edible and wood used as torches and as timber.

NOTES.

1. This species is polymorphic in the leaf shape and size and inflorescence length but the specimens that I have examined throughout its distributional range are consistent and distinctive in twig colour (whitish to greyish), leaf venation (veins sunken above, brownish to dark brownish and basal secondary veins arcuate), inflorescence type (paniculate, to second order branching, flowers compact at

branch-end) and hypanthium shape (small, obconic and pseudostalk indistinct). Some of the morphological variations observed perhaps warrant infraspecific rank. *Syzygium borneense* is chosen as the oldest name for this species, although the type has smaller leaves than the typical form. In Thailand, *S. cinereum* and *S. borneense* are treated as separate species with only subtle difference in twig colour: whitish grey in the former species and brown to whitish grey in the latter species but in my opinion they share the same leaf venation, inflorescence and floral type. Chantaranothai and Parnell (1994) referred the specimen *Kerr 12061*, which was earlier identified as *E. myrtillus* by Craib's (1931), as a variety of *S. borneense* (var. *myrtillus*). After examining the type of *E. myrtillus* Stapf (*Haviland 1109*, **K**!) and *E. borneense* Miq., I agree with Craibs (1931) identification but disagree with Chantaranothai and Parnell (1994) in treating this specimen as *S. borneense*: unlike the venation of *S. borneense*, the secondary veins are numerous and not sunken adaxially and the hypanthium cup has a distinct pseudostalk.

2. Duthie (1878) misidentified specimens belonging to *S. cinereum* as *E. brachiata* Roxb. and Gagnepain (1920) followed his identification.

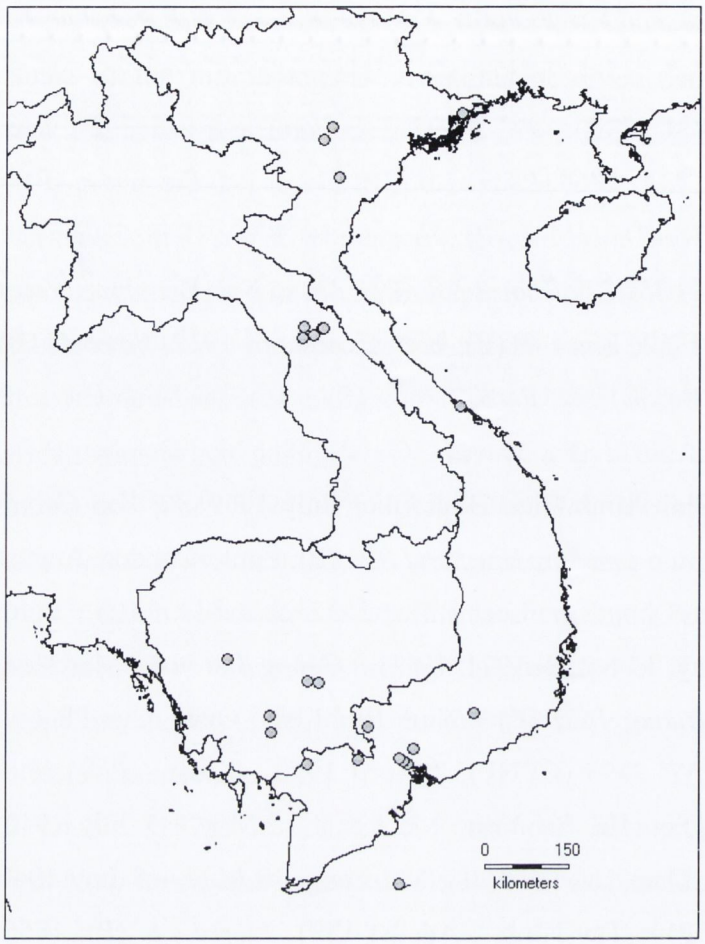
SPECIMENS EXAMINED.

CAMBODIA. 24 June 1929, *Bejaud 553* (A); *Gourgand s.n.* (**P**); February 1877, *Harmand 866* (**P**); *Petelot s.n.* (**P**); 24 June 1929, *Bejaud 553* (**P**); 19 January 1907, *Gourgand s.n.* (**P**) – Kampong Chhnang: Kralanh forest reserve, March 1914, *Chevalier 31733* (**P**) – Kampong Speu: Preah Khae, 8 August 1873, *Pierre s.n.* (**P**) – Kompong Speu: Samraong Tong, May 1870, *Pierre 988* (**P**) – Preah Vihear: Ka Kek, February 1876, *Harmand 418* (**P**) – Pursat: Svay Pak, 6 July 1965, *M.A.Martin 182* (**P**).

LAOS. Khammouan: road along Nakai to Lak Sau, 19 February 2005, *M.F.Newman, P.Thomas, K.E.Armstrong, K.Sengdala & V.Lamxay LAO 331* (**E**); road from Nakai to Nakai-Nam Theun, 17 February 2005, *M.F.Newman, P.Thomas, K.E.Armstrong, K.Sengdala & V.Lamxay LAO 265* (**E**); Ban Mak Phueang, 10 February 2005, *M.F.Newman, P.Thomas, K.E.Armstrong, K.Sengdala & V.Lamxay LAO 29* (**E**); road along Nakai near Houang Nong Pa, 11 February 2005, *M.F.Newman, P.Thomas, K.E.Armstrong, K.Sengdala &*

V.Lamxay LAO 59 (**E**); Nakai, 27 May 2006, *K.Nanthavong & C.E.Ridsdale BT 557* (**E**).

VIETNAM. *Pierre s.n.* (**BM**); 23 December 1971, *Vu Van Cuong 1587* (**P**) – An Giang: Candoc, Mt. Cham, May 1869, *Pierre s.n.* (**P**); Chau Doc, *Pierre s.n.* (**P**) – Cochinchina: *Pierre s.n.* (**K**); *Thorel s.n.* (**P**); *Thorel 336* (**BM**); 1868, *Talmy s.n.* (**P**); *Thorel s.n.* (**P**); , *Thorel 336* (**P**); *Thorel 336* (**P**) – Dong Nai: Bien Hoa, *Vinot s.n.* (**K**); Bien Hoa, April 1912, *Vinot 49* (**P**); Bien Hoa, April 1912, *Vinot 45* (**P**) – Ha Tay: Da Chong, 14 April 1940, *Petelot 2665* (**P**) – Ho Chi Minh City: , 8 March 1911, *C.B.Robinson 1011* (**P**); *Thorel 367* (**P**); Phu My, October 1874, *Godefroy s.n.* (**P**) – Ho Chih Minh City: Binh Quoi, July 1959, *Vu Van Cuong 1306* (**P**) – Khanh Hoa: Poulo-Condor, *Harmand 886* (**P**); Poulo-Condor, August 1870, *Perry s.n.* (**P**) – Lam Dong: Bao Loc, 1 May 1953, *Schmid s.n.* (**P**) – Long An: Moc Hoa, Vam Co Tay, 13 March 1971, *Vu Van Cuong 1644* (**P**); Moc Hoa, 13 March 1971, *Vu Van Cuong 1651* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, *Anon. CPNP 3998* (**CPNP**); 3 April 1970, *Anon. CPNP 3999* (**CPNP**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, 18 May – 5 July 1940, *W.T.Tsang 29839* (**K**, **P**); Dam Ha, Sai Vong Mo Leng, 18 May – 5 July 1940 *W.T.Tsang 29960* (A, K, P) – Tay Ninh: , August 1891, *Pierre s.n.* (**P**); 1866, *Pierre s.n.* (**P**); 1866, *Pierre s.n.* (**P**) – Thua Thien-Hue: Bo Giang, 28 June 1916, *Eberhardt 2772* (**P**); Bo Giang, 28 June 1916, *Eberhardt 2786* (**P**).



Map 11. Distribution of *Syzygium borneense* (Miq.) Miq. in Cambodia, Laos and Vietnam.

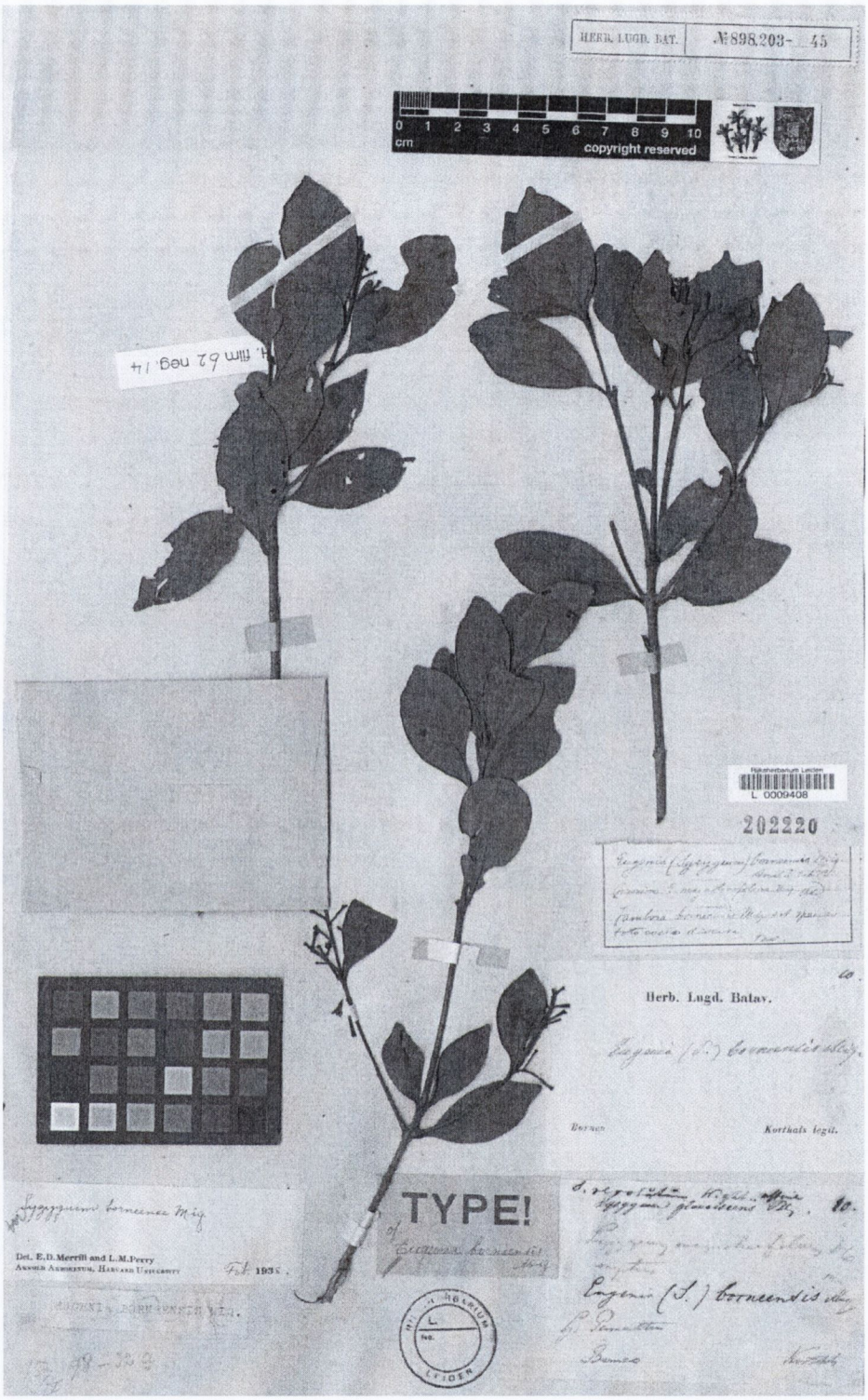


Plate 5.9. Holotype of *Syzygium borneense* (Miq.) Miq.

14. *Syzygium bullockii* (Hance) Merr. & L.M.Perry, J. Arnold Arbor. 19: 107 (1938); P.H.Hô, Fl. Ill. Viêtnam (Cây co Viêtnam) 2: 48, fig. 3720 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 902 (2003); J. Chen &

Craven, Fl. China 13: 354 (2007); M.F.Newman et al., Checkl. Vas. Pl. Laos: 244 (2007) – *Eugenia bullockii* Hance, Jour. Bot. 16: 227 (1878): Forbes & Hemsl. Jour. Linn. Soc. Bot. 23: 296 (1887): Merr. Philip. Jour. Sci. 15: 249 (1919); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 817 (1920); Merr. Lingnan Sci. Jour. 5: 136 (1927), Trans Amer. Phil. Soc. 24: 284 (1935). **Type**: China, Hainan, Hoi-hau, *Bullock 20289* (holotype **BM**!; isotype **E**!, **K** n.v.).

– *Syzygium finetii* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 116 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 50, fig. 3736 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 904 (2003) – *Eugenia finetii* Gagnep. Not. Syst. 3: 324 (1918), et in Lecomte, Fl. Gén. Indo-Chine 2: 842 (1921). **Type** Annam [Vietnam], Than-hoa, Din-hoa, fl., 8 Feb. 1893, *Bon 5881* (lectotype **P**! [barcode P00589281] here designated; isolectotype **P**!). Remaining former syntypes: Tourane[Vietnam], Bien-cho, fr, *Lecomte & Finet 883* (**P**!, cited as 983 in protologue); Tourane[Vietnam], Lazaret, fr., *Lecomte & Finet 940* (**P**!); Tourane[Vietnam], Lazaret, fr., Lecomte & Finet 943 (**P**!), **syn. nov.** (see note)

– [*Myrtus androsaemoides* auct. non Linn.: Lour. Fl. Cochinch. 312 (1790).] (fide Merr., Trans Amer. Phil. Soc. 24: 284 (1935))

Shrub or tree, 0.8 – 2 to 5 – 7 m tall. Glabrous on all parts. **Twig** terete and compressed, c. 2 mm diameter, stout, surface smooth, whitish, contrasting to leaf colour. **Leaves** opposite, subsessile, 5 – 10 × 2.5 – 5 cm, 2 – 2.5 times as long as wide, elliptic, cordate, sometimes rounded, margin recurved, apex acute or acuminate, acumen if present to 0.5 mm long, 1/20 – 1/25 of blade length, blade chartaceous to subcoriaceous, dark brownish; midrib sunken above, raised below; secondary veins (Type A.I) 15 – 25 per side per blade, broadly spaced, 3 – 5 mm apart, 60 degrees ascending from midrib, prominent and raised above, prominent below; tertiaries prominent, reticulate; outer intramarginal veins c. 1 mm from margin, straight, outer intramarginal veins faint; petiole very short, 0.1 – 0.2 cm, 1/37 – 1/60 of blade length, 1 – 1.5 mm diameter, stout, dark brownish, constrasting to blade colour. **Inflorescence** terminal and axillary near apex of leafy twig, 2.5 – 4.5 long, paniculate, second order branching, flowers many, to 27, paniculate; axes 2 – 4 cm long, angular; bract and bracteoles persistent, triangular, bract 0.6 × 0.6 mm, bracteoles 0.3 × 0.3 mm. **Flowers** yellowish or whitish (in vivo), sessile, hypanthium not glaucous, not fibrous, c. 4 × 2.5 mm,

obconic, pseudostalk distinct, 1.5 – 2 mm; sepals 4, free, 0.2 × 1 mm, semiorbicular, undulating on hypanthium rim, inconspicuous; petals 4, coherent, 2 × 2.5 mm, orbicular; outer stamens c. 5 mm long, anthers c. 0.15 mm long, sacs parallel, connective gland conspicuous; style c. 6 mm long, ovules 8 – 10 per locule, irregularly radiating. **Fruit** globose or obloid, 0.8 – 1 × 0.6 – 0.8 cm, surface smooth, blackish, calyx ring with smooth rim; seed 1, obloid, c. 0.6 × 0.6 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: China (Guangdong, Guangxi and Hainan), Laos and Vietnam

ECOLOGY OR HABITAT. In open vegetation, on clay or sandy soil.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: May-September. Fruiting: September-November.

VERNACULAR NAME(S): Vietnam: Cay moc (Annam), Cay sen (Than-hoa).

USES. Fruit edible, consumed by village children.

NOTES.

All the specimens cited by Gagnepain (1920) as *Eugenia finetii* are fruiting specimens. In the *Flore Générale de L'Indo-Chine*, Gagnepain (1920) excluded *Eugenia finetii* from the species key because flowering specimens were unavailable therefore he treated this species as insufficiently known. In the same treatment for *Eugenia bullockii*, Gagnepain (1920) excluded the fruiting character in the species description, although one of the specimens he cited (*Bauche 85*) is a fruiting specimen. After having examined both of these species, I find they are conspecific in having the same infructescence and vegetative character. The fruits are small and with a smooth calyx ring, the twig is whitish and the leaves are very distinctive in having a rounded to cordate base, a very short petiole and a dark brownish blade.

SPECIMENS EXAMINED.

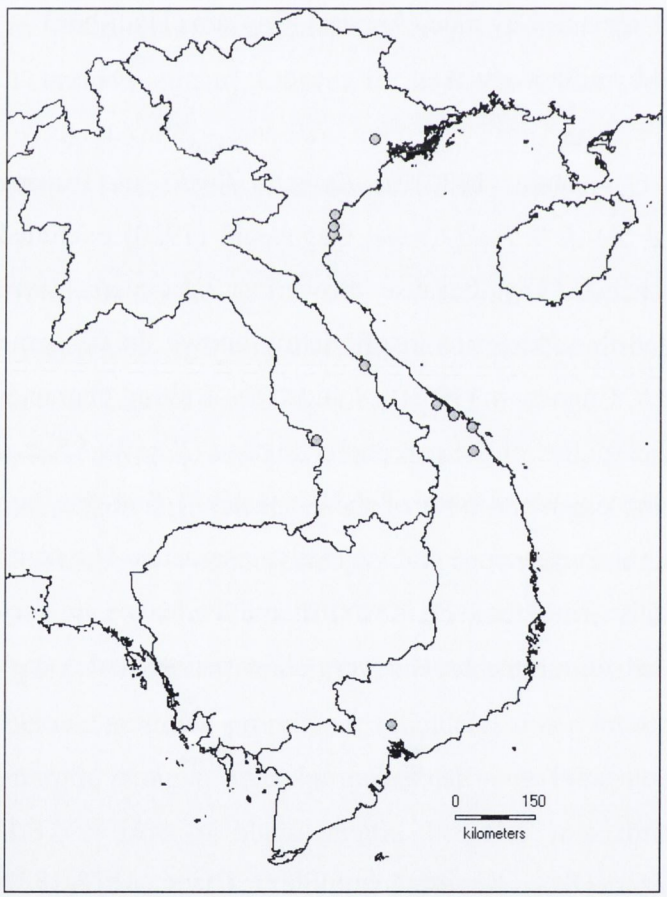
LAOS. sin. loc., *Harmand s.n.* (**P**) – Khammouan: Phou Thane, 1875-1877, *Harmand s.n.* (**P**).

VIETNAM. Bac Giang: Viet Yen,9 October 1909,*Bauche 85* (**P**) – Da Nang: Tourane, Bien Cho, 12 September 1911, *Lecomte & Finet 883* (**P**); Tourane, Lazaret, 12 November 1911, *Lecomte & Finet 940* (**P**); Tourane, Lazaret, 12

November 1911, *Lecomte & Finet 943* (**P**); Tourane and vicinity,May 1927, *J. & M.S. Clemens 3716* (**BM**, **K**, **P**) – Dong Nai: Bien Hoa,July 1908, *d'Alleizette s.n.* (**L**) – Quang Binh: Dam Thuy village, June 1930, *Petelot 6150* (A); Nu Co Regor, 23 August 1892, *Bon 5645* (**P**) – Quang Nam: Que Son, *Anon. LX-VN 3111* (**HN**) – Than-hoa: Cua Bang,2 August 1892, *Bon 5511* (**P**); Dinh Hoa, *Bon 5881* (**P**) – Thua Thien-Hue: *Eberhardt 2336* (**P**); Hue,September 1877, *Pierre 1870 (Harmand)* (**P**); Phu Loc, *Thai & Thuan 136* (**HN**); Phu Loc, *Thai & Thuan 146* (**HN**); Phu Loc, *Thai & Thuan 721* (**HN**).

ADDITIONAL SPECIMENS EXAMINED.

CHINA. Hainan: *A.N.Henry 8083* (**P**); Po-teng, June 1935, *F.C.How 72983* (**P**); Ching Mai, Pak Shik Ling and vicinity, 21 Sept 1933, *C.I. Lei 1022* (**P**) – Guangdong: Zhanjiang [Kouang-tcheou], 29 October 1910, *Decker 96* (**P**).



Map 12. Distribution of *Syzygium bullockii* (Hance) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

15. *Syzygium buxifolium* Hook. & Arn. Bot. Beechey's Voy. 187 (1833); Walpers Rep. 2: 180 (1843); Benth. Jour. Bot. Kew Gard. Misc. 4: 118 (1852), Fl. Hongk. 118 (1861); Merr. & L.M.Perry, J. Arnold Arbor. 19: 104 & 234 (1938) [excl. var. *austrosinense*]; P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 48, fig. 3731 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 902 (2003); J.Chen & Craven, Fl. China 13: 351 (2007) – *Eugenia sinensis* Hemsl. Jour. Linn. Soc. Bot. 23: 298 (1887), nom. nov. **Type**: China, Canton, *Anon. s.n.* [*Messrs Lay & Collie*], all sheets annotated by Sir Willian Jackson Hooker (holotype **K**! [*Herb. Hooker* – with the annotation '*Syzygium* buxifolium, China, Beechey']; isotypes **E**! [mounted on **GL** sheet, with the annotation '*Syzygium buxifolium*, Canton, Beechey'], frag. **A** n.v. [barcode 232670]).

– *Eugenia microphylla* Abel, Narr. Jour. China 181, 364 (1818); Forbes, Jour. Bot. 22: 124 (1884); Rehder & Wilson in Sargent, Pl. Wils. 2: 420 (1915), Jour. Arnold Arb. 8: 179 (1927); Groff, Lingnan Univ. Sci. Bull. 2: 76 (1930); McClure, Lingnan Univ. Sci. Bull. 3: 30 (1931); Handel-Mazzetti, Symb. Sin. 7: 596 (1933); Merr. Jour. Arnold Arb. 18: 71 (1937); non *Syzygium microphyllum* Gamble (1919). **Type**: not to be found in **BM** and **K** (see note 1)

– *Syllsium buxifolium* Meyen & Schauer, Nov. Act. Acad. Leop. – Carol. Nat. Cur. 19: Suppl. 1: 334 (1843). **Type**: n.v. (fide Merr. & L.M.Perry, J. Arnold Arbor. 19: 234 (1938))

– *Eugenia somai* Hayata in R.Kanehira, Formos. Trees: 255 (1918). *Syzygium somai* (Hayata) Mori, Trans. Nat. Hist. Soc. Taiwan 28: 440 (1938). **Type**: n.v. (fide J.Chen & Craven, Fl. China 13: 351 (2007))

– *Syzygium buxifolium* var. *verticillatum* C.Chen, Harvard Pap. Bot. 11: 25 (2006); J.Chen & Craven, Fl. China 13: 351 (2007). **Type**: China, Guangxi, San Chuen to Chuen Yen, 12 July 1937, *T.S. Tsong 83404* (holotype **A** n.v.).

– [*Syzygium microphyllum* sensu Masamune, Mem. Fac. Sci. Agr. Taihoku Univ. 11: 323 (1934), non Gamble.] (fide Merr. & L.M.Perry, J. Arnold Arbor. 19: 104 & 234 (1938))

Shrub to 3 m tall. Glabrous on all parts. **Twig** angular, slightly winged, terete when old, c. 1 mm diameter, slender, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, 2.5 – 3 × 1 – 2, 1.5 to 2 times as long as wide, elliptic to obovate, base cuneate, slightly attenuate, 45 – 50 degrees from midrib,

margin flat, apex acute, obtuse, coriaceous, pale greenish brown or yellowish brown; midrib sunken above, raised below; secondary veins (Type A.I) 10 – 15 per side per blade, narrowly spaced, 1 – 2 mm apart, c. 45 degrees ascending from midrib, faint above and below; tertiaries faint, reticulate; inner intramarginal veins c. 0.5 mm from leaf margin, straight, outer intramarginal veins absent or faint; petiole, 0.3 – 0.4 cm, 1/8 – 1/12 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** (recorded from Chinese specimens) terminal and axillary on leafy twig, c. 1 – 1.5 cm long, racemose or paniculate, to first order branching, flowers few, 3 to 9; axes c. 1 cm long, angular; bracts persistent, c. 0.8 × 0.4 mm, triangular. **Flower** (recorded from Chinese specimens) white (in vivo), pedicellate or sessile, pedicel , hypanthium not glaucous, not fibrous, 1.5–2 × 2 – 3 mm, obconic, pseudostalk indistinct, to 0.5 mm if present; sepals 4, free, c. 0.2 × 0.3 mm, triangular; petals 4, coherent, 1.5–2 × 1.5–2 mm, orbicular; outer stamens c. 2.5 mm long, anther c. 0.4 mm, sacs parallel, connective gland conspicuous; style c. 2.5 mm, ovules c. 8 per locule, radiating. **Fruit** reddish turning purplish to blackish (in vivo), globose to subglobose, 0.5 – 0.7 × 0.5 – 0.6 cm, surface smooth, calyx ring with smooth rim; seed 1 – 2, subglobose, 0.4 – 7 × 0.3 – 0.6 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: North Vietnam, South China, Hainan, Taiwan and South Japan.

ECOLOGY OR HABITAT. In open forest and scrub.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD)

PHENOLOGY. Flowering: June-August (China). Fruiting: October-December (China).

VERNACULAR NAME(S). Tram la ca na (Vietnam).

USES. Used as a bonsai tree in China and Taiwan.

NOTES.

1. This species was first described by Clark Abel (1818) as *Eugenia microphylla* Abel but in *Syzygium*, the specific epithet was invalidated by *S. microphyllum* Gamble. The original specimen cannot be found in **BM** or **K**, presumably lost in shipwreck (Stafleu & Cowan, 1976). Later, Hemsley (1887) moved *S. buxifolium*

to *Eugenia* L. and gave it a new name, *E. sinense* because the original epithet was pre-empted by *Eugenia buxifolia* Lam (1789).

2. In Indochina, Merrill had annotated two specimens as *S. buxifolium*, namely, *Petelot 4678* and *W.T.Tsang 27051*. In *Petelot 4678*, Merrill had noted the peculiarity of this specimen as it appeared different to typical *S. buxifolium*: this specimen I consider as *S. hancei*. The latter specimen (*W.T.Tsang 27051*), which is collected near the border of Vietnam and China, is so far the only collection of *S. buxifolium* known in Indochina.

3. This is a widespread and vegetatively variable species. Merrill (1938) recognised one variety, var. *austrosinense*, which was later changed to species level (*Syzygium austrosinense*) by Chang and Miao (1982). In the recent treatment in the Flora of China, a variety with verticillate leaves was formally recognised. In the current context of our understanding of htis species, which is based largely on Chinese specimens, the Indochinese specimen would fall into the strictly opposite leaved variety, var. *buxifolium*.

SPECIMENS EXAMINED.

VIETNAM. Quang Ninh: Ha Coi, Tsai Wong Mo Shan and vicinity, October 1936, *W.T.Tsang 27051* (E, P).

ADDITIONAL SPECIMENS EXAMINED.

Syzygium buxifolium Hooker & Arnott:

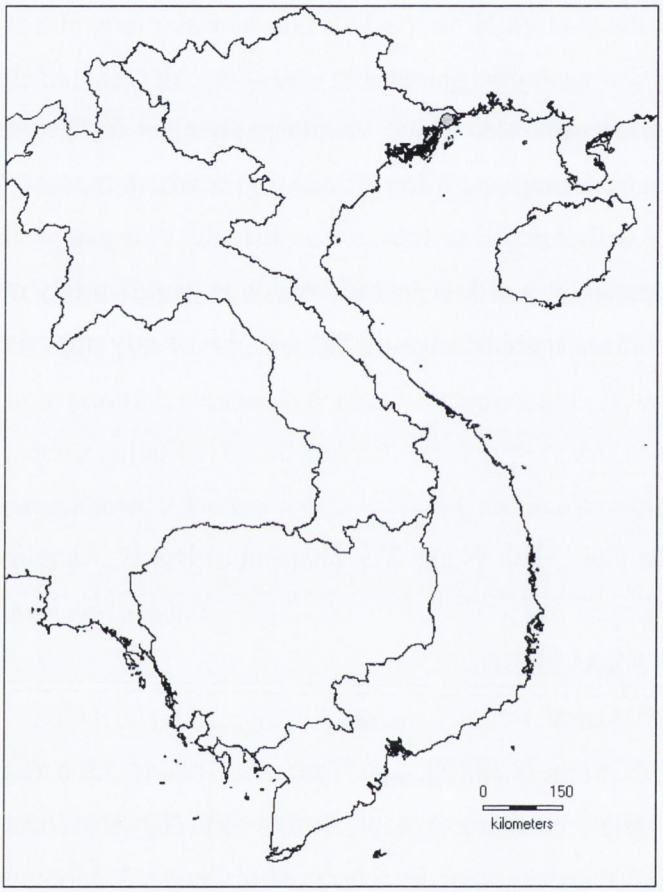
CHINA. Anhui: Li Shan, *R.C.Ching 3106* (**E**); Wu Yuan, *R.C.Ching 3306* (**E**); Wu Yuan, *R.C.Ching 3311* (**E**) – Fujian: Amoy, Anon. 631 (**E**); Foochow, *W.R.Carles 562* (**E**) & *658* (**E**); Kushan, near Foochow, *H.H.Chung 2253* (**E**) – Guangdong: Mt. Lung Tau, *Canton Christian College 12388* (**E**) & 12786 (**E**); Ren Hua – Bei Hi Ling, *W.Y.Chun 5620* (**E**); Pan Ling Tsze, *W.Y.Chun 5879* (**E**); Shaoguan, Ruyan Yao, Nan Ling nature reserve, *P.Thomas & Nan Li 7* (**E**); Sam Kok Shan, *W.T.Tsang 25092* (**E**); Hwei-Yang, Lin Fa Shan, *W.T.Tsang 25699* – Guizhou: Tong-Tcheou, *J.Esquirol 3237* (**E**) & *3767* (**E**) – Hong Kong: *Bodinier 1013* (**E**) & *1149* (**E**); wood of little Hongkong, *Bodinier 709* (**E**) – Hunan: Mt. Mangshan, 21 June 2004, *B.Z.Xiao 3632* – Jiangxi: Hong San, *J.L.Gressitt 1553* (**E**) – Zhejiang: Tai Chow, R.C.Ching 1314 (**E**); Ping Yung, *R.C.Ching 1981* (**E**).

JAPAN. Ryukyu, Yaeyama Is. *M.Furuse 1058* (**TCD**).

TAIWAN. Taipei City, Neihu, *Y.C.Chen 14* (**E**); Pingtung, Lanjenchi, *S.C.Wu & C.C.Ling 1371* (**E**).

Syzygium austrosinense (Merrill & L. M. Perry) Hung T.Chang & R. H.:

CHINA. Guizhou: Miao Wang, Kiangkou Hsien, *A.N.Steward, C.Y.Chiao & H.C.Cheo 545* (**E**) − Hubei: Enshih Hsien, Chow 1854 (**E**) − Sichuan: Pa Hsien, W.P.Fang 5612 (**E**).



Map 13. Distribution of *Syzygium buxifolium* Hook. & Arn. in Cambodia, Laos and Vietnam.

16. *Syzygium championii* (Bentham) Merr. & L.M.Perry, J. Arnold Arbor. 19: 219 (1938); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003); J.Chen & Craven, Fl. China 13: 347 (2007) − *Acmena championii* Bentham, Hooker's J. Bot. Kew Gard. Misc. 4: 118 (1852) ; Walp. Ann. 4: 840 (1857); Bentham, Fl. Hongk.: 119 (1861) − *Eugenia championii* (Benth.) Hemsl., J. Linn. Soc., Bot. 23: 296 (1887); Dunn & Tutcher, Bull. Misc. Inform. Kew Add. Ser.

10: 105 (1912); Merr. Lingnan Sci. J. 13: 41 (1934). **Type**: Hong Kong, in *Herb. Bentham*, *Champion 321* (lectotype **K**! [specimen on the upper right, labelled 'A' by Merrill] here designated; isolectotypes **K**! [specimen on the right], **BM** n.v.) (see note 2)

– *Eugenia henryi* Hance, J. Bot. 23: 7 (1885). **Type**: Hainan, Wo-shi, 31 Oct 1882, *Hendry 111* in *Hance Herb. Prop. No 22263* (holotype **BM**!; isotype K n.v.).

– *Eugenia maclurei* Merr., Philipp. J. Sci. 21: 350 (1922). **Type**: Hainan, Taai Uen, 26 Oct 1921, *McClure 7678* (holotype **PNH** †; isotype **A** n.v. [barcode 69407], **K**!, **P**!).

Shrub to 3 m tall. Glabrous on all parts. **Twig** angular and winged when young, terete or subterete when becoming old, c. 2 mm diameter, smooth, whitish, contrasting or not to leaf colour. **Leaves** opposite, 4 – 8.5 × 1 – 4 cm, 2 – 3 times as long as wide, elliptic to oblong, base cuneate, slightly attenuate and extending to base of petiole, margin flat, apex acuminate, acumen 0.7 – 1.5 cm long, 1/5 – 1/6 of blade length, blade chartaceous, brownish green; midrib sunken above, raised below; secondary veins (Type A.I) 25 – 30 per side per blade, narrowly spaced, 1 – 2 mm apart, 70 degrees ascending from midrib, slender, prominent or faint, raised above, prominent below; tertiaries faint, reticulate; inner intramarginal c. 0.5 mm from margin, straight, outer intramarginal veins faint; petiole short, 1.5 – 2 mm long, 1/30 – 1/40 of blade length, c. 1 mm diameter, stout. **Inflorescence** terminal and axillary on leafy twig, 1.2 – 3.0 cm long, racemose, flowers few, 3 – 7, sometimes due to short axes; axes 0.2 – 1.5 cm, angular; bract and bracteoles persistent, lanceolate, bract 1.2 × 0.5 mm, bracteoles 0.5 × 0.1 mm. **Flowers** whitish (in vivo), sessile, hypanthium not glaucous, fibrous, 1 – 1.3 × 2 – 4 mm, clavate, pseudostalk very prominent, 0.6 – 0.8 cm long, tapering gradually; sepals 4, free, 0.5 × 2 mm triangular, undulate on hypanthium rim; petals 4, coherent, 1.5 × 1.5, orbicular; outer stamens c. 6 mm long, anthers c. 0.3 mm long, sacs parallel, connective gland conspicuous; style c. 7 mm, locules 2 – 3, ovules c. 7 per locule, in two longitudinal row. **Fruit** obloid, clavate (immature), 1.25 × 0.5 cm, surface smooth, calyx ring with smooth rim; seed 1, obloid, clavate (immature), 1 × 0.5 cm, cotyledons free, intercotyledonary intrusion present, ramifying from the apex.

DISTRIBUTION: China (Guangdong, Guangxi, Hainan), Cambodia and Vietnam.

ECOLOGY OR HABITAT. In primary forest, frequently along river, on sandy soil.

CONSERVATION STATUS. IUCN Global Status: Data Deficient (DD); IUCN Regional (Indochina) Status: Data Deficient (DD)

PHENOLOGY. Flowering: June-November. Fruiting: September.

VERNACULAR NAME(S): Tram vo dich (Vietnam)

USES. Not documented.

NOTES.

1. *Syzygium championii* is closely related to *S. claviflorum* and falls into the subg. *Perikion* in having a clavate hypanthium cup, racemose inflorescence and seed with intercotyledonary intrusion. Vegetatively it differs from *S. claviflorum* in its smaller leaf size, shorter petiole and narrowly spaced secondary veins (Type A.I).

2. In the protologue, the description of *Acmena championii* Bentham was based on two species mounted on the same herbarium sheet (*Champion 321* and *Champion s.n.*), one is the current species and the other one is *Syzygium hancei* Merrill & L. M. Perry (for detail see Merr. Lingnan Sci. J. 13: 41 (1934)).

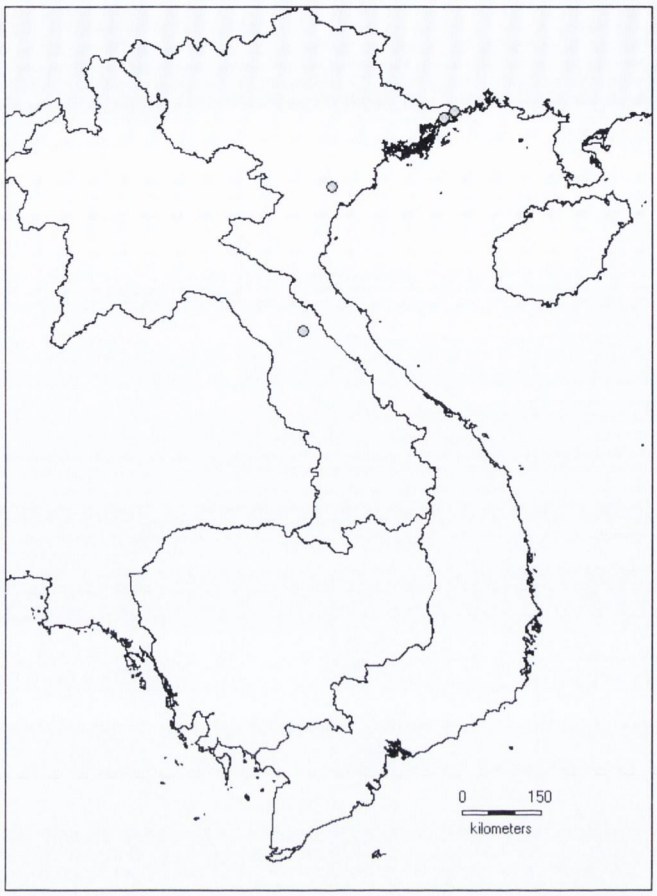
SPECIMENS EXAMINED.

LAOS. Khammouan: Kaeng Maw, Nakai-Nam Theun, 21 October 2005, *M.F.Newman, P.I.Thomas, K.E.Armstrong & K.Sengdala,V. Lamxay LAO 357* (**E**).

VIETNAM. Ninh Binh: July 1900, *d'Alleizette* (**L**) – Quang Ninh: Ha Coi, Tsai Wong Mo Shan and vicinity, 10-17 November 1936, *W.T.Tsang 27222* (**E**, **K**, **P**); 23-31 October 1936, *W.T.Tsang 27174* (**A**, **E**, **K**, **P**); *W.T.Tsang 27222* (**K**); Mon Cay, September 1936, *W.T.Tsang 26900* (**K**); September 1939, *W.T.Tsang 26910* (**E**, **P**).

ADDITIONAL SPECIMENS EXAMINED.

CHINA. Hainan: Chang-kiang district, Ka Chik Shan and vicinity, 26 April 1933, *S.K.Lau 1638* (**P**); Po-teng, September 1935, *F.C.How 73597* (**P**) – Hong Kong: 26 September 1894, *Bodiner 670* (**P**); Happy Valley, 20 June 1894, *Bodiner 670* (**P**); 17 June 1894, *Bodiner 670* (**P**).



Map 14. Distribution of *Syzygium championii* (Bentham) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

17. *Syzygium chantaranothaianum* W.K.Soh & J.Parn. sp. nov. **Type**: Vietnam, Dac Lac, 4 April 1954, *Schmid s.n.* (holotype **P**! [P00589474]).

Syzygio scortechinii similis ramulis quandrangularibus alatis, folii basi cordata, inflorescentia racemosa, sed ramulis brunneolis nec cinereis foliis (in sicco) concoloris, folii lamina nitida atrobrunneola (in sicco), venis secundariis approximatis, tertiariis scalariformibus, hypanthiis minoribus (8 – 10 × 5 – 6 mm contra 13 – 18 × 12 – 15 mm) differt.

Tree. Glabrous on all parts. **Twig** angular (4-angled) and winged, c. 2 mm diameter, slender, smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, subsessile, 11 – 16 cm × 4.5 – 6 cm, 2 to 3 times as long as wide, ovate to oblong-ovate, *base* strongly cordate, apex acute to acuminate, acumen if

present 1 – 1.5 cm long, 1/10 – 1/13 of blade length, blade subcoriaceous, dark brownish, silky below; midrib sunken above, raised below; secondary veins (Type A.II) 20 – 25 per side, 6 – 8 mm apart, 50 – 60 degrees from midrib, prominent and raised on both sides; tertiary veins prominent, scalariform; inner intramarginal 2 – 3 mm from margin, straight, outer intramarginal veins inconspicuous; leaf blade subsessile, petiole 1 – 2 mm, 1/80 – 1/130 of blade length, 1 – 1.5 mm diameter, brownish, not contrasting to blade colour. **Inflorescence** strictly terminal, 2 – 2.5 cm long, racemose, few flowers, 3 to 5; axes 1 – 1.5 cm, 4-angled, winged; bract and bracteole lanceolate, bract 2 – 2.5 x 0.5 – 0.7 mm, bracteole 1.5 – 2 x 0.4 – 0.5 mm. **Flowers** pedicellate, pedicel 1 – 2 mm long, hypanthium not glacous, not fibrous, 8 – 10 × 5 – 6 mm, pyriform, pseudostalk distinct, c. 2 mm long; sepals 4, free, semiorbicular, unequal, outer lobes smaller than inner lobes, outer lobes c. 3.5×5 mm, inner lobes c. 4×7 mm; petal coherent; outer stamens to 9 mm long, anthers c. 0.5 mm long, sacs parallel, connective gland conspicuous; style c. 0.8 mm long, ovary 2 locular, ovules 69 to70 per locule, irregularly arranged. **Fruit** unknown.

DISTRIBUTION: Endemic to Vietnam, only known from the type locality in Dac Lac.

ECOLOGY OR HABITAT. At edge of a stream under forest on granite, to 1200 m.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: April.

ETYMOLOGY. This species is name after Prof. Pranom Chantaranothai, a prominent Thai botanist who had made significant contributions to the systematics of Thai *Syzygium*.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

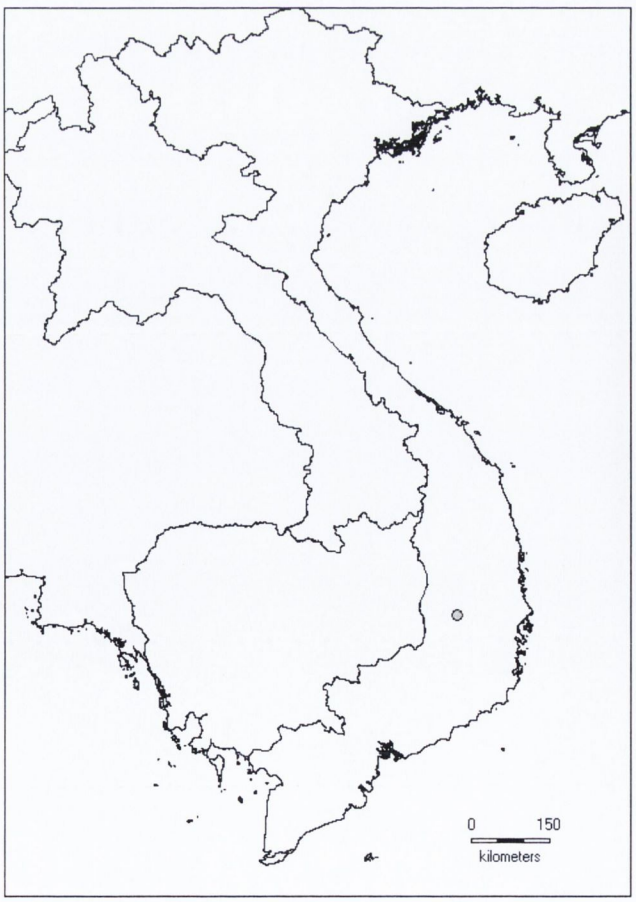
NOTES.

1. Vegetatively, this species is very distinctive compared with many *Syzygium* species in Indochina in having a combination of the following characters: 4-angled and winged twigs, strongly cordate leaf base, subsessile leaf blade, scalariform tertiary veins, racemose inflorescence and large flowers. In having a

4-angled and winged twig, cordate leaf base and racemose inflorescence, this species resembles *S. scortechini* but differs in that the twig is brownish not greyish and contrasting in colour with the leaf, the secondary veins are narrowly spaced and the tertiary veins are scalariform, the leaf blade is shiny and dark brownish as opposed to pale greenish and the flowers are smaller.

ADDITIONAL SPECIMENS EXAMINED.

Syzygium scorthechini (King) P.Chantaranothai & J.Parn.: MALAYSIA. Peninsular Malaysia, Perak: Larut, August 1883, *King 4734* (**K**, **P**); February 1886, *King 10437* (**BM**, **P**); July 1883, *King 7801* (**BM**); Perak, *Scortechini 649* (**E**) – Sabah: Tawau, 11 February 1965, *SAN 48491 (J.Singh & Nordin)* (**KEP**); Ranau, 27 July 2005, *SAN 146786 (L.G.Saw)* (**KEP**); Ulu Segama, Danum Valley, 9 March 1987, *G.Argent & K.Jong 37187* (**KEP**) – Sarawak: Miri, Lambir National Park, *S 24069 (Awang Morahidi)* (**KEP**). THAILAND. Pattani: Ban Sai Kao, 3 April 1928, Kerr 15020 (**BK**, **K**); 18 April, 1938, *M.C.Lakshanakarae 699* (**BK**); Siricha, Kow Kieo, 13 March 1976, *J.F.Maxwell 76-137* (**BK**).



Map 15. Distribution of *Syzygium chantaranothaianum* W.K.Soh & J.Parn. in Cambodia, Laos and Vietnam.

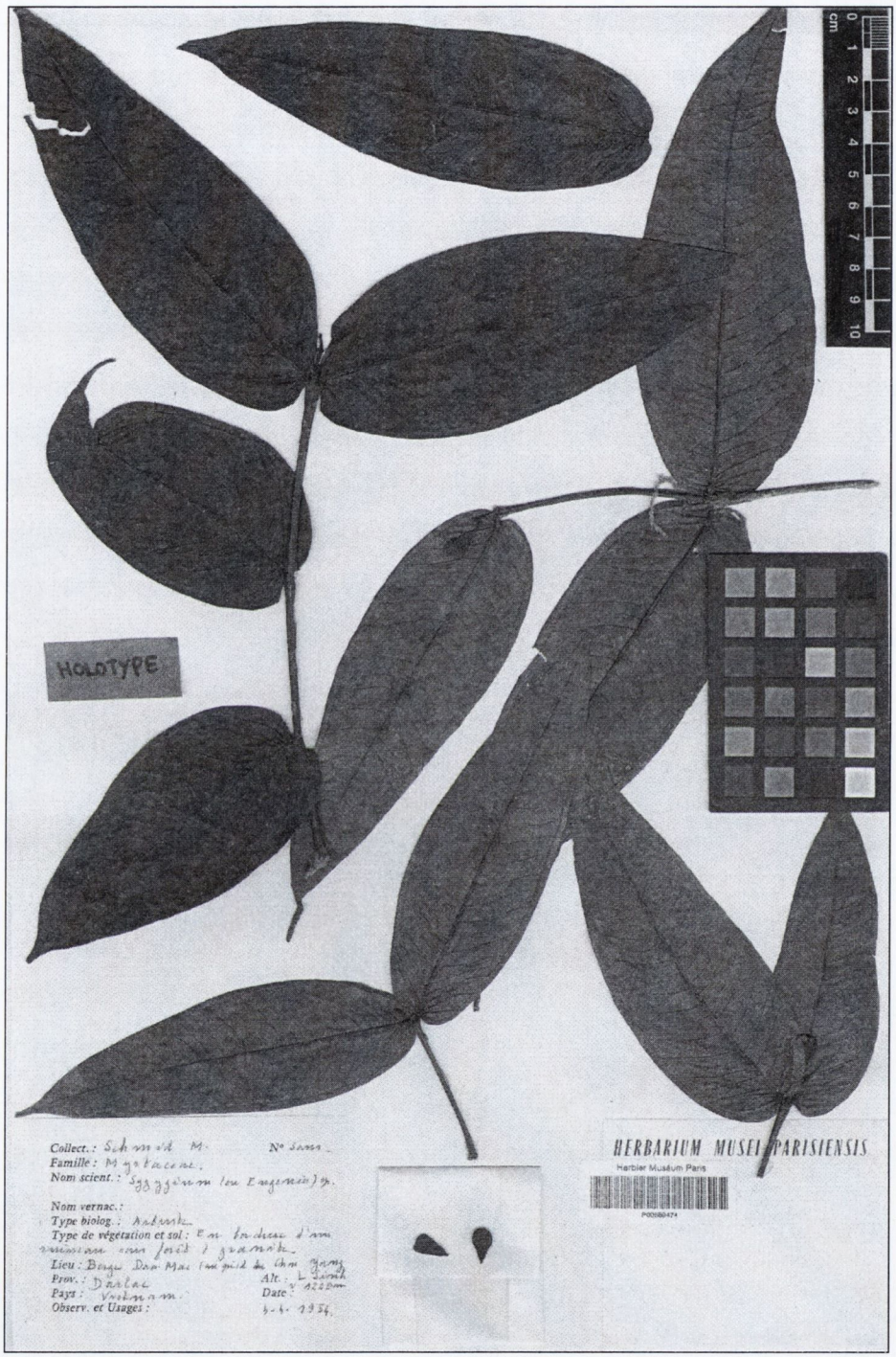


Plate 5.10. Holotype of *Syzygium chantaranothaianum* W.K.Soh & J.Parn.

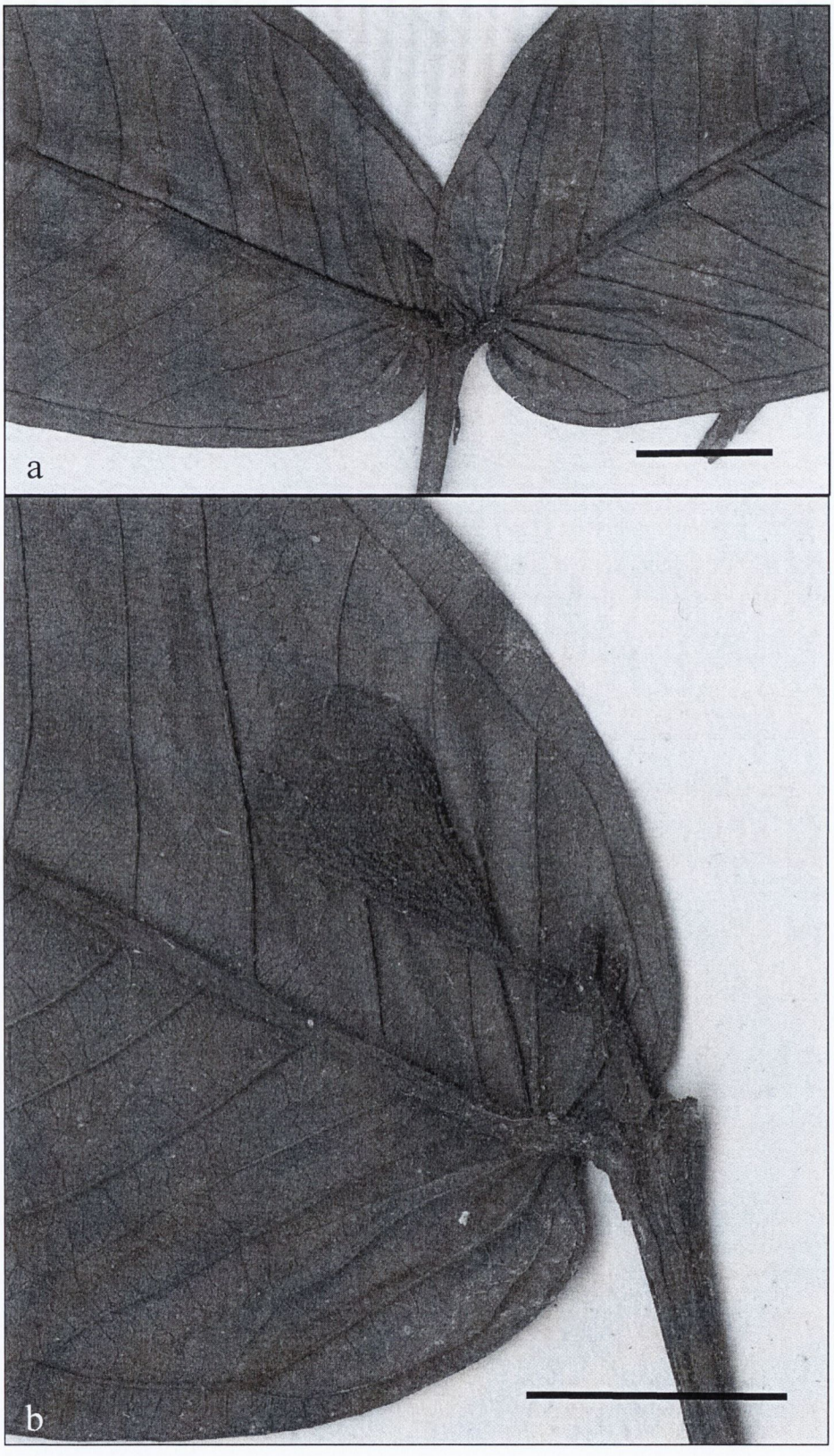


Plate 5.11. *Syzygium chantaranothaianum* W.K.Soh & J.Parn. – a. Leaf and twig; b. Inflorescence, two other flowers were detached. Bar = 1 cm.

18. ***Syzygium claviflorum*** (Roxb.) Wall ex Steudel, Nomencl. Bot. ed. 2, 2: 657 (1841); A.M. Cowan & Cowan, Trees N. Bengal: 67 (1929) 67; Merr. & L.M.Perry, J. Arnold Arbor. 19: 221 (1938); Merr., Philipp. J. Sci. 79: 382 (1950); T.G. Hartley & L.M.Perry. J. Arnold Arbor. 54: 210 (1973); D.G. Long & Rae in Grierson & D.G. Long, Fl. Bhutan 2: 284 (1911), figs. 33c & e; P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 53 (1994); I.M.Turner, J. Singapore Natl. Acad. Sci. 22 – 24: 17 (1996); P.Chantaranothai & J.Parn., Fl. Thailand 7: 844, plate 13, plate XXVIII – 3 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 126 (2003); J. Chen & Craven, Fl. China 13: 348 (2007). – *Eugenia claviflora* Roxb., [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed. 2, 2: 488 (1832); Wight, Ic. 2: t. 606 (1843); Kurz, Forest Fl. Burma 1: 480 (1877), J. Asiat. Soc. Bengal 46: 65 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 484 (1878); King, J. Asiat. Soc. Bengal 70: 107 (1901), Mater. Fl. Mal. Pen. 12: 537 (1901); Brandis, Ind. Trees: 319 (1906); Ridl., Fl. Malay. Penins. 1: 742 (1922), fig. 63; Craib, Fl. Siam. Enum. 1: 635 (1931); Merr. & Chun, Sunyat. 2: 43 (1934); Corner, Wayside Trees. 1: 495 (1940), figs. 168, 169; M.R.Henderson, Gard. Bull. Sing. 12: 252 (1949), figs. 4 & 49a; Kochummen in Ng, Tree Fl. Mal. 3: 186 (1978). – *Acmena claviflora* (Roxb.) Walp., Repert. Bot. Syst.: 181 (1843). – *Clavimyrtus claviflora* (Roxb.) Blume, Mus. Bot. 1: 113 (1850). – *Acmenosperma claviflorum* (Roxb.) Kausel, Ark. Bot. 3: 609 (1957); B. Hyland, Aust. J. Bot., Suppl. 9: 24 (1983), fig. 8. **Type**: Ic. Roxb. No. 2499, ined. (lectotype **K**! [downloaded from Royal Botanic Gardens, Kew. (2006)] here designated, **C** n.v.)). (see note 3)

– *Jambosa clavata* Korth., Ned. Kruidk. Arch. 1: 201 (1847) – *Eugenia clavata* (Korth.) Merr., J. Straits Branch Roy. Asiat. Soc. 77: 225 (1917) – *Syzygium clavatum* (Korth.) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 180 (1939). **Type**: Indonesia, Borneo [Pamatton & Sakoembang], *Korthal s.n.* (holotype **U**! [barcode L0009414]).

– *Eugenia leptantha* Wight, Ill. Ind. Bot. 1: 15 (1841), non Benth, nomen illeg., Icon. Pl. Ind. Orient. 2: t. 528 (1843); Kurz, Forest Fl. Burma 1: 480 (1877), J. Asiat. Soc. Bengal 46: 65 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 484 (1878); Ridl., J. Fed. Malay States Mus. 10: 91 (1920), Fl. Malay. Penins. 1: 741 (1922); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 833 (1920) – *Syzygium leptanthum*

(Wight) Nied., in Engl. & Prantl, Nat. Pfl. Fam. 3(7): 85 (1893); Merr. & L.M.Perry, J. Arnold Arbor. 19: 222 (1938); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003) – *Eugenia claviflora* Roxb. var. *leptanta* (Wight) King, J. Asiat. Soc. Bengal 70: 108 (1901), Mat. Fl. Malays Penins. 12: 538 (1901) – *Eugenia leptalea* Craib, Fl. Siam. Enum. 1: 649 (1931), nom. nov. pro *Eugenia leptantha* Wight – *Eugenia claviflora* Roxb. var. *leptalea* M.R.Henderson, Gard. Bull. Sing. 12: 255 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 187 (1978). **Type**: Burma, Mergui, 'Mergui 854, Griffith', *Griffith s.n.* [*Herb. Hooker*] (lectotype **K**! here designated). (fide Noltie (2005: 357))

– *Eugenia rhododendrifolia* Miq., Anal. Bot. Ind. 1: 19 (1850), tab. 2. – *Syzygium rhododendrifolium* (Miq.) Masam., Enum. Phan. Born.: 538 (1942). **Type**: Borneo, Martapura, *Korthal s.n.* (**L**! [barcode L0009414]).

– *Eugenia rhododendrifolia* forma *longifolia* Miq., Anal. Bot. Ind. 1: 20 (1850), tab 3. – *Jambosa borneensis* Miq., Fl. Ind. Bat. 1: 434 (1855), nom. nov. pro *Eugenia rhododendrifolia* forma *longifolia* Miq. **Type**: Indonesia, Borneo [Sakoembang], *Korthal s.n.* (**L**! [barcode L0009415]).

– *Jambosa melanocarpa* Miq., Fl. Ind. Bat. 1: 430 (1855). **Type**: Indonesia, Java, Lampong, *Herb. Zollinger*, possible type is *Anon. s.n.*, Java, with Zollinger's handwriting on the label (**U**! [barcode U0005209]).

– *Eugenia maingayi* Duthie in Hook.f., Fl. Brit. Ind. 2: 484 (1878). – *Eugenia claviflora* var. *maingayi* (Duthie) King, J. Asiat. Soc. Bengal 70: 108 (1901), Mat. Fl. Malays Penins. 12: 556 (1901); . – *Syzygium claviflorum* var. *maingayi* (Duthie) P.Chantaranothai & J.Parn., Kew Bull. 48: 590 (1993); Turner, Gard. Bull. Singapore 47: 373 (1995), J. Singapore Natl. Acad. Sci. 22 – 24: 17 (1996). **Type**: Malaysia, Pulau Pinang, *Maingay 750* (lectotype **K**! here designated; isolectotypes **K**!).

– *Eugenia ruminata* Koord. & Valeton, Bull. Inst. Bot. Buitenzorg 2: 8 (1899), Med. 40: 117 (1900), Atlat Baumart. Java 3: fig. 486 (1915). – *Syzygium ruminatum* (Koord. & Valeton) Amshoff in C.A.Backer & R.C.Bakhuizen van der Brink, Bekn. Fl. Java 4b(98): 11 (1944). **Type**: Java, not found (**L** n.v.). (fide M.R.Henderson, Gard. Bull. Sing. 12: 252 (1949))

– *Eugenia claviflora* var. *excavata* King, J. Asiat. Soc. Bengal 70: 108 (1901); M.R.Henderson, Gard. Bull. Sing. 12: 257 (1949), fig. 49c. – [*Syzygium*

excavatum Wallich, *Wallich Numer. List 3574* (1841), nom. nud.; Duthie in Hook.f., Fl. Brit. Ind. 2: 484 (1878), in syn. – *Syzygium claviflorum* var. *excavatum* (King) Turner, Gard. Bull. Singapore 47: 373 (1995), J. Singapore Natl. Acad. Sci. 22 – 24: 17 (1996). **Type**: Malaysia, Penang, 'Amherst 1827', *Wall. Numer. List 3574* (lectotype **K-W**! here designated; isolectotypes **K**! [2 sheets, *Herb. Bentham & Herb. Hooker*], **SING** n.v.).

– *Eugenia claviflora* var. *glandulosa* King, J. Asiat. Soc. Bengal 70: 108 (1901).

– *Syzygium claviflorum* var. *glandulosum* (King) P.Chantaranothai & J.Parn., Kew Bull. 48: 590 (1993); Turner, Gard. Bull. Singapore 47: 373 (1995), J. Singapore Natl. Acad. Sci. 22 – 24: 17 (1996). **Type**: Malaysia, Malaca, Mt. Ophir, April 1888, *Hullett 780* (holotype **K**!; isotype **SING** n.v.).

– *Eugenia viridifolia* Elmer, Leafl. Philipp. Bot. 4: 1420 (1912) – *Syzygium viridifolium* (Elmer) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 183 (1939)). **Type**: Philippine, Palawan, Puerto Princesa, Mt. Pulgar, *Elmer 12975* (holotype **PNH** †: isotypes **A** n.v. [barcode 69824]; **GH** n.v. [barcode 69823]; **US**! [barcode 00118214).

– *Eugenia baviensis* Gagnep. Notul. Syst. 3: 316 (1917); in Lecomte, Fl. Gén. Indo-Chine 2: 802, f. 86 1920 – *Syzygium baviense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 102 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 46, fig. 3725 (1992); P.Dy Phon, Plants used in Cambodia: 377 (2000); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 901 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 429 (2004); J. Chen & Craven, Fl. China 13: 348 (2007). e**Type**: Tonkin [Vietnam], Mt. Bavi, valley of Lankok, 24 June 1877, fl., *Balansa 2880* (lectotype **P**! [barcode P00589300]; isolectotype **L**! [barcode L0404219], **K**! [barcode K000276180]), **syn. nov.** (see note 2)

– *Eugenia fraseri* Ridl., J. Bot. 68: 33 (1930). – *Syzygium fraseri* (Ridl.) Masam., Enum. Phan. Born.: 528 (1942). **Type**: Sabah, Kudat, Jan 1885, *Fraser 139*, (**K** n.v.; **SING** n.v.). (fide Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 183 (1939)).

– *Eugenia claviflora* var. *montana* M.R.Hend. , Gard. Bull. Singapore 12: 260 (1949) – *Syzygium claviflorum* var. *montanum* (M.R.Hend.) Turner, Gard. Bull. Singapore 47: 373 (1995), J. Singapore Natl. Acad. Sci. 22 – 24: 17 (1996).

Type: Malaysia, Terengganu,Gunong Padang, *SFN 33914* (holotype **SING** n.v.; isotypes **K**!, **L**!).

– *Eugenia claviflora* var. *riparia* M.R.Hend. , Gard. Bull. Singapore 12: 257 (1949) – *Syzygium claviflorum* var. *riparium* (M.R.Hend.) Turner, Gard. Bull. Singapore 47: 373 (1995), J. Singapore Natl. Acad. Sci. 22 – 24: 18 (1996). **Type**: Malaysia, Pahang, Kuala Tahan, *Seimund 927* (holotype **SING** n.v.; isotype **K**!).

– *Syzygium wightianum* Wallich ex Wight & Arn., Prodr. Fl. Ind. Orient.: 330 (1834); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 61, fig. 3769 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 909 (2003) – *Eugenia* wightiana Wight, Ill. Ind. Bot. 2: 15 (1841); Wight, Icon. Pl. Ind. Orient. 2: t. 529 (1843); Duthie in Hook.f., Fl. Brit. Ind. 2: 485 (1878); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 841 (1920). **Type**: India, Dindygul Hills, 3000ft, *Wallich Numer. List 3577* (lectotype **K**! [*Herb. Hooker*] here designated; isolectotypes **E**!, **K**! [*Herb. Bentham*], **K-W**!), **syn. nov.** (see note 2)

– [*Syzygium longiflorum* Wallich, *Wallich Numer. List* 3572 B (1831) (**E**!, **K-W**!, **L**!, **P**!) nom. nud.]

– [*Syzygium suavissimum* Wallich, *Wallich Numer. List* 3573A (1831) (**K-W**!) nom. nud.]

– [*Syzygium lanceolatum* auct. non Lam: Wight & Arn., Prodr. Fl. Ind. Orient.: 330 (1834); Wight, Icon. Pl. Ind. Orient. 2: t. 530 (1843)]

Tree 2 – 8 m tall, to 20 cm dbh. Glabrous on all parts. **Twig** terete to subangular, 1 – 2.5 mm diameter, stout, smooth or fissured, brownish, not contrasting to leaf colour**. Leaves** opposite, (6 –)8 – 10(– 22) × (1.5 –)2 – 3.5(– 7.5) cm, 2 – 4 times as long as wide, elliptic, ovate, sometimes obovate, base cuneate, slightly attenuate, margin flat, apex mostly acute without acumen, sometimes acuminate with distinct acumen, acumen if present 0.3 – 0.5(– 1) cm long, 1/10 – 1/24 of blade length, blade chartaceous to coriaceous, greenish to yellowish brown; midrib sunken above, raised below; secondary veins (Type A.II) 15 – 30 side per blade, narrowly or broadly spaced, 1.5 – 5(– 10) mm apart, ascending 60 – 70 degrees from midrib, prominent or faint, raised above, prominent below; tertiaries prominent or faint below, of tertiaries trength, reticulate; inner intramarginal veins 1 – 3 mm from margin, straight, outer intramarginal veins absent or faint; petiole 0.3 – 0.5(– 0.6) cm long, 1/14 – 1/44 of blade length, 1 – 2 mm diameter, stout,

brownish, not contrasting to blade lenght. **Inflorescence** terminal or axillary on leafy twig, (1.5 –)2 – 3.5 cm long, racemose, flowers few , 3 – 8, usually 7, sometimes facicle, up to 3 inflorescences clumping together at leaf axil; axes 0.5 – 2 cm long, angular; bract and bracteoles caduceus. **Flowers** white, sessile, hypanthium not glaucous, fibrous, 1.5 – 2 × 0.3 – 0.5 cm long, clavate, tapering gradually into narrow base, pseudostalk distinct, 5 – 10 mm long; sepals 4, free, 0.5 – 1.0 × 0.8 – 2.5 mm, triangular, tip blunt; petals 4 – 6, coherent (sometimes petal agglutinate to hypanthium, looking as if free), (1 –)1.5 – 2.5 × (1 –)1.5 – 2.5 mm, orbicular; outer stamens 5 – 10 mm long, anthers 0.5 mm long, sacs parallel connective gland inconspicuous; style 5 – 8 mm long, ovules 10 – 24 per locule, in two longitudinal row. **Fruit** reddish (in vivo), ellipsoid to obovoid, 1 – 1.5 × 0.5 – 0.9 cm, surface smooth, calyx ring with smooth rim, pericarp 0.5 – 1.0 mm thick; seed 1, ellipsoid, 0.8 – 1.2 × 0.5 – 0.7 cm, cotyledons free, intercotyledonary intrusion present, ramifying from the side.

DISTRIBUTION: Widely distributed from India to the Northern Australia. In Indochina it occurs in Cambodia and Vietnam and may possibly occur in Laos but this so far it has not been collected there.

ECOLOGY OR HABITAT. Lowland to montane forest, secondary, primary and beach forest, to 1050 m alt.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: January, February, March, June, November. Fruiting: March, April, June, August.

VERNACULAR NAME(S): Cambodia: Prinh ach kanndaor, Prinh ach romeang. Vietnam: Tram trang (Ba Ria-Vung Tau).

USES. Fruit edible, wood used as firewood and construction.

NOTES.

1. *Syzygium claviflorum* is characterised by its short racemose inflorescence, clavate hypanthium with ovules arranged in longitudinal rows and seed with intercotyledonary intrusion. This is a variable species in leaf size and shape, and inflorescence size. Nevertheless, I agree with Chantaranothai & Parnell (1994b) that these variations are not discrete and display a continuum of variation. However at the extreme poles of the continuum are morphologically distinct

forms which could be easily perceived as distinct species per se. Some of the variation seen in the herbarium collections may be correlated with the environment. For example specimens found in beach forest (*T.Smitinand & E.C.Abbe 6428*) and stunted montane forest (*Dy Phon 1145* and *Middleton & Monyrak 660*) from Indochina have stouter twigs, thicker leaves, involute leaf margin and short petioles with attenuating bases. *S. iwahigensis* (*Elmer 12743*) from the Philippines, which resembles *S. claviflorum*, shows the characters mentioned above and was documented as growing in a dry rocky habitat. Other ecological forms that have been formally described are the rheophytic form (*Syzygium claviflorum* var. *riparium*) with linear lanceolate leaves and the montane form (*Syzygium claviflorum* var. *montana*) with stout twigs, leaf stalks and coriaceous leaves. Field observations, ecological and population genetic studies are needed to resolve the status of *Syzygium claviflorum* and its allies.

2. In Indochina, Gagnepain (1920) grouped *E. baviensis* and *E. wightiana* into section II and IV respectively with the differences in the petal number: 4 – 5 in *E. baviensis* and 8 to 12 in *E. wrightiana*. I have examined the flowers of *E. wightiana* and found that the petals number varies from 4 to 6. In the *Flora of China* account (Chen & Lyn, 2007), *S. baviense* is differentiated from *S. claviflorum* on the basis of the style length; c. 3 mm in the former species and 10 –15 mm in the latter species. All the morphological differences mentioned above are regarded by me as variation seen within a morphologically variable *S. claviflorum*.

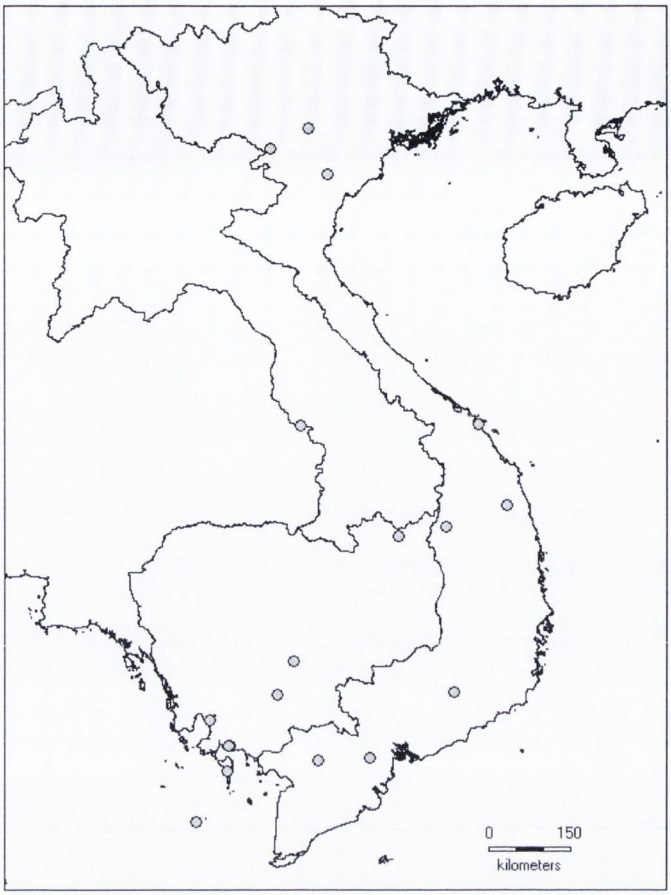
3. Hyland (1983) designated Wight's drawing (Icon. Pl. Ind. Orient. 2: t. 528 (1843)) of *Eugena lepthantha* as a neotype of *Eugenia claviflora* on the ground that Roxburgh failed to cite any specimen for typification. However Wight's illustration was not drawn from Roxburgh's plate. There is no possible Roxburgh specimen at **BM** and **K.** I disagree with Ashton (2009), who choose specimen *Wallich 3575B* (**K-W**!) as the lectotype of *Eugenia claviflora* Roxb. on the basis that the ticket bearing '*Syzygium claviflorum* Wall.' on the sheet is Roxburgh's handwriting. This is in fact Wallich's hand writing and Roxburgh who had died in 1815, would not have labelled it as '*Syzygium claviflorum* Wall.'. However, Roxburgh's icon is a good representation of this species, as it vividly depicts the clavate hypanthium and racemose inflorescence, which are distinct characters for this species.

SPECIMENS EXAMINED:

CAMBODIA. s. loc. *Hance, H.F. 19247* (**BM**) – Kampong Chhnang: Kralanh forest reserve, 11 March 1914, *Chevalier 31723* (**P**) – Kampot: Mt. Bokor, *Dy Phon 1145* (**P**); Mt. Bokor, 10 March 2001, *D.Middleton & M.Monyrak 660* (**P**) – Kandal: Phnom Penh, *Bejaud 558* (**P**) – Koh Kong: Kompong Som, 5 May 2008, *K.C.Cheng, S.Hul, B.David & M.Leti CL 965* (**P**) – Ratanikiri: Virachey National Park, 17 December 2005, *P.Thomas, Koun Theah, Thon Sokhon, Seth Teng, Srun Sokhon & Yan Bounsoeung 83* (**E**).

THAILAND. Kemmarath [Laos], *Thorel s.n.* (**P**).

VIETNAM. An Giang: Mt. Lap Vo, *Pierre s.n.* (**BM**) – Ba Ria-Vung Tau: Ba Ria, March 1918, *Chevalier 36811* (**P**) – Cochinchina: August 1869, *Pierre s.n.* (**P**) – Da Nang: Tourane vicinity, 12 February 1960, *T.Smitinand & E.C.Abbe 6428* (**K**, **L**) – Ha Tay: Mt. Ba Vi, Lankok valley, 24 June 1887, *Balansa 2880* (**P**); Mt. Ba Vi, 12 June 1888, *Balansa 2877* (**P**) – Ken Giang: Dao Tho Chu, 9 April 1987, *Bin 1075* (**HN**); Phu Quoc Is., 1874, *Pierre s.n.* (GH, P); Phu Quoc Is., January 1874, *Pierre s.n.* (**P**) – Kon Tum: Huyen Sa Thay, 17 November 1976 , *Dung 323* (**HN**); Huyen Sa Thay, 16 November 1978, *T.D.Dai 222* (**HN**) – Lam Dong: 27 February 1954, *Schmid VN 1368* (**P**); 1959, *Schmid s.n.* (**P**); Bao Loc, *Schmid VN 1390* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 11 June 1970, *Anon. s.n.* (**HN**) – Son La: Xuan Nha, November 2003, *Phuong 7187* (**HN**) – Tay Ninh: Ben Tranh, April 1866, *Pierre s.n.* (**P**).



Map 16. Distribution of *Syzygium claviflorum* (Roxb.) Wall ex Steudel in Cambodia, Laos and Vietnam.



Plate 5.12. Icon of *Syzygium claviflorum* (Roxb.) Wall ex Steudel from Roxburgh's *Flora Indica* (1832) (Image courtesy of Royal Botanic Gardens, Kew, 2006).



Plate 5.13. Lectotype of *Eugenia baviensis* Gagnep.

19. *Syzygium corticosum* (Lour.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 105 (1938); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 903 (2003) – *Eugenia corticosa* Lour., Fl. Cochinch. 1: 308 (1790), ed. Willd. 376 (1793);

Moore, J. Bot. 63: 283 (1925); Merrill, E.D. Comm. Fl. cochinch. Trans Amer. Philos. Soc. 24(2): 284 (1935) − *Myrtus corticosa* Spreng., Syst. 2: 488 (1825). **Type**: Cochinchina [Vietnam], Hue, *Loureiro s.n.* (holotype **BM**!).

Tree 17 m tall, 25 cm dbh. Glabrous on all parts. **Twig** terete and sometimes compressed, c. 1.5 mm diameter, slender, surface smooth, brownish, old twig whitish, not contrasting to leaf colour. **Leaves** opposite, 5.5 − 12 × 3.0 − 7.0, 1.6 to 4 times as long as wide, elliptic, base attenuate, c. 30 degrees from midrib, apex acuminate, acumen c. 0.5 cm, 1/11 − 1/17 of blade length, tip deflexed, blade chartaceous, pale brownish to greenish; midrib sunken above, raised below; secondary veins (Type A.II) 8 − 10 per side per blade, broadly spaced, 4 − 10 mm apart, c. 60 degrees from midrib, faint and raised above, prominent below; tertiaries faint, reticulate; inner intramarginal veins distinct, c. 2 − 0.5 mm from margin, looped, outer intramarginal veins prominent; petiole, 0.8 − 1.2 cm, 1/5 − 1/7 of blade length, 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal and axillary near apex of leafy twig, 5.5–7 cm long, paniculate, to second order branching, many flowers, c. 65, not compact; axes 5.5–7 mm long, angular; bracts and bracteoles caducous. **Flower** sessile, small, hypanthium, not glaucous, not fibrous, 2.5 × 1.5 mm, obconic, pseudostalk c. 1 mm long; sepals 4, free, c. 0.2 × 0.5 mm, undulating on hypanthium rim; petals 4, coherent, c. 1 × 1 mm, orbicular; stamens c. 1 mm long; anther 0.3 mm, sacs parallel, connective gland inconspicuous; style c. 2 mm, ovules c. 10 per locule, irregularly radiating. **Fruit** globose, 0.3 × 0.3 cm, surface smooth, calyx rim with smooth rim.

DISTRIBUTION: Thailand and Vietnam.

ECOLOGY OR HABITAT. Primary forest, to 950 m altitude.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD)

PHENOLOGY. Flowering: January, May, June.

VERNACULAR NAME(S): Cay tram boi (Vietnamese)

USES. Not documented.

NOTE.

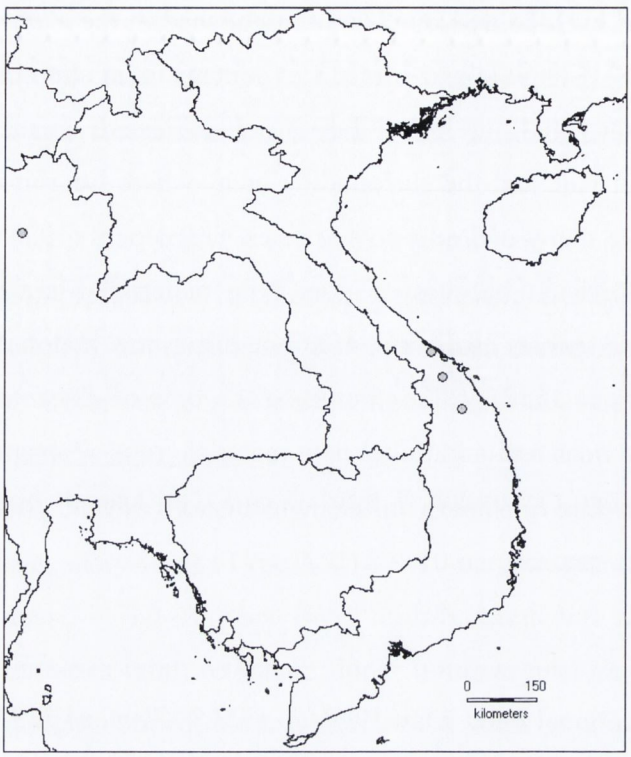
Eugenia corticosa was described by João de Loureiro and published in the *Flora Cochinchinensis* in 1790. In 1927, Chaplain and Mrs. J.C. Clemens in an attempt to gather representative specimens in Loureiro's *Flora Cochinchinensis*, made extensive botanical collections at Hue and the surrounding areas where Loureiro would have likely collected. Like many of Loureiro's species, Gagnepain (1920) omitted this species from his revision because of poor type material. Merrill (1935; 1938b) later reinstated the species as distinct after acquiring new material from Clemens' collection (*Clemens 3532*). After examining the type of *Eugenia corticosa* in **BM**, Clemens specimens and additional new material from Vietnam (*VN 1151*) and Thailand (*Maxwell J.F. 97-84*), I fully concur with Merrill that *Syzygium corticosum* is a distinct species.

SPECIMENS EXAMINED.

VIETNAM. Da Nang: Ba Na National Park, May 1927, *J. & M.S. Clemens 3532* (**BM**) – Quang Nam: Tra My, *N.Q.Binh & D.D.Cuong VN 1150* (**HN**) – Thua Thien-Hue: Hue, *Loureiro s.n.* (**BM**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND. Lampang: Chae Son, Chae Son National Park, 29 January 1997, *J.F.Maxwell 97-84* (**BKF**).



Map 17. Distribution of *Syzygium corticosum* (Lour.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

20. *Syzygium crassiflorum* Merr. & L.M.Perry, J. Arnold Arbor. 19: 114 (1938); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 903 (2003). **Type**: Vietnam, Annam, *Clemens 3831* (holotype **A** n.v. [barcode 71326]; isotype **K**!, **NY**!).

Tree. Glabrous on all parts. **Twig** terete, 4 – 5 mm diameter, stout, smooth or flaky, brownish, not contrasting to leaf colour**. Leaves** opposite, 27 – 38 × 3 – 6.5 cm, 5 to 9 times as long as wide, linear lanceolate, base strongly cordate, margin recurved, apex acute, blunt, no acumen, blade thickly coriaceous, pale greenish; midrib sunken above, raised below; secondary veins (Type A.II) 30 – 40 per side per blade, broadly spaced, 7 – 10 mm apart, 70 – 80 degrees ascending from midrib, prominent and raised on both surfaces; tertiaries prominent, reticulate; inner intramarginal veins c. 2 mm from margin, straight, outer intramarginal veins prominent; petiole 0.7 – 1 cm, 1/30 – 1/40 of blade length, 4 – 5 mm diameter, stout, brownish, not contrasting to blade colour**. Inflorescence** terminal, possibly solitary or racemose, few flowers , possibly one to three. **Flowers** reddish, large,

hypanthium not glaucous, not fibrous, c. 2.5 cm × 1 cm, pyriform, pseudostalk distinct, c. 1.5 cm long; sepals 4, free, unequal, inner lobe 2 × 1.7 cm, outer lobe 1.5 × 1 cm, semiorbicular; petals not seen; outer stamens 5 cm long, anthers 1 mm long, sacs parallel, connective gland inconspicuous. **Fruit** (immature) subglobose, 2.5 × 2.5 cm, surface smooth, calyx ring with persistent sepal lobes.

DISTRIBUTION: Laos and Vietnam.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering and Fruiting: May – July.

VERNACULAR NAME(S): Laos: Choum kieng pa (Xaignabouli). Vietnam: Tram hoa day.

USES.

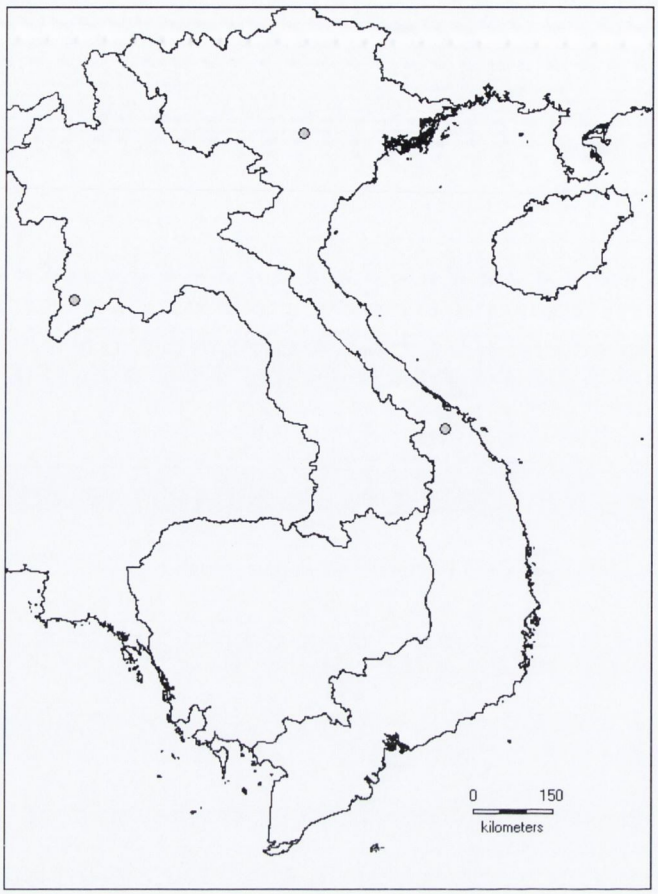
NOTES.

1. Merrill and Perry (1938b) described this species from an immature fruiting specimen. In this study, a flowering material (*d'Alleizette s.n.*) was found and added to the description. The large and lanceoloate leaves of this species is distinctive and resemble *S. tekuensis* from Peninsular Malaysia but this species has glabrous leaves and the latter species is velvety hairy.

SPECIMENS EXAMINED.

LAOS. Xaignabouli: Pak Lay, 7 January 1953, *Vidal 2118* (**P**)

VIETNAM. Da Nang: Ba Na National Park, May 1927, *J. & M.S. Clemens 3831* (**NY**) – Ha Tay: Mt. Ba Vi, July 1928, *d'Alleizette s.n.* (**L**).



Map 18. Distribution of *Syzygium crassiflorum* Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

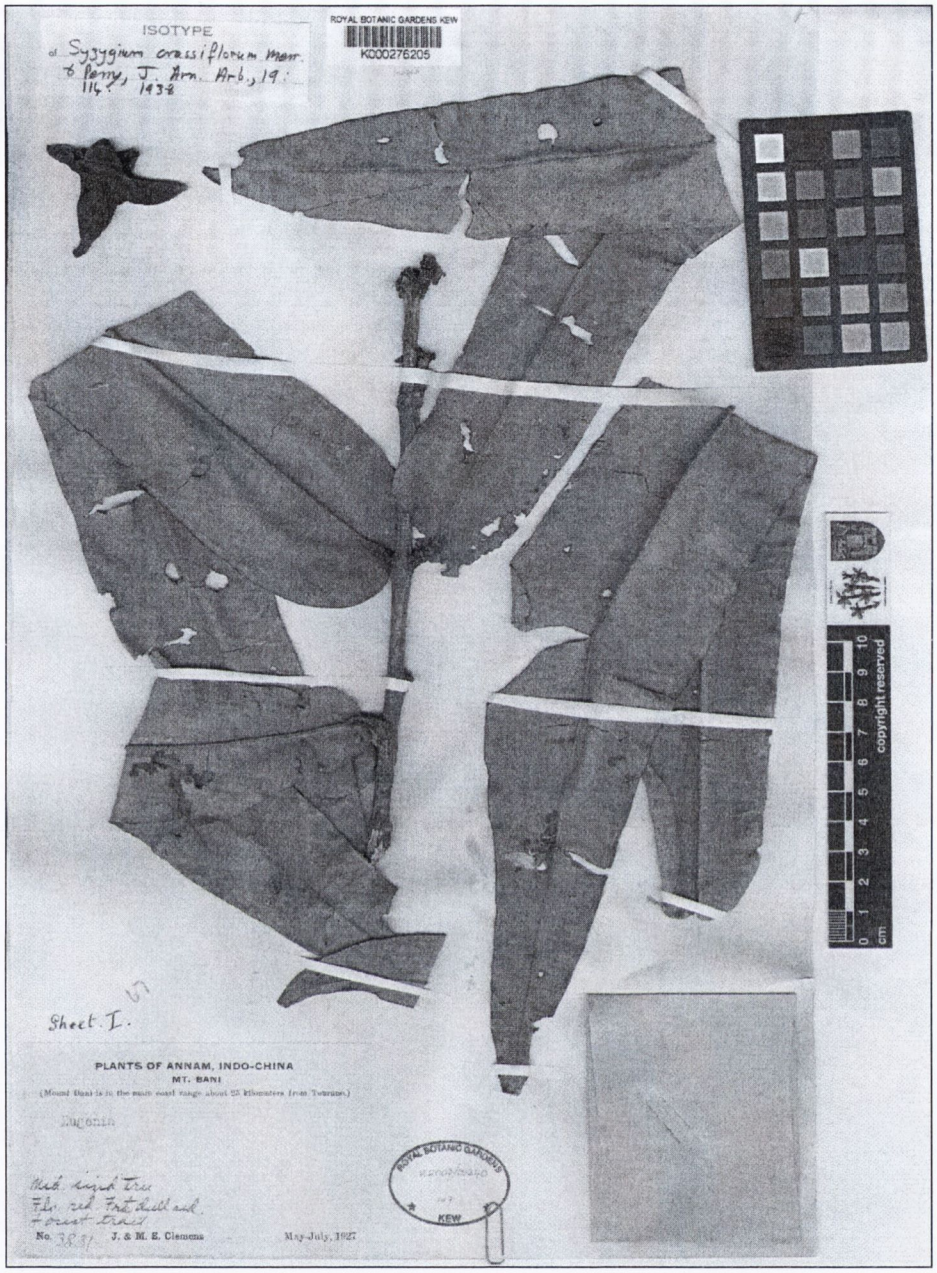


Plate 5.14. Isotype of *Syzygium crassiflorum* Merr. & L.M.Perry.

21. *Syzygium cucphuongense* W.K.Soh & J.Parn. sp. nov. **Type**: Vietnam, Ninh Binh, Nho Quan, Cuc Phuong National Park, 15 June 2001, *P.K.Loc PKL 10455* (holotype **CPNP**! [sheet no. 00587]; isotypes **CPNP**! [sheet no. 09334, 09309, 09310, 09307]).

[*Syzygium melanophyllum* auct. non H.T.Chang & R.H.Miao: D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 432 (2004). (fide type of *Syzygium melanophyllum* **:** China, Yunnan, *Y.F. Li 3376* (holotype **HITBC**!))]

A Syzygio melanophyllo folii apice mucronato (contra acuto gradatim contracto), ramulo atrobrunneo foliis concoloro (contra albido folii colore diferenti), nervo intramarginali interiore parum crenato (contra recto), fructu i.s. nigricanti (contra albido) differt.

Tree to 48 m tall, to 60 cm dbh. Bark smooth, whitish grey, slash bark dark reddish violet. Glabrous on all parts. **Twig** terete, 2 – 3 mm diameter, stout, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, 7.5 – 14 × 3.5 – 5.5 cm, 2 to 3 times as long as wide, elliptic, obovate or elliptic , base attenuate, 30 – 45 degrees ascending from midrib, margin flat, apex mucronate, acumen 0.3 – 0.5 cm, 1/17 – 1/35 of blade length, blade subcoriaceous, dark brownish, young leaves reddish (in vivo); midrib sunken above, raised below; secondary veins (Type A.II) 10 – 13 per side per blade, broadly spaced, 6 – 10 mm apart, 50 – 60 degrees from midrib, prominent and raised above, prominent below; tertiaries prominent, reticulate; inner intramarginal veins 2 – 3 mm from leaf margin, straight or slightly scalloped, outer intramarginal veins prominent or faint; petiole 1.5 – 2.5 cm, 1/5 – 1/6 of blade length, 1 – 1.5 mm diameter, stout, dark brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, to 8 cm long, paniculate, second order branching, flowers many, to 300, clustering at branch-end in 7 to 9 flowers; axes to c. 8 cm, angular, stout; bract and bracteoles caducous. **Flower** sessile, hypanthium not glaucous, not fibrous, c. 4 × 3 mm, obconic, pseudostalk distinct, c. 2 mm; sepals violet, 4, free, 1.5 × 2 mm, triangular; petals whitish, 4, free, 2 × 3 mm, suborbicular; outer stamens to 7 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style c. 5 mm, ovules c. 18 per locule, irregularly radiating. **Fruit** depressed globose, blackish, c. 1 × 1.5 cm, surface smooth, calyx ring with smooth to undulating rim; seed 1, subglobose, 0.5 × 0.4 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Vietnam, Cuc Phuong National Park.

ECOLOGY OR HABITAT. Primary lowland to hill forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: June. Fruiting: August, September.

ETYMOLOGY. The specific epithet is derived from the locality of Cuc Phuong in Vietnam.

VERNACULAR NAME(S). not documented

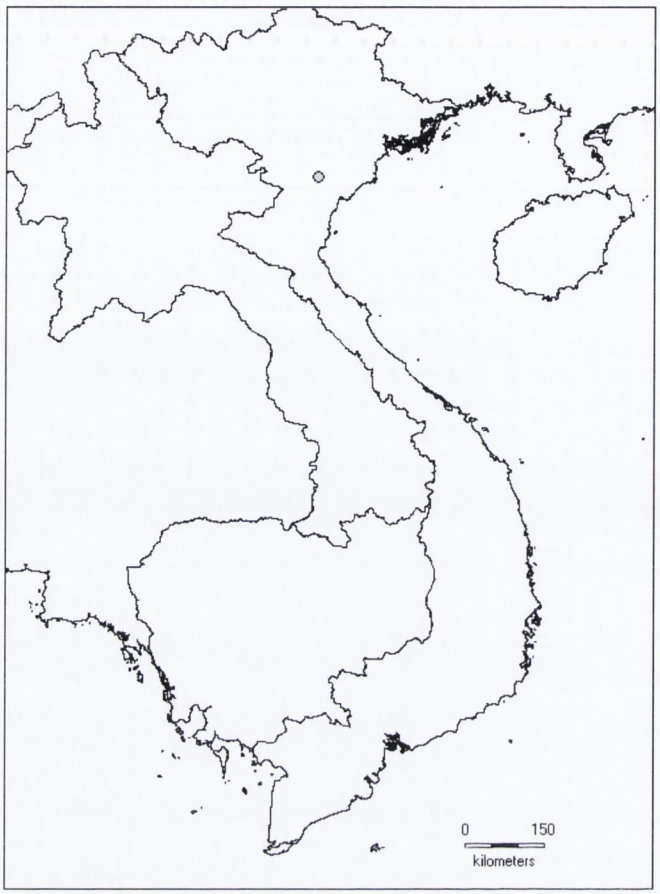
USES. Not documented

NOTES.

1. This species has been collected several times in the Cuc Phuong National Park, at lowland to hill forest and was misidentified as *Syzygium melanophyllum* H.T.Chang & R.H.Miao. The latter species is found in Yunnan at c. 1400 m. *Syzygium cucphuongense* differ from *S. melanophyllum* in having mucronate leaf apex (versus acute, tapering gradually), twig dark brownish in colour and not contrasting in colour with leaves (versus whitish and contrasting in colour with leaf), inner intramarginal vein slightly scalloping (versus straight), fruit in dried state blackish (versus whitish).

SPECIMENS EXAMINED.

VIETNAM. Ninh Binh: Nho Quan, Cuc Phuong National Park, 17 September 1999, *N.M.Cuong 530* (**GH**); 16 November 2000, *Nguyen Tien Hiep NTH 4269* (**CPNP**); 26 August 1999, *N.M.Cuong, H.L.Quyen & M.V.Xinh NMC 458* (**CPNP**); 15 June 2001, *P.K.Loc PKL 10455* (**CPNP**).



Map 19. Distribution of *Syzygium cucphuongense* W.K.Soh & J.Parn. in Cambodia, Laos and Vietnam.

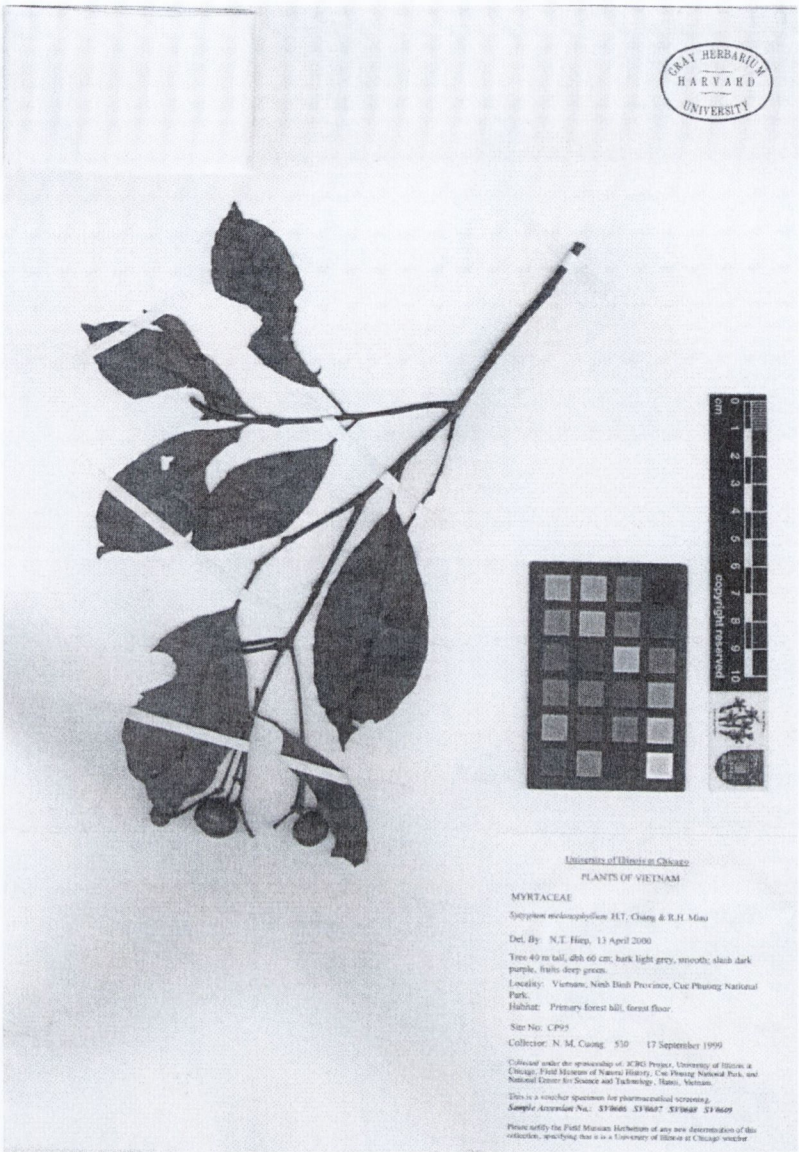


Plate 5.15. Paratype (*N.M. Cuong 530*) of *Syzygium cucphuongense* W.K.Soh & J.Parn.

22. *Syzygium cumini* (L.) Skeels, U.S. Dept. Agr. Bur. Pl. Ind. Bull. 248: 25 (1912); Alston, Hanb. Fl. Ceyl. 6 (Suppl.): 116 (1931); Merr. & L.M.Perry, J. Arnold Arbor. 19: 108 (1938); Backer & Bakh.f., Fl. Java 1; 340 (1963); Kosterm., Quat. J. Taiwan Mus. 34: 134 (1981); N.P. Balakr., Fl. Jowai 1: 199 (1981); P.S. Ashton in Dassan. & Fosberg, Fl. Ceylon 2: 443 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 349 (1985); A.J.Scot, Fl. Masc. 92: 40 (1990); D.G. Long & Rae in Gierson & D.G. Long, Fl. Bhutan 2: 284 (1991); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 45, fig. 3721 (1992) [as *S. cumini* (L.) Druce,

nom. illeg.]; W.M. Verheij & R.E. Coronel (eds.), Prosea 2, Edible Fruit: 294-296 (1992); V.D.Nguyen, Medicinal plants of Vietnam, Cambodia and Laos: 286 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 56 (1994); M.C.Le & T.H.Le Forest Plants (Thực vật rừng): 319, fig. 270 (2000); P.Dy Phon, Plants used in Cambodia: 378 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 847 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 313 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 903 (2003); V.S.Hoang, N.Khamseng & P.J.A. Kessler, Blumea 49: 315 (2004); M.F.Newman et al., Checkl. Vas. Pl. Laos: 245 (2007); J. Chen & Craven, Fl. China 13: 355 (2007) – *Myrtus cumini* Linn. L., Sp. Pl.: 471 (1753) – *Calyptranthes cumini* (L.) Pers., Syn. Pl. 2: 32 (1806) – *Eugenia cumini* (L.) Druce, Rep. Bot. Exch. Club Brit. Isl. 3: 418 (1914); Merr. Interpr. Herb. Amboin. 394 (1917); Merr. Lingnan Sc. J. 5: 136 (1927); Craib, Fl. Siam. Enum. 1: 637 (1931); Corner, Wayside Trees Mal. 1: 496, fig. 168 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 182, fig. 35 & 52 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 247 (1978). **Type**: Sri Lanka, *Herb. Hermann 1: 45, No. 185*, right specimen [barcode BM000621389] (lectotype **BM**! designated by Kostermans op. cit. (1981: 134) & Verdcourt, Fl. Trop. East Africa: 72 (2001)). (see note 1).

– *Eugenia caryophyllifolia* Lam., Encycl. 1: 198 (1789); Roxb., Fl. Ind. 2: 486 (1832); Ic. Roxb. No. 1142, ined. [downloaded from Royal Botanic Gardens, Kew (2006)] – *Calyptranthes caryophyllifolia* (Lam.) Willd. (1796: 22) – *Syzygium caryophyllifolium* (Lam.) DC., Prodr. 3: 260 (1828) – *Eugenia jambolana* var. *caryophyllifolia* (Lam.) Duthie in Hook.f., Fl. Brit. Ind. 2: 499 (1879) – *Syzygium cumini* var. *caryophyllifolium* (Lam.) K.K.Khann, Fl. Bihar, Analysis: 199 (2001). **Type**: *Sonnerat & Séré s.n.*, in *Herb. Lamark* (holotype **P-LA**! [barcode P00297820]).

– *Syzygium pseudojambolana* Miq., Fl. Ned. Ind. 1: 458 (1855). **Type**: Java, Djokjokarta, *Herb. Junghuhn 33* (holotype **L**! [barcode L0329920]), **syn. nov.**

– *Eugenia jambolana* Lam., Encycl. 1: 198 (1789); Roxb., [Hort. Bengal.: 37 (1814), nom. nud.] Fl. Ind. 2: 484 (1932); Wight, Icon. Pl. Ind. Orient. 2: t. 535 (1843); Kurz, Forest Fl. Burma 1: 67 (1877); Kurz, J. Asiat. Soc. Bengal 46: 67 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 499 (1879); King, J. Asiat. Soc. Bengal 70: 131 (1901); King, Mat. Fl. Malays Penins. 12: 561 (1901); Brandis, Ind.

Trees: 323 (1906); Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 818 (1920); Ridl., Fl. Malay. Penins. 1: 754 (1922) – *Calyptranthes jambolana* (Lam.) Willd., Ann. Bot. (Usteri) 17: 23 (1796) – *Syzygium jambolanum* (Lam.) DC. Prodr. 3: 259 (1828); Wight & Arn., Prodr. Fl. Ind. Orient.: 329 (1834); Gamble, Fl. Pres. Madras 1: 481 (1919); A.M.Cowan & Cowan, Tree N. Bengal: 68 (1929). **Type**: Rumphius, Herb. Amboin. 1: 131, t. 42 (1741) lectotype here designated (based on *Jambolana* Rumph.).

– *Eugenia obovata* Poir. Encycl., Suppl. 3: 124 (1813) – *Myrtus obovata* (Poir.) Spreng., Syst. Veg. 2: 486 (1825) – *Syzygium obovatum* (Poir.) DC., Prodr. 3: 259 (1828). **Type**: La Réunion, *Bory s.n.* (holotype: **FI** n.v.). (fide A.J.Scot, Fl. Masc. 92: 40 (1990))

– *Jambolifera chinensis* Spreng., Syst. Veg. 2: 216 (1825) (fide Merr. & L.M.Perry, J. Arnold Arbor. 19: 230 (1938)).

– *Syzygium fruticosum* DC., Prod. 3: 260 (1828); A.M.Cowan & Cowan, Tree N. Bengal: 68 (1929); Merr. & L.M.Perry, J. Arnold Arbor. 19: 109 (1938); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 64 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 855 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); J.Chen & Craven, Fl. China 13: 355 (2007) – *Eugenia fruticosa* Roxb., [Hort. Bengal.: 37 (1814), nom. nud.] Fl. Ind. 2: 487 (1932); Wight, Icon. Pl. Ind. Orient. 2: t. 624 (1843); Kurz, Forest Fl. Burma 1: 485 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 499 (1879); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 843 (1920); Craib, Fl. Siam. Enum. 1: 642 (1931). **Type**: Chittagong, *Roxburgh s.n.* (lectotype **BM**! here designated, with a ticket in Wallich's handwriting '*Eugenia fruticosa*, Roxburgh'; isolectotypes **BR** n.v., **K-W**! (=Wallich 3559A?), **P**!, Ic. Roxb. No 1440 ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.)) , **syn. nov.** (See note 3)

– *Eugenia obtusifolia* Roxb. Fl. Ind. 2: 485 (1832); Wight, Icon. Pl. Ind. Orient. 2: t. 620 (1843) – *Syzygium obtusifolium* (Roxb.) Kostel., Allg. Med. – Pharm. Fl. 4: 1532 (1835) – *Eugenia jambolana* var. *obtusifolia* (Roxb.) Duthie in Hook.f., Fl. Brit. Ind. 2: 500 (1879) – *Syzygium cumini* var. *obtusifolium* (Roxb.) K.K.Khanna, Fl. Bihar, Analysis: 202 (2001). **Type**: Ic. Roxb. No. 2070, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.))

– *Eugenia brachiata* Roxb. Fl. Ind. 2: 488 (1832); Miq., Fl. Ind. Bat. 1: 460 (1855); Wight, Icon. Pl. Ind. Orient. 2: t. 626 (1843); Duthie in Hook.f., Fl. Brit. Ind. 2: 496 (1878). **Type**: Ic. Roxb. No. 1978, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.).

– *Eugenia calyptrata* Roxb. ex Wight & Arn., Prodr. Fl. Ind. Orient.: 329 (1834) [as syn. of *Eugenia jambolanum*, nom. nud]. **Voucher**: *Roxburgh s.n.*, (**K**! [*Herb. Bentham*], **BM**!, **BR** n.v., **P**!)

– *Eugenia tsoi* Merr. & Chun, Sunyatsenia 2: 291 (1935) – ***Syzygium cumini*** var. ***tsoi*** (Merr. & Chun) H.T.Chang & R.H.Miao Acta Bot. Yunnan. 4: 22 (1982); J. Chen & Craven, Fl. China 13: 355 (2007). **Type**: China, Hainan, Yaichow, Namshan Ling, *Tso 23006* (holotype **A** n.v. [barcode 69412]; isotypes **K**!, **NY**!).

– *Calyptranthes oneillii* Lundell, Bull. Torrey Bot. Club 64: 554 (1937) (fide Govaerts et. al. (2010))

– *Eugenia tenuis* Wall ex Duthie in Hook.f., Fl. Brit. Ind. 2: 500 (1879) – *Syzygium tenue* (Duthie) N.P.Balakr., Bull. Bot. Surv. India 22: 175 (1980 publ. 1982). **Type**: Nepal, Sukanaghar, *Hamilton 1165* in *Wallich Numer. List 3570* (lectotype **K-W**! here designated; isolectotype **E**!). (based on *Calyptranthes tenuis* Buch-Ham. MSS, nom. nud.)

– [*Jambolifera coromandelica* Houtt., Nat. His. 2,2: 275, fig. 2 (1774). **Type**: **L** n.v., not found] (see note 2)

– [*Jambolifera pedunculata* auct non L.: Houtt., Nat. His. 2,2: 273, fig. 1 (1774). **Type**: **L** n.v., not found] (see note 2)

– [*Jambolifera pendunculata* auct non L.: Lour. Fl. Cochinch. 230. 1790 (fide Merr. Comm. Fl. Cochinch. Trans Amer. Philos. Soc. 24(2): 220 & 284 (1935))] (see note 2)

– [*Calyptranthes capitellata* Buch.-Ham. ex Wallich, *Wallich Numer. List 3560D* (1831) (**K-W**!), nom. nud.]

– [*Eugenia frondosa* Wallich, *Wallich Numer. List 3560G* (1831) (**K-W**!), nom. nud.]

Tree to 35 m tall, 45 cm dbh. Bark unknown, slash bark unknown. Glabrous on all parts. **Twig** terete, *c.* 2 mm diameter, stout, smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 7–12 × 4–6 cm, 1–2 times as long as wide, elliptic or

obovate, base cuneate, 30 – 45 degrees from midrib, margin flat, mostly acuminate, sometimes obtuse, acumen to 0.5–0.7 cm long, 1/14–1/18 of blade length, chartaceous to subcoriaceous, light brownish to greenish; midrib sunken above, raised below; secondary veins (Type A.I) 20 – 30 pairs, narrowly spaced, 2–5 mm apart, ascending c. 50 degrees from midrib, faint and raised above, prominent below; tertiaries prominent, slender, reticulate; inner intramarginal veins prominent, 1–2 mm from leaf margin, straight, outer intramarginal veins faint; petiole 1.5–2 cm, 1/4–1/8 of blade length, 1–1.5 mm diameter, long, slender, brownish, not contrasting to blade colour. **Inflorescence** mostly lateral-axillary in axil of fallen leaves, rarely terminal, 4–9 cm long, paniculate, second to third order branching, first order branch spreading and long, second or third order branch very short, flowers many, 45–99, flowers often grouped in compact head at branch-end; axes 4 – 9 cm long, angular and smooth; bracteoles caducous, 0.5 × 1 mm, triangular. **Flower** sessile, cream or whitish (in vivo), hypanthium not glaucous, not fibrous, 2.5–3 × 2–2.5 mm, obconic, pseudostalk very short or indistinct, to 1 mm long; sepals 4, free, 0.3 – 1 × 0.5 mm, triangular; petals 4, coherent, 1.5 – 3 × 1.5 – 3 mm, orbicular; stamens 4 – 5 mm; anther 0.5 – 1 mm, sacs parallel, connective gland inconspicuous; style 2 – 5 mm, ovule irregularly radiating. **Fruit** globose to obloid-ellipsoid, 10 – 15 × 6 – 10 mm, smooth, blackish, calyx ring with smooth rim; seed 1, large, 7 – 10 × 4 – 6 mm, obloid, cotyledons fused, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread in the tropics and subtropics in Africa, Asia, Australia to the Pacific. In Indochina, it occur in Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. Primary or secondary forest, from lowland to montane forest, swamp and savannah, to 1200 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: March to December. Fruiting: July, December.

VERNACULAR NAME(S): Cambodia: Krian (Ratanakiri), Pring (Kampong Chhnang), Pring bai, Pring das krebey, Pring kom (Kandal), Pring thom (Kandal), Pring toeuk (Stung Treng). Laos: Hai kham (Xaignabouli), Ma va (Viangchan), Sa (Xieng Khouang), Sa leng, Va. Vietnam: Cay voi rung (Tonkin), Emao (Lam

Dong), Tram ba vo, Tram goi, Tram moc, Tram voi, Tram xe (Tay Ninh), Voi rung.

USES. Fruits and young leaves are eaten by the local. Wood is used for fuel, construction and carpentry. Fruit decoction is used to treat stomach ache. M.C. Le & T.H. Le, 2000). Decoction of leaves, wood and fruit is used as antidiabetic medicine (Dy Phon, 2000). Juice from leves is used to treat dysentery and cleaning wounds (Hoang et al., .A. Kessler, 2004). (for other usages see Verheij & Coronel (1992))

NOTES.

1. Kostermans (1981) designated *Herb. Herman* material as the type, but he overlooked the fact that Scott (1990) had already designated a lectotype, 637.10 (LINN). However, Chantaranothai & Parnell (1994b) pointed out that the type designated by Scott is not *S. cumini*. Verdcourt (2001) made a second step lectotypification of Kostermans' typificiation, to two undifferentiated sheets in Herman's herbarium.

2. In the protologue, the description provided by Houttuyn is for a member of the Rutaceae: it is likely that he had used Linnaeus' species name and description of *Jambolifera pedunculata* which is actually *Acronychia laurifolia* (Rutaceae), but the drawing he gave was of *S. cumini*. In the same publication, the description and plate for *Jambolifera coromandelica* Houtt. is not *S. cumini* but possibly Solanaceae or Sapotaceae. The same goes for Loureiro's *Jambolifera penduculata*, which is just a case of a misapplied name. (for further discussion on *Jambolifera pendunculata* Linn. see Merr. Interpr. Herb. Amboin. 394 (1917)).

3. *Syzygium cumini* is a widespread species and is found in the wild and in cultivation. The consumption of the fruits by the local people in Southeast Asia was documented as early as the sixteenth century by Lamark (1789) and Rhumphius (1741) and could possibly imply that the species was already in cultivation before that. At present, *S. cumini* is widely cultivated throughout its range in the tropics and subtropics, and to date, many cultivars have been created (Verheij & Coronel, 1992). Therefore it is not surprising to see wide morphological variation with gradation in the leaves and fruits of *S. cumini* in term of their size, colour and shape. As a result of this, many new species have been described by various authors based on these subtle and overlapping

morphological variations of the leaf and fruit. For example, Roxburgh (1832) recognised four distinct species: *Eugenia caryophylifolia* Lam., *E. jambolana* Lam., *E. obtusifolia* Roxb. and *E. fruticosa* Roxb. Duthie (1879) later sunk two of the species (*Eugenia caryophylifolia* Lam. and *E. obtusifolia* Roxb.) as variety of *E. jambolana* Lam. and recognised an additional new species, *Eugenia tenuis* Wall ex Duthie. In my opinion, it is best to treat these morphological variations as infraspecific variations (subspecies, variety or form). However, in this study, I will not deal with these issues as it is more of a monographic task that will require extensive field observations covering the species geographical range.

4. In the *Flore générale de l'Indochine* account, *Syzygium fruticosum* was represented by a single collection from *Kerr 625* (**TCD**!), Chiang Mai, Thailand. Due to insufficient information, Gagnepain (1920) excluded this species from the species key. The original understanding of *S. fruticosum* by Roxburgh (1832) and followed closely by Duthie (1879), is that it differs from the typical *S. cumini* in being a shrub (versus tree), in having globose fruit (versus oblong fruit) and a shorter petiole. Over the years, the species concept of *S. fruticosum* seems to have changed or expanded since it was first described by Roxburgh in 1832. For example, in Thailand *S. fruticosum* is a tree to 12 m tall; it differs from *S. cumini* in its decurrent leaf base, shorter and prominently angled peduncle and shorter pseudostalk (Chanaranothai & Parnell, 2002). In China, *S. fruticosum* differs from *S. cumini* in its obconic flower bud (versus obovoid or subglobose) and narrower leaves (Chien & Craven, 2007). I consider *S. fruticosum* conspecific to *S. cumini* in having the same flower morphology, leaf venation and inflorescence type. The range of other morphological variation observed in *S. fruticosum* falls within that of *S. cumini*.

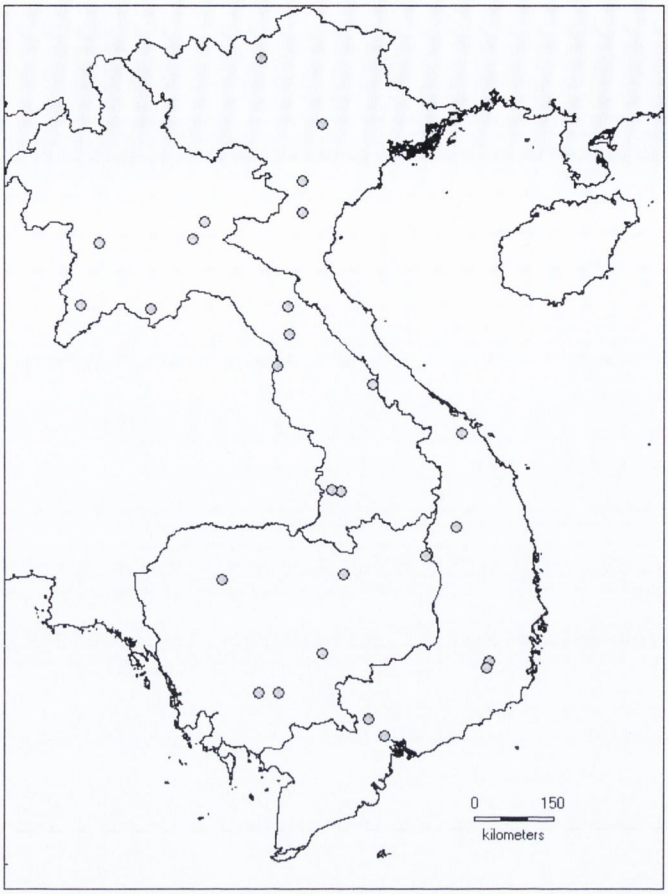
SPECIMENS EXAMINED.

CAMBODIA. s. loc., December 1876, *Harmand Pierre 3190* (**P**); s. loc., April 1870, *Pierre 989* (**BM**); s. loc., 19 May 1924, *Herbier Forestier du Cambodge 504* (**P**); s. loc., *Bejaud 559* (**P**); s. loc., *Bejaud 363* (**P**); s. loc., 27 April 1907, *Magnen, Gourgand & Chatillion s.n.* (**P**); s. loc., April 1907, *Petelot s.n* . (**P**) – Kampong Chhnang: *Chevalier 32026* (**P**); 2 December 1917, *Chevalier 35782* (**P**) – Kampot: March 1914, *Chevalier 31770* (**P**) – Kandal: Phnom Penh, 10 July 1933, *Bejaud 562* (**P**); Phnom Penh, *Bejaud 570* (**P**) – Kompong Speu: Samraong

Tong, April 1879, *Pierre 989* (**P**) – Ratanakiri: Bantuk, 1 September 1969, *M.A.Martin 1404* (**P**); Bantuk, 9 January 1969, *M.A.Martin 1404* (**P**) – Siem Reap: Angkor Thom, *Thorel* (**P**) – Stung Treng: Thala Barivat, 26 July 2000, *M.Monyrak 169* (**K**).

LAOS. 17 March 1956, *Tixier 9* (**P**) – Attapeu: Bolaven plateau [Attopeu plateau], *Harmand s.n.* (**P**) – Bolikhamxai: Khamkeuth, Ban Namphao, 22 April 2000, *D.D.Soejarto, S.Bouamanivong, M.Sensanang & S.Vorasing 11378* (**P**) – Champassak: *J.F.Maxwell 98 -431* (**L**) – Khammouan: Ban Phong Tiou, 12 April 1950, *Vidal 1209* (**P**); Nakai, 23 May 2006, *K.Nanthavong & C.E.Ridsdale BT 493* (**E**) – Savannakhet: Ban Chai, 20 May 1949, *J.E.Vidal 947 B* (**P**) – Viangchan: Muang Ban, 27 March 1932, *Kerr 21278* (**L**); Tha Ngon, 13 November 1949, *Vidal 1122 B* (**P**) – Xaignabouli: , 1 February 1965, *Vidal 4283* (**P**); Pak Lay, *Thorel s.n.;* (**P**) – Xieng Khouang: Xieng Khouang, April 1952, *Vidal 2202* (**P**).

VIETNAM. s. loc., 20 April 1923, *Service General des Foret 7* (**P**); s. loc., *Pierre s.n.* (**P**); Lang An, 2 April 1964, *Schmid, M. s.n.* (**P**); Lang Hanh, 19 September 1965, *M.A.Martin 958* (**P**) – Cochinchina: *Pierre s.n.* (**BM**, **P**); *Talmy s.n.* (**P**) – Hao Binh: 5 May 1938, *Petelot 6394* (A) – Ho Chi Minh City: *Thorel s.n.* (**P**) – Kontum: Dak Poko river, 30 March 1995, *Averyanov* et al. *VN 1010* (**P**) – Lam Dong: Mt. Lang Bian, 24 April 1919, *Chevalier 40296* (**P**); Da lat, March 1932, *Squires 925* (**BM**, **K**); Dalat, *Schmid 1000* (**P**) – Quang Nam - Da Nang: Mt. Bana, May 1927, *J. & M.S. Clemens 4040* (A, **BM**, K) – Tay Ninh: Cai Cong, 23 April 1866, *Pierre s.n.* (**P**) – Tonkin: Mu Cua, 23 August 1892, *Bon 5643* (**P**) – Vinh Phuc: Vinh Yen, April 1931, *Petelot 4679* (**P**).



Map 20. Distribution of *Syzygium cumini* (L.) Skeels in Cambodia, Laos and Vietnam.

23. *Syzygium diospyrifolium* (Wall. ex Duthie) S.N.Mitra, Indian Forester 99: 100 (1973); N.P. Balakr., Fl. Jowai 1: 200 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 395 (1985); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 57 (1994); I.M.Turner, Gard. Bull. Singapore 47: 374 (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: 849 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003) – *Eugenia diospyrifolia* Wall. ex Duthie in J.D.Hooker, Fl. Brit. India 2: 472 (1878); Brandis, Ind. Trees: 318 (1906); Craib, Fl. Siam. Enum. 1: 638 (1931); M.R.Henderson, Gard. Bull. Sing. 12: 67, fig. 13a (1949); Kochummen in Ng, Tree Fl. Mal. 3: 190 (1978) – *Jambosa diospyrifolia* (Wall. ex Duthie) C.E.C.Fisch., Rec. Bot. Surv. India 12: 95 (1938) – *Syzygium diospyrifolium* (Wallich ex Duthie) K.N. Bahadur & R.C. Gaur, Indian J. Forest 1: (1978), nom.

illeg.. superfl. **Type**: Bangladesh, Silhet, *Wallich Numer. List 3617* (lectotype **K**! [*Herb. Hooker*] here designated; isolectotype **K**! [*Herb. Bentham*], **K-W**!).

– *Eugenia diospyrifolia* var. *lanceolata* Craib, Fl. Siam. 1: 639 (1931), sphalm., non *Jambosa* lanceolata Korth., Ned. Kruidk. Arch. 1: 199 (1846), (fide type: Sumatra, G. Melintang, *Korthals s.n.* (holotype: **L**! [barcode L0009610]). **Voucher**: Thailand, Pattani, Betong, *Kerr 7688* (**K**!). (see note 1)

– [*Eugenia formosa* Wallich var. ternifolia auct. non (Wallich) Masam.: Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 837 (1921), quoad specim. *Balansa* 2865, *Chevalier 37702* and *Eberhardt 4532*. (see *Syzygium formosum*).]

Tree 3 – 10 m tall, to 20 cm dbh. Bark smooth greyish. Glabrous on all parts. **Twig** angular (3-angled) towards node, terete at internode, 2 – 3 mm diameter, slender, surface smooth, brownish to whitish, not contrasting to leaf colour. **Leaves** verticillate in whorls of three, rarely opposite, 11 – 18.5 × 3 – 7.5 cm, 2 to 5 times as long as wide, oblanceolate or elliptic, base cordate, margin wavy, apex acute without distinct acumen, blade chartaceous to subcoriaceous, greenish brown; midrib sunken above, raised below; secondary veins (Type A.II) 10 – 14 per side per blade, 10 – 15 mm apart, c. 45 degrees or more ascending from midrib, prominent and raised above, prominent below; tertiaries prominent, reticulate; inner intramarginal veins 2 – 5 mm from leaf margin, looped, outer intramarginal veins prominent; petiole 0.3 – 0.5 cm, 1/30 – 1/60 of blade length, 1 – 2 mm diameter, not contrasting to blade colour. **Inflorescence** usually terminal, rarely axillary on leafy twig, 4 – 5 cm long, racemose, flowers few, 3 to 7, arranged in whorls of three; axes 1 – 2 cm, subangular to terete; bract and bracteoles persistent, triangular, bracteoles 1 × 1 mm. **Flower** big, pedicellate, pedicel 1.5 – 2.5 cm long, hypanthium not glaucous, not fibrous, 15 – 20 × 15 – 20, pyriform, pseudostalk distinct or indistinct, tapering gradually, 1 – 5 mm long; sepals reddish green, 4, free, semiorbicular, outer sepal 2 – 3 × 4 mm, inner sepals 5 × 7; petals white, 4, free, 9 – 12 × 9 – 12 mm, orbicular; outer stamens c. 2 cm, anthers c. 1.5 mm , sacs parallel, connective gland conspicuous; style 3 – 5 mm, ovules 30 – 35 per locule, irregularly radiating. **Fruit** globose (immature, based on Thailand: specimens) subglobose, 1.8 × 2 cm, surface smooth, calyx

ring with persistent sepal lobes; seed 1, subglobose, 1.5 × 1 cm, cotyledon free, intercotyledonary intrusion absent.

Distribution: India, Myanmar, Peninsular Malaysia, Thailand, Cambodia and Vietnam. Possibly occurs in Laos but not yet collected there.

ECOLOGY OR HABITAT. In lowland forest, to 350 m alt.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: March, May, August, September.

VERNACULAR NAME(S): Vietnam: Cay doi (Phu Tho), Cay quoi (Bac kan).

USES. Fruits edible and sold in the market.

NOTES.

1. Craib (1931) referred *Kerr 7688* to *Jambosa lanceolata* Korth as a variety of *S. diospyrifolium* under var. *lanceolata*. In my opinion, these two are different species. The type of *Jambosa lanceolata* differs from *S. diospyrifolium* in having longer and narrower leaves and strongly winged and auriculate twigs, while in *S. diospyrifolium* the twig is terete and the leaves are shorter and broader.

2. *Syzygium diospyrifolium* and *S. formosum* are closely related. They are similar in having verticillate terminal leaves, a cordate leaf base and racemose inflorescence with large flowers. Anatomically, they are closely related in having circular leaf vascular bundle, as opposed to arc vascular bundles that are typical in *Syzygium*. However, *S. diospyrifolium* differs from *S. formosum* in having smaller leaves (versus bigger leaves), leaves greenish (versus brownish) in colour and a terminal or axillary inflorescence on leafy twigs (versus lateral-axillary on axil of fallen leaves).

SPECIMENS EXAMINED.

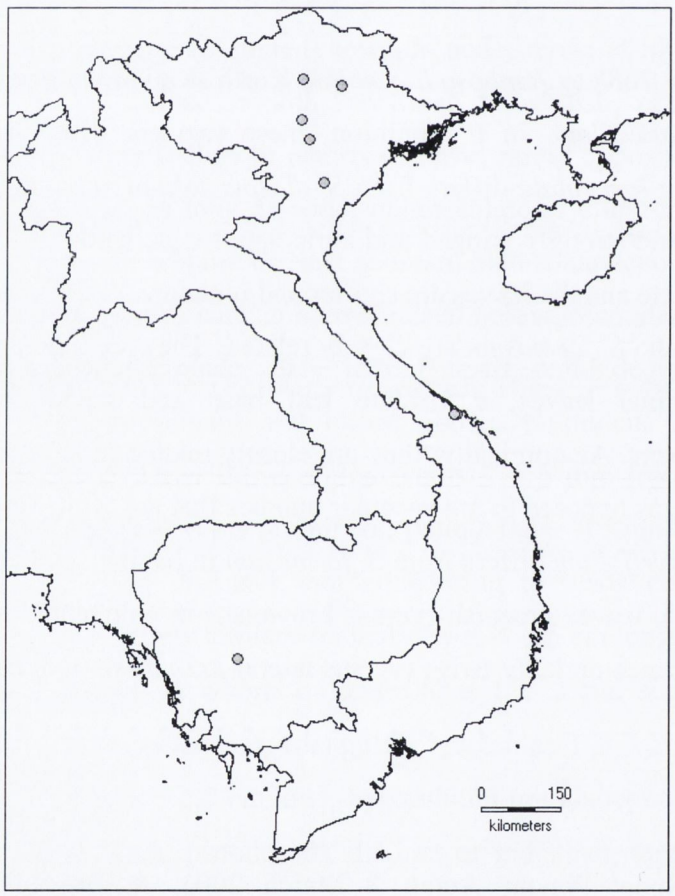
CAMBODIA. Kampong Spoe: Phnum Aural, 8 March 2001, *K.Enghourt, M.Sophal & S.Kosal MoE Herb. Cat. 661* (**K**).

VIETNAM. *S. loc.*, 15 May 1998, *Franck VN 381* (**HN**) − Bac Kan: Cho Moi, *Eberhardt 4532* (**P**) − Ha Tay: Mt. Ba Vi, Lankok valley, 16 April 1888, *Balansa 2865* (**K**, **P**) − Phu Tho: Chan Moung forest reserve, 18 April 1914, *Chevalier 30093* (**P**) − Ninh Binh: Nho Quan, Cuc Phuong National Park, *Anon. 10369*

(**CPNP**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, *Anon. 10369* (**CPNP**) – Thua Thien – Hue: 19 March 1980, *Thai & Thuan 553* (**HN**); Phu Loc, 2 September 1980, *Phuc 81* (**HN**); Phu Loc, 28 August 1980, *Thai & Thuan 657* (**HN**) – Tuyen Quang: Hui La forest reserve, 8 May 1918, *Chevalier (Fleury) 37702* (**P**).

ADDITIONAL SPECIMENS EXAMINED (fruit in species description).

THAILAND. Petchaburi: Kaeng Krachan National Park, 3 may 1998, *Wongprasert s.n* (**BKF**) – Trang: Khao Chong National Park, 9 July 2000, *Middleton D.J., Boonthavikoon T., Davies S.J., C.Hemrat & M.F.Newman 354* (**BKF**).



Map 21. Distribution of *Syzygium diospyrifolium* (Wall. ex Duthie) S.N.Mitra in Cambodia, Laos and Vietnam.



Plate 5.16. Inflorescence of *Syzygium diospyrifolium* (Wall. ex Duthie) S.N.Mitra. Photo by Pranom Chantaranothai.

24. *Syzygium fastigiatum* (Blume) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 152 (1939); Merr., Philipp. J. Sci. 79: 389 (1950); Backer & Bakh.f., Fl. Java 1; 339 (1963); T.G. Hartley & L.M.Perry. J. Arnold Arbor. 54: 204 (1973); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 60 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 851 (2002); I.M.Turner, Gard. Bull. Singapore 47: 375 (1995); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 904 (2003); M.F.Newman et al., Checkl. Vas. Pl. Laos: 245 (2007) − *Calyptranthes fastigiata* Blume, Bijdr.: 1090 (1826) − *Caryophyllus fastigiatus* (Bl.) DC. Prod. 3: 262 (1828); Miq., Fl. Ind. Bat. 1: 465 (1855) − *Eugenia fastigiata* (Bl.) Koord. & Valeton, Med. 40: 104 (1900); M.R.Henderson, Gard. Bull. Sing. 12: 190 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 191 (1978). **Type**: *S. loc.* [Java], annotation by Blume *'Calyptranthes fastigiata, 2188/a, 1826', Blume s.n.* (holotype **L**! [Sheet No. 908.146-1771]).

− *Calyptranthus floribunda* Bl., Bl., Bijdr: 1091 (1826) − *Caryophyllus floribundus* (Bl.) DC, Prodr. 3 (1828) 262; Korth., Nederl. Kruick. Arch. 1: 198 (1847); Miq., Fl. Ind. Bat. 1: 465 (1855) − *Eugenia confertiflora* Koord. &

Valeton, Med. 40: 106 (1900), nom. nov., nom. illeg. non A. Gray (1854). **Type**: Java, *Blume s.n.* (holotype **L**! [barcode L0009426]).

– *Eugenia bracteolata* Wight, Ill. Ind. Bot. 2: 15 (1841), in Icon. Pl. Ind. Orient. 2: t. 531 (1843); Kurz, Forest Fl. Burma 1: 482 (1877), in J. Asiat. Soc. Bengal 46: 66 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 488 (1878); King, J. Asiat. Soc. Bengal 70: 122 (1901); King, Mat. Fl. Malays Penins. 12: 552 (1901); Brandis, Ind. Trees: 324 (1906); Gagnep. in Lecomte, Fl. Gén. Indo – Chine 2: 815 (1920); Ridl., Fl. Malay. Penins. 1: 747 (1922), in Ridl., in J. Bot. 68: 35 (1930); Craib, Fl. Siam. Enum. 1: 633 (1931) – *Acmena bracteolata* (Wight) Walp., Repert. Bot. Syst. 2: 181 (1843) – *Syzygium bracteolatum* (Wight) Masam. Enum. Phan. Born.: 524 (1942), nom. illeg..; P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 47, fig. 3728 (1992) **Type**: Myanmar, Mergui, *Anon. s.n.* (presumely by Griffith) (holotype **K**! [*Herb. R. Wight., Prop.* 'Myrtaceae, Feb 1835', annotated by Wight. E.A. bracteolate RWIll]; isotype **K**! [*Herb. Hooker*, 'Mergui Griffith' annotated by Hooker]). (fide Noltie (2005: 357))

– *Eugenia sablanensis* Elmer, Leafl. Philipp. Bot. 1: 328 (1908). **Type**: The Philippines, Luzon, Benguety Province, Boguis, March 1907, *Elmer 8879* (holotype **PNH**†; isotypes **A** n.v. [barcode 69776], **K**!).

– *Eugenia bibracteata* Greves, J. Bot. 61(Suppl.): 18 (1923) – *Syzygium bibracteatum* (Greves) Merr. & L.M.Perry, J. Arnold Arbor. 23: 249 (1942). **Type**: New Guinea, Sogere, Mt. Wori wori, *Greves 729*, (holotype **K**!; isotypes **BM**!, **A** n.v. [barcode 69584]).

– *Eugenia elmeri* Merr., Univ. Calif. Publ. Bot. 15: 218 (1929) – *Syzygium elmeri* (Merr.) Masam., Enum. Phan. Born.: 528 (1942). **Type**: Malaysia, Sabah, near Tawau, Elphinstone province, October 1922 to March 1923, *Elmer 21448* (**PNH**†; isotypes **GH** n.v. [barcode 69484], **K**!, **L**! [barcode L000924]).

Tree to 20 m tall, 45 cm dbh. Bark unknown; slash bark unknown. Glabrous on all parts. **Twig** angular (4-angled) and winged, c. 3 mm diameter, stout, surface smooth, occasionally lenticellate, brownish, not contrasting to leaf colour. **Leaves** opposite, 11.5 – 16.5(– 27) × 4.5 – 7 cm, 2 times as long as wide, obovate, base, strongly attenuate, margin flat, apex shortly acuminate, mostly rounded or obtuse, acumen if present to 1 mm long, 1/100 of blade length, blade coriaceous, brownish, pale below; midrib flat above, raised and angled below; secondary

veins (Type A.I) 28 – 30 per side per blade, narrowly spaced, 2 – 3 mm apart, spreading, c. 60 degrees from midrib, prominent and raised on both surfaces; tertiaries faint, reticulate; inner intramarginal veins c. 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.5 – 0.7 cm long, 1/14 – 1/16 of blade length, c. 1 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal, 7.5 – 10.0 cm long, paniculate, flat-top, second order branching, many flowers , to 135, dense; axes 7.2 – 9.7 cm long, angular; bract and bracteoles persistent and triangular, bract 1.5 × 1 mm, bracteoles 1 ×1 mm. **Flower** pedicellate, pedicel c. 1 mm long, hypanthium not glaucous, not fibrous, 2.5 – 3 × 2 mm, obconic, pseudostalk indistinct, very short, c. 1 mm or less; sepals 4, free, 0.5 – 0.6 × 0.5 – 0.7 mm, semiorbicular; petals 4, coherent, 1.5 – 2 × 1.5 – 2 mm, orbicular; outer stamens 2 – 2.5 mm long, anthers 0.5 mm long, sacs parallel, connective gland conspicuous; style 1 mm long, ovules c. 5 per locule, irregularly, radiating. **Fruit** ellipsoid (immature fruit), 0.6 × 0.5 cm, surface smooth, brownish, calyx ring with persistent sepal lobes, lobed; seed 1, ellipsoid, 0.5 × 0.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread from India, China , Southeast Asia to Papua New Guinea. In Indochina found in Vietnam and probably in Cambodia and Laos but not yet collected there.

ECOLOGY OR HABITAT. In primary forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: March.

VERNACULAR NAME(S). Tram tieu diep (Vietnam).

USES. Wood is used for house building and light construction (R.H.M.J. Lemmens, I.Soerianegara & W.C. Wong, 1995).

NOTES.

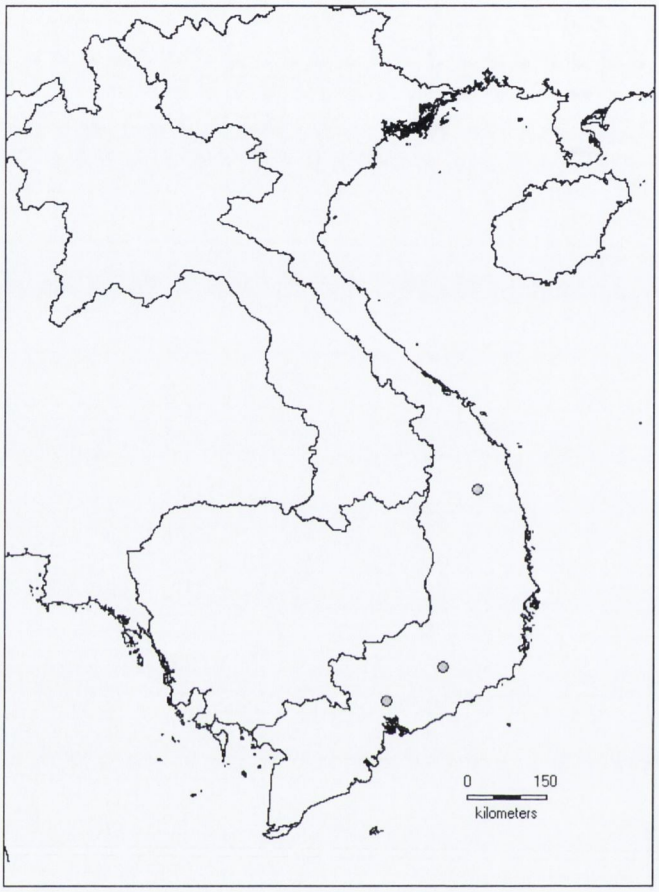
1. This is a widespread species but undercollected in Indochina.

SPECIMENS EXAMINED.

VIETNAM. Cochinchina: *Pierre s.n.* (**K**, **P**) – Dong Nai: Bien Hoa, March 1877, *Pierre s.n.* (**P**) – Lam Dong: Bao Loc, *Schmid s.n.* (**P**) – Kon Tum: Phuong 1231 (**HN**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND. Narathiwat: Sungai Kolok, 28 February 1974, *K. & S.S. Larsen BKF 70849* (**BKF**) – Surah Thani: February 1930, *Kerr 18155* (**TCD**).



Map 22. Distribution of *Syzygium fastigiatum* (Blume) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

25. *Syzygium formosum* (Wallich) Masam., Enum. Phan. Born.: 528. 1942. N.P. Balakr., Fl. Jowai 1: 199 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 396 (1985); D.G. Long & Rae in Gierson & D.G. Long, Fl. Bhutan 2: 280, fig. 33i & j (1991); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 50, fig. 3737 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 62 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 852 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 904 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 430 (2004) – *Eugenia formosa* Wallich.,

Pl. Asiat. Rar. 2: 6, t. 108 (1830); Brandis, Ind. Trees: 317 (1906); Kurz, Forest Fl. Burma 1: 492 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 471 (1878); Craib, Fl. Siam. Enum. 1: 641 (1931) – *Jambosa formosa* (Wall.) G.Don, Gen. Hist. 2: 969 (1832) – [*Jambosa formosa* Wight, Ill. Ind. Bot. 2: 14 (1841), nom. nud.; Walp. Repert. 2: 191 (1843); Miq. Miq., Fl. Ind. Bat. 1: 412 (1855); A.M.Cowan & Cowan, Tree N. Bengal: 66 (1929)]. **Type**: Myanmar, Moulmein, *Wallich Numer. List 3609* (lectotype (**K-W**!) here designated; isolectotype **K**! [*Herb. Hooker*]).

– *Eugenia ternifolia* Roxb., [Hort. Bengal. 37 (1814), nom. nud.] Fl. Ind. ed. 1832, 2: 489 (1832); Wight, Icon. Pl. Ind. Orient. 2: t. 611 (1843) – *Jambosa ternifolia* (Roxb.) Walp. Repert. Bot. Syst. 2: 191 (1843) – *Eugenia formosa* Wall. var. *ternifolia* (Roxb.) Duthie in Hook Fl. Brit. Ind. 2: 471 (1878) [excl. *Wall 2309*, Silhet, **K**! = *S. malaccense*]; Gagnep, in Lecomte, Fl. Gén. Indo-Chine 2: 837 (1921), pro parte, incl. specim. *Pierre s.n.* (Mt. Chereer) and *Thorel s.n.* (cultivated) – *Syzygium ternifolium* (Roxb.) P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 59, fig. 3762 (1992). **Type**: Ic. Roxb. No 2495 ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.)).

– *Syzygium perakense* (King) I.M.Turner, J. Singapore Natl. Acad. Sci. 22-24: 22 (1996); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 29: 58 (2001); P.Chantaranothai & J.Parn., Fl. Thailand 7: 884 (2002) – *Eugenia perakensis* King J. Asiat. Soc. Bengal 70: 81 (1901); Ridl., Fl. Malay. Penins. 1: 726 (1922); M.R.Henderson, Gard. Bull. Sing. 12: 51, fig. 8 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 209 (1978). **Type**: Malaysia, Perak, Larut, February 1884, *King's collector 5595* (holotype **K**!; iso **BM**!, **P**!), **syn. nov.** (see note 1)

– *Jambosa mappacea* Korth., Ned. Kruidk. Arch. 1: 200 (1847) – *Syzygium mappaceum* (Korth.) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 164 (1939). **Type**: Borneo, *Korthal s.n.* (holotype **L**! [barcode L0009653]; isotype **L**! [barcode L0638268]). (see note 1)

Tree 5 – 7 m tall. Bark greyish, lenticellate. Glabrous on all parts. **Twig** angular (3-angled) towards node but not winged, terete at internode, 4 – 5 mm diameter, stout, surface smooth, greyish or whitish, not contrasting to leaf colour. **Leaves** verticillate in whorls of three, rarely opposite, 15 – 35 × 6 – 18 cm, 2 to 4 times as long as wide, usually oblanceolate or sometimes elliptic, base cordate, margin

wavy, apex acute, without distinct acumen, blade chartaceous to subcoriaceous, dark brownish to yellowish brown; midrib sunken above, raised below; secondary veins 13 – 14 per side per blade, 15 – 20 mm apart, accending c. 45 degrees or more from midrib, prominent and raised on both surfaces; tertiaries prominent, reticulate; inner intramarginal veins 4 – 5 mm from leaf margin, looped, outer intramarginal veins conspicuous; petiole 0.5 – 2 cm, 1/30 – 1/70 of blade length, 3 – 5 mm diameter, not contrasting to blade colour. **Inflorescence** lateral-axillary on axil of fallen leaves, 4 – 6 cm long, racemose, flowers few, 3 to 7, arranged in whorls of three; axes 1 – 2 cm, subangular to terete; bract and bracteoles persistent, triangular, bracteoles 1 × 1 mm. **Flower** big, pedicellate, pedicel 1.5 – 2.5 cm long, hypanthium not glaucous, not fibrous, 15 – 20 × 15 – 20, pyriform, pseudostalk distinct or indistinct, tapering gradually, 1 – 5 mm long; sepals reddish, 4, free, semiorbicular, outer sepal c. 4 × 7 mm, inner sepals c. 7 × 12; petals reddish, 4, free, 9 – 12 × 9 – 12 mm, orbicular; outer stamens c. 2 cm, anthers c. 1.5 mm , sacs parallel, connective gland conspicuous; style 4 – 5 mm, ovules 30 – 12 per locule, irregularly radiating. **Fruit** (based on Flora of Thailand account) depressed globose, 3 – 4 cm long, calyx ring with persistent sepal lobes.

Distribution: India, Bangladesh, Myanmar, Thailand, Cambodia, Vietnam, Peninsular Malaysia and Borneo. Possibly occurs in Laos but not yet collected there.

ECOLOGY OR HABITAT. Primary forest and swamp.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: April, May , October.

VERNACULAR NAME(S): Cambodia: Prinh ach romeang (Kandal). Vietnam: Tram dep, Tram chum ba, Tram dai loan.

USES. Fruit edible.

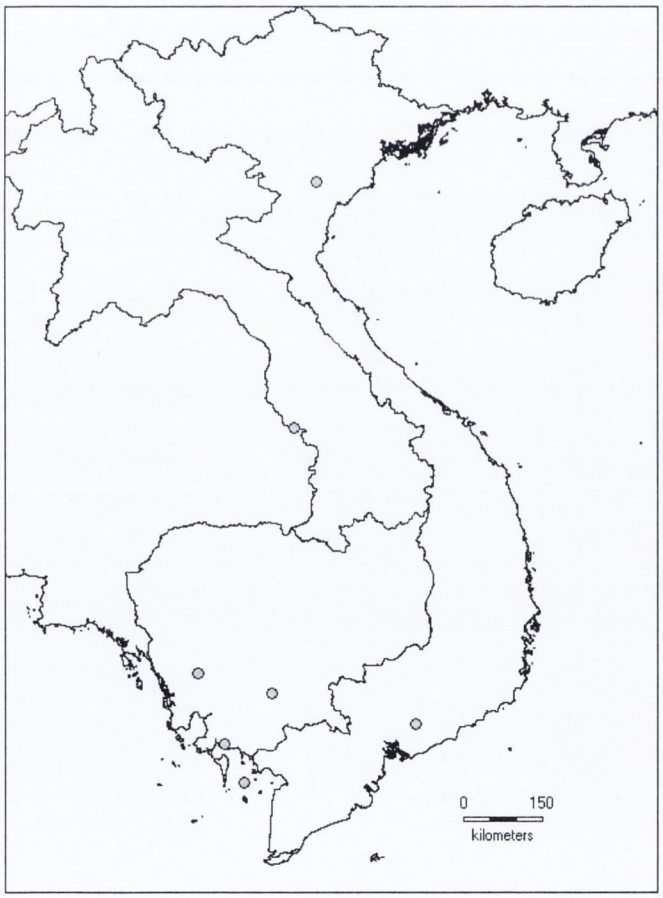
NOTES.

1. The type of *S. perakense* of Peninsular Malaysia and *S. mappaceum* of Borneo match with the type of *S. formosum* in having large leaves that are arranged in whorls of three at the twig-ends, racemose inflorescence borne in the axil of fallen leaves and pedicellate flowers. In addition to this, *S perakense* in Peninsular Malaysia share the same swampy habitat type with *S. formosum*. I concur with

Miquel (1855), who had recognised *Jambosa mappacea* as conspecific with *S. formosum*. The specimen *Niyomdham 5184* (**BKF**!) from Thailand, which was identified as *S. perakense* (Chantaranothai, 2001) belongs to *S. formosum*.

SPECIMENS EXAMINED:

CAMBODIA. Kampong Speu: Samroang Tong, Phnum Chreav [Mt. Cherev], April 1870, *Pierre 993* (**BM**, **K**, **P**) – Kampot: Mt. Bokor, 10 March 2001, *D.Middleton & M.Monyrak 671* (**P**) – Kandal: Phnom Penh, *Bejaud 552* (**P**). **VIETNAM**. *s. loc.* 22 April 1984, *Bai Due Binh B 992* (**K**) – Cochinchina: *Thorel s.n.* (**P**) – Dong Nai: Bao Chanh , September 1865, *Pierre 86* (**P**) – Ken Giang: Donai highland, Langanh station, 3 October 1932, *Poilane 21066* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 8 May 1971, *CPNP 3984* (**CPNP**).



Map 23. Distribution of *Syzygium formosum* (Wallich) Masam. in Cambodia, Laos and Vietnam.

26. *Syzygium glomerulatum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 112 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 51, fig. 3738 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 904 (2003) – *Eugenia glomerulata* Gagnep. Not. Syst. 3: 325 (1918), in Lecomte Fl. Gén. Indo-Chine 2: 826, f. 89-1,2. 1921. **Type**: Cambodia, Mt. Schrall, Jun 1870, *Herb. Pierre s.n.* (lectotype **P**! [barcode P00589212], with a drawing by Delpy dated Nov. 1899 attached, here designated; isolectotypes **P**! [2 sheets] [barcode P00589213 & P00589214], **E**!, **K**! [barcode K000276210]). (see note 1)

Tree. Glabrous on all parts. **Twig** terete, 3 mm diameter, stout, smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, 12 – 17.5 × 6.5 – 8.5 cm, 2 – 2.5 times as long as wide, elliptic to broadly elliptic, base cuneate, slightly attenuate, 40 – 50 degrees from midrib, margin flat, apex acute or acuminate, acumen 0.3 – 0.6 cm, 1/30 – 1/40 of blade length, blade chartaceous, blade shiny, brownish; midrib sunken above, raised below; secondary veins (C.II) 8 – 10 per side per blade, 12 – 15 mm apart, 60 – 70 degrees from midrib, arcuate 1 – 2 mm from margin, intramarginal veins absent; tertiaries prominent, subscalariform; petiole 0.4 – 0.7 cm, 1/17 – 1/35 of blade length, 2 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal, 5.5 – 6.5 cm long, second to third order, flowers many, to 488 flowers, glomerulate (due to very short branch at the branch-end, forming head of 9 or 27 to 61 flowers per head); axes 5 – 5.5 cm, angular; bract and bracteoles persistent, triangular, bract 2 × 2 mm, bracteoles 1.5 × 1.5 mm. **Flowers** sessile, hypanthium 2 – 3 × 1.7 – 2 mm, obconic, pseudostalk indistinct or very short, 1 mm or less; sepals 4, free, 1.5 × 1.8 mm, semiorbicular; petals, 4 – 5, free, 1.5 × 1.5 mm, orbocular; outer stamens c. 1.5 mm long, anthers c. 0.5 mm long, sacs parallel, connective gland conspicuous; style c. 2 mm long, ovules 5 – 10 per locule, irregularly radiating. **Fruit** not seen.

DISTRIBUTION: Cambodia and Vietnam.

ECOLOGY OR HABITAT. In primary and secondary forest.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: May - June.

VERNACULAR NAME(S). Tram chum (Vietnam).

USES. Not documented.

NOTES.

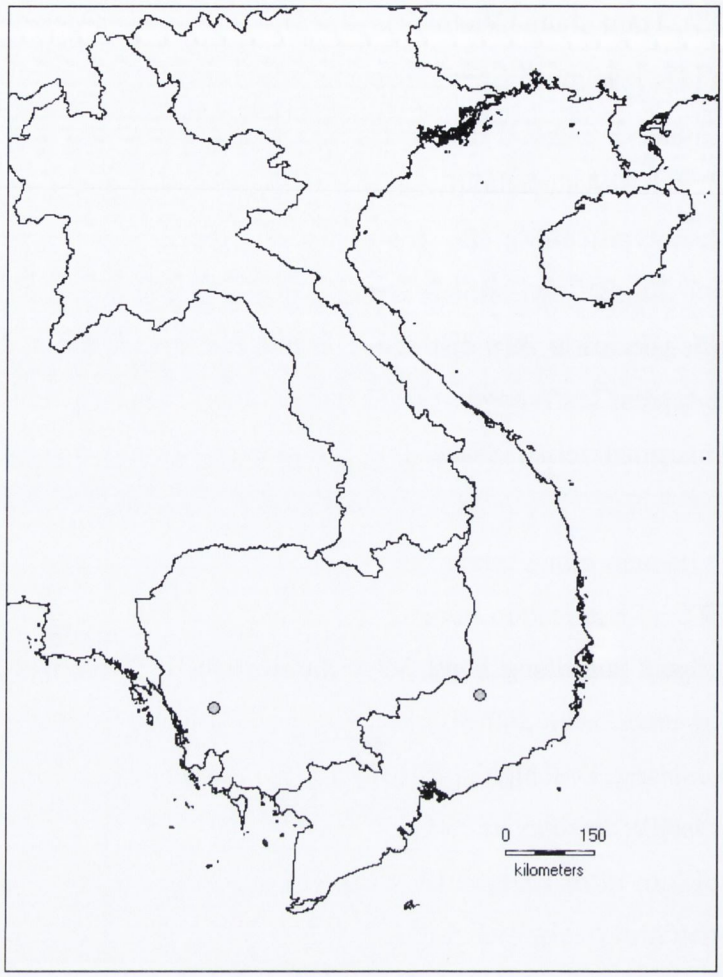
1. *Pierre s.n.* from Cambodia (Mt. Schrall) is the only specimen cited by Gagnepain, however lectotypification is required as there are three undifferentiated sheets.

2. The inflorescence of this species is very distinctive in that the flowers are in a compact head. Unlike the typical leaf venation of *Syzygium*, the secondary veins do not form distinct intramarginal veins, instead they are pinnate-like and arcuate near the leaf margin.

SPECIMENS EXAMINED.

CAMBODIA. Kampong Speu: Samraong Tong, Mt. Schrall, June 1870, *Pierre s.n.* (**K**, **P**).

VIETNAM. Dac Lak: Dak Nang, Dao Nghia, 17 May 1979, *Phdong 939* (**HN**) – Lam Dong: *Schmid, M. s.n.* (**P**).



Map 24. Distribution of *Syzygium glomerulatum* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

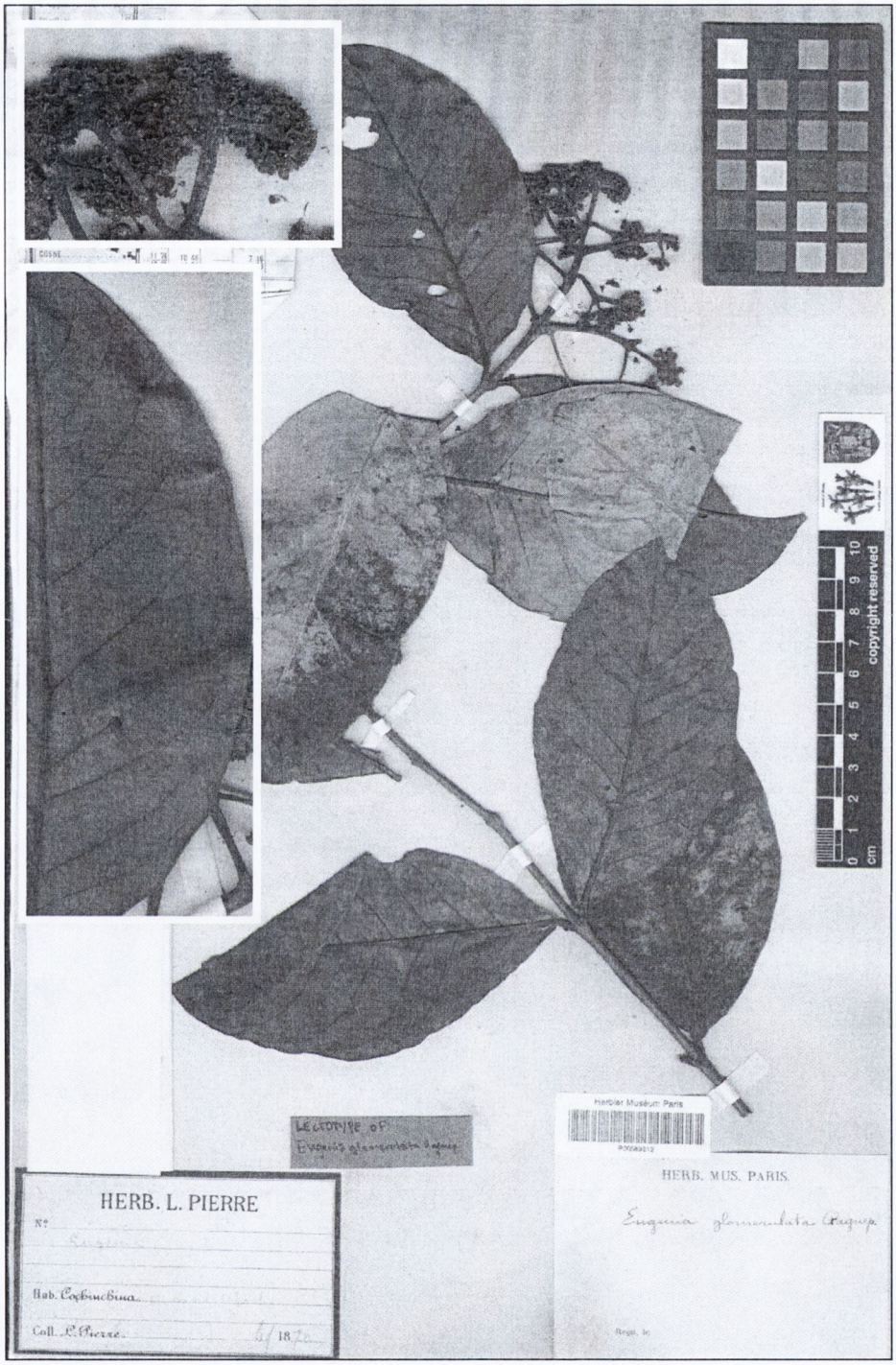


Plate 5.17. Lectotype of *Syzygium glomerulatum* (Gagnep.) Merr. & L.M.Perry.

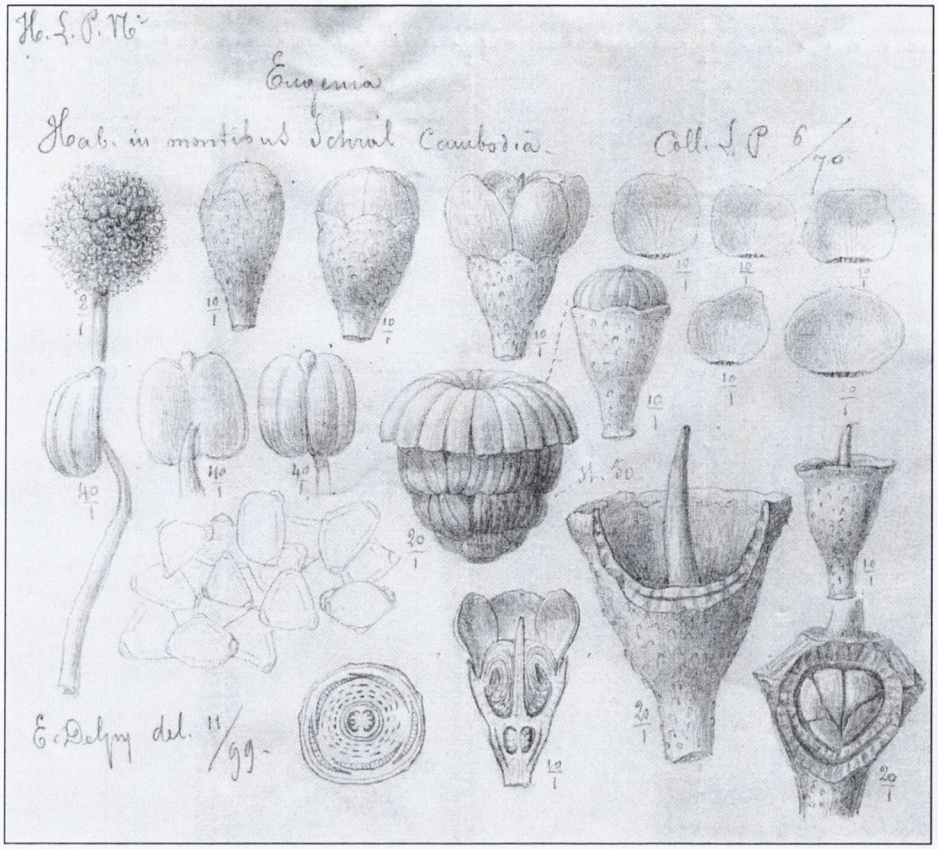


Plate 5.18. Delpy's drawing on the lectotype of *Syzygium glomerulatum* (Gagnep.) Merr. & L.M.Perry.

27. *Syzygium grande* Walp., Repert. Bot. Syst. 2: 180 (1843); Merr. & L.M.Perry, J. Arnold Arbor. 19: 112 (1938); Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 176 (1939); N.P. Balakr., Fl. Jowai 1: 200 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 397 (1985); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 51, fig. 3739 (1992) [as Zyzygium grandis]; P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 68 (1994); I.M.Turner, Gard. Bull. Singapore 47: 376 (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: 858, fig. 17, plate XXVII − 4A,B (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 904 (2003); M.F.Newman et al., Checkl. Vas. Pl. Laos: 245 (2007) − *Eugenia grandis* Wight Wight, Ill. Ind. Bot. 2: 17 (1841); Wight, Icon. Pl. Ind. Orient. 2: t. 614 (1843); Kurz, Forest Fl. Burma 1: 489 (1877); Duthie in Hooker f. Fl. Brit. Ind. 2: 475 (1878); King, J. Asiat. Soc. Bengal 70: 91 (1901); King, Mat. Fl. Malays Penins. 12: 521 (1901); Brandis, Ind. Trees: 320 (1906); Merr., J.

Straits Branch Roy. Asiat. Soc. 77: 214 (1917); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 826 (1921); Ridl., Fl. Malay. Penins. 1: 729 (1922); Craib, Fl. Siam. Enum. 1: 643 (1931); Corner, Wayside Trees Mal. 1: 498, figs. 167 & 168, plate 148 & 149 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 87, fig. 18a (1949); Kochummen in Ng, Tree Fl. Mal. 3: 195 (1978) – *Jambosa grandis* (Wight) Blume, Mus. Bot. 1: 108 (1850). **Type**: Myanmar, Mergui, 'Hb Mergui 82 Moalman', '2369 Cat. Griff. & Helf.', *Griffith s.n.*, (lectotype **K**!, here designated). (fide Noltie (2005: 358))

– *Jambosa firma (Wallich)* ex Blume, Mus. Bot. 1: 108 (1850) – [*Eugenia firma* Wallich, *Wallich Numer. List 3603A*, nom. nud., nom. illeg.., non DC.] – *Syzygium firmum* (Blume) Thwaites & Hook.f., Enum. Pl. Zeyl.: 417 (1864). **Type**: Bangladesh, Silhet, *Wall. Numer. List 3603A* (lectotype **L**! [barcode L0404160] here designated, **K-W**!, **K**! [*Herb. Bentham*], **P**!).

– *Eugenia cymosa* Roxb., Fl. Ind. ed. 1832, 2: 492 (1832), nom. illeg.., non Lam. **Voucher**: Ic. Roxb. No. 2498, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.)).

– *Eugenia montana* Wight, Icon. Pl. Ind. Orient. 3: t. 1060 (1846), nom. illeg.., non Aubl. (1775) – *Syzygium montanum* Thwaites & Hook.f. in G.H.K.Thwaites, Enum. Pl. Zeyl.: 116 (1859), nom. illeg.., non Gamble – *Syzygium tamilnadensis* Rathakr. & V.Chithra in N.C.Nair & A.N.Henry, Fl. Tamil Nadu 1: 158 (1983) – *Syzygium gadgilii* M.R.Almeida, Fl. Maharashtra 2: 273 (1998), nom. superfl. **Type**: Neilgherries, *Herb. Gardner s.n.* [*Herb. Hooker & Herb. Bentham*] (n.v.). (fide Noltie (2005: 359))

– *Eugenia laosensis* Gagnep., Notul. Syst. (Paris) 3: 326 (1917) pro parte [excl. spec. *Thorel s.n.*, Nong-kay (**P**!) = *S. thumra*] – *Syzygium laosense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 113 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 52, fig. 3743 (1992); P.Dy Phon, Plants used in Cambodia: 579 (2000); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 905 (2003). **Type**: Laos, Mulu-prey, Harmand 260 ([first – step] lectotype **P**!, first designated by Chantaranothai & Parnell (1994)); *Harmand 260 in Herb. Pierre 3193,* fl., Dec. 1875 ([second – step] lectotype **P**! [barcode P00589203] with attached Delpy drawing dated Jan. 1900, here designated; isolectotype **BM**!, **P**!, 2 sheets [barcode P00589204 & P00589205]). Remaining former syntypes: Laos, Khone, *Harmand 135* (**P**!). (see note 1)

– *Eugenia laosensis* var. *quocensis* Gagnep., Notul. Syst. (Paris) 3: 327 (1917) – *Syzygium laosense* var. *quocense* (Gagnep.) H.T.Chang & R.H.Miao in Fl. Republ. Popul. Sin. 53(1): 70 (1984). **Type**: Vietnam (cited as Cambodia in the protologue), Phu – quoc, vernacular name Tam-xe, fl., *Pierre s.n. in Herb. Hort. Bot. Saigonensis* (lectotype **P**! [barcode P00589200] here designated; isolectotype **P**! [2 sheets, barcodes P00589201 & P00589202]). (see note 1)

– *Syzygium megalophyllum* Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 179 (1939). **Type**: Malaysia, Sabah, *Creagh s.n.* (holotype **NY**! [barcode 00405152]; isotypes **A** n.v., **K** n.v.).

– *Syzygium grande* var. *parviflorum* P.Chantaranothai & J.Parn., Kew Bull. 48: 598 (1993). **Type**: Thailand, Chaiyaphum, Pu Kio, 25th Feb 1931, *Kerr 20267* (holotype **K**!; isotype **BK**!).

– *Syzygium endertii* Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 167 (1939). **Type**: East Kalimantan, Kutet, near Kg Sabantulung, *Endert 1523*, (holotype BO n.v.; isotype fragment in **A** n.v., **L**!, [barcode L0329615]).

Tree to 20 m tall, c. 20 cm dbh. Bark brownish to greyish. Glabrous on all parts. **Twig** terete and sometimes compressed, 4 – 5 mm diameter, stout, surface smooth, slightly flaky, greyish to whitish, contrasting to leaf colour. **Leaves** opposite, 10 – 18.5 × 5 – 8 cm, 2 times as long as wide, elliptic to ovate, base, cuneate, slightly attenuate, 60 – 65 degrees from midrib, margin flat, apex obtuse, acute, without acumen, tip deflexed, blade coriaceous, pale brownish; midrib sunken above, raised below; secondary veins (A.II or A.III) 8 – 12 per side per blade, broadly spaced, 8 – 10 mm apart, 60 – 70 degrees ascending from midrib, very prominent and raised on both leaf surfaces; tertiaries prominent, reticulate; inner intramarginal veins 3 – 5 mm from margin, looped, outer intramarginal veins prominent or faint; petiole 1 – 2 cm, 1/9 – 1/12 of blade length, 2 – 3 mm diameter, stout, dark brown or blackish, contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, 4 – 6.5 cm long, paniculate, first to second order branching, many flowered, 35 – 105, compact at branch-end; axes c. 4 – 6 cm long, angular or subangular; bract and bracteoles caducous. **Flowers** white, sessile, hypanthium not glaucous, not fibrous, 7 – 8 × 6 – 7, obconic, pseudostalk distinct, 2.5 – 3 mm long; sepals 4, free, semiorbicular, unequal, outer sepals 2.5 × 2.6 – 3, inner sepals 3 × 4.2 – 4.5 mm; petals 4, free, 5 – 6 × 5 – 6

mm, orbicular; outer stamens 2 – 2.2 cm long, anthers c. 0.5 mm long, sacs parallel, connective gland inconspicuous; style c. 10 mm long, ovules 12 – 15 per locule, irregularly radiating. **Fruit** subglobose, 7 × 7 cm, surface smooth, calyx ring with smooth rim; seed 1, subglobose, 4.4 × 4 cm, cotyledons free, intercotyledonary intrusion absent.

Distribution: Widespred, from Seycelles to Borneo. In Indochina found in Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. In forest or planted along roadside.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: March, May, November and December. Fruiting: April, May and September.

VERNACULAR NAME(S): Cambodia: Pring chan. Vietnam: Tram dai, Tram deo, Tram to, Tram xe (Phu Quoc).

USES. This species is planted on roadsides. The wood is used for house and ship building (Lemmens et al., 1995).

NOTES.

1. Second step lectotypification is designated here for *Eugenia laosensis*. Chantaranothai & Parnell (1994b) first designated the lectotype, but there are three undifferentiated sheets of *Harmand 260* at **P**. One sheet from *Harmand 260-131* in Herb. *Pierre 3193* was labelled with the locality Mulu-prey, the other two sheets are without locality, with Herb. Mus. Paris labels numbered 260 and indicated in print the collection from *Harmand's expedition at Semoun basin, Laos*. Since the number is the species number and there is doubt about the locality of the latter sheets, I consider these two sheets to be from a different collection than *Harmand 260-131* in Herb. *Pierre*. For the var. *quocense*, *Pierre s.n.* is the only specimen cited by Gagnepain, however lectotypification is required as there are three undifferentiated sheets, with the annotated vernacular name 'Tam-xe' as indicated in the protologue.

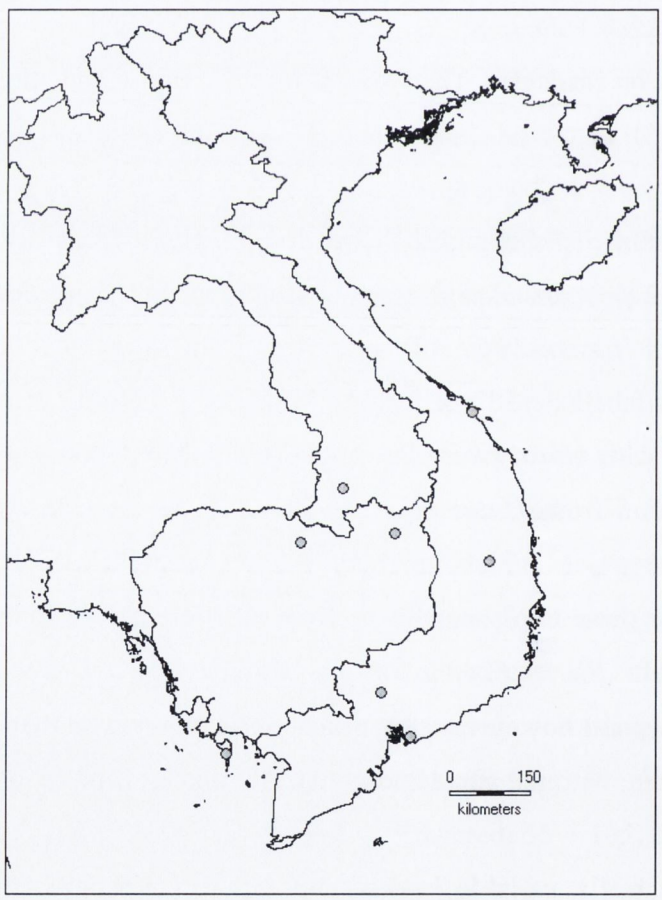
2. This species is morphologically variable in leaf and inflorescence size. In Thailand, populations with small flowers are formally recognised as var. *parviflorum*.

SPECIMENS EXAMINED:

CAMBODIA. Kampong Speu: Samraong Tong, Mt. Tamire, May 1870, *Pierre 992* (**K**, **P**) – Preah Vihear: Mlu Prey, December 1875, *Harmand 260 in Herb. Pierre 3193* (**BM**, **P**).

LAOS. Champassak: Bassac, 1866-1868, *Thorel s.n.* (**P**); Khone, *Harmand 135* (**P**) – Louang Phabang: Paksanan, 23 March 1956, *Tixier 6* (**P**).

VIETNAM. Cochinchina: 1875, *Godefroy s.n.* (**P**) – Ba Ria-Vung Tau: Ba Ria, December 1866, *Pierre s.n.* (**P**); Binh Duong: Ben Cat, December 1865, *Pierre s.n.* (**K**) – Da Nang: Tourane and vicinity, May-July 1927, *J. & M.S. Clemens 3777* (**BM**, **K**); Tourane and vicinity, 5 September 1927, *J. & M.S. Clemens 3395* (**BM**, **P**) – Gia Lai: Ayun Pa , 22 April 1978, *Phdong 582* (**HN**) – Ken Giang: Phu Quoc Is., November 1874, *Pierre s.n.* (**E**, P).



Map 25. Distribution of *Syzygium grande* Walp. in Cambodia, Laos and Vietnam.

28. ***Syzygium hancei*** Merr. & L.M.Perry, J. Arnold Arbor. 19: 242 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 51, fig. 3750 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 904 (2003); J. Chen & Craven, Fl. China 13: 356 (2007) – *Eugenia minutiflora* Hance, J. Bot. 9: 5 (1871); Forbes & Hemsl. Jour. Linn. Soc. Bot. 23: 297 (1887); Dunn & Tutcher, Bull. Misc. Inform. Kew Add. Ser. 10: 105 (1912); Merr. Lingnan Sci. Jour. 5: 136 (1927); Groff. Lingnan Univ. Sci. Bull. 2: 77 (1930); non *Syzygium minutiflorum* (Bedd.) Gamble (1919). **Type**: China, Kwangtung, Hui-tung, *Sampton & Hance 13754* (holotype **BM**!; isotype **K**!).

– *Eugenia bonii* Gagnep., Not. Syst. 3: 318. 1917; Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 808, f. 87 (1920); Craib, Fl. Siam. Enum. 1: 652 (1931) – *Syzygium bonii* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 102 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 48, fig. 3729 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 901 (2003). **Type**: Annam [Vietnam], Than-hoa, Cua-bang, 17 Aug. 1812, fl., *Bon 5603* (lectotype **P**! [barcode P00589297] here designated; isolectotypes **P**! [2 sheets, one sheet with barcode P00589368 & the other sheet without barcode and with Gagnepain's drawing attached]), **syn. nov.** (see note 1)

– *Eugenia campylocarpa* Gagnep., Notul. Syst. (Paris) 3: 320 (1917) – *Syzygium campylocarpum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 116 (1938). **Type**: Laos, Attopeu plateau, fl., fr., Mar. 1877 *Harmand 1257* (hololectotype **P**! barcode P00589291, here designated; isolectotypes **P**! [4 sheets] - 2 sheets with barcode, P0058992 & P00589293, both with tickets bearing Harmand's signature, 2 other sheets without barcode, labelled *Harmand 1237* in *Herb. Pierre 3189*), **syn. nov.** (see note 1)

– *Eugenia mekongensis* Gagnep. Not. Syst. 3: 328 (1918); Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 802 (1920); Craib, Fl. Siam. Enum. 1: 652 (1931) – *Syzygium mekongense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 102 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 54, fig. 3747 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 88 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 876 (2002); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 432 (2004), [excl. *S. szemoaense* = *Memecylon sp.*]; M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 245 (2007). **Type**: Laos, between Ubon and

Kemmarat, Ubon river, fl., *Thorel s.n.* (lectotype **P**! [barcode P00589243] here designated). Remaining former syntypes: Annam [Vietnam], Than-hoa, fr., *Bon 5808* (**P**! [2 sheets, barcodes P0089195 & P00589196]); Cochinchina [Vietnam], Baria, Mt. Dinh, *Pierre s.n.* **P**!.; Cambodia, around Pnom Penh, *Gourgand* (**A** n.v., **P**!), **syn. nov.** (see note 1)

– *Syzygium petelotii* Merr. & L.M.Perry, J. Arnold Arbor. 19: 103 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 55, fig. 3752 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 907 (2003). **Type**: Tonkin [Vietnam], Phu Tho, Phu Ho, *Petelot 1043* (holotype A; **US**!), **syn. nov.** (see note 1)

– *Syzygium szemaoense* Merr. & L.M.Perry, J. Arnold Arbor. 19: 105 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 61, fig. 3770 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 908 (2003); J. Chen & Craven, Fl. China 13: 352 (2007). **Type**: China, Yunnan, Szemao, *Hendry 12138* (holotype **NY**!; isotype **A** n.v., **K**!), **syn. nov.** (see note 1)

Shrub or tree to 20 m tall, to 25 cm dbh. Bark brownish or greyish, slash bark dark purplish. Glabrous on all parts. **Twig** terete and compressed, subangular or 4-angled, 1.5 – 2 mm diameter, stout, surface smooth, brownish, not contrasting to blade colour. **Leaves** opposite to subopposite, 3 – 7.5 × 1.5 – 3 cm, 2 to 3 times as long as wide, elliptic to obovate, base cuneate, slightly attenuate, margin flat, apex acute, acuminate, obtuse or rounded, acumen if present 0.4 – 0.6 cm, 1/12 – 1/14 of blade length, subcoriaceous to coriaceous, dark greenish to brownish; midrib sunken above, raised below; secondary veins (Type A.I) 10 – 20 per side per blade, narrowly spaced, 1 – 3 mm apart, 45 – 60 degrees from midrib, faint and raised on both surfaces; tertiaries faint, reticulate; inner intramarginal veins 0.5 – 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.3 – 0.7 cm, 1/9 – 1/15 of blade length, c. 1 mm diameter, stout, dark brownish, not contrasting to blade colour. **Inflorescence** terminal and axillary on leafy twig, 1 – 2 cm long, paniculate, first order branching, flowers few, 5 – 23; axes 0.85 – 1.5 cm, angular, stout; bract persistent, 0.5 – 1 × 0.3 – 0.5. **Flower** whitish, sessile or pedicellate, pedicel 0.5 – 1 mm, hypanthium pale greenish (in vivo), not glaucous, not fibrous, 1.5 – 4 × 1.5 – 3.5 mm, obconic, pseudostalk indistinct, c. 0.5 mm; sepals whitish, 4, free, triangular, 0.2 – 0.3 × 0.4 – 0.5 mm, undulate on rim; petals whitish, 4, coherent, 1.5 × 1.5 mm, orbicular; stamens whitish, outer

stamens 1.5 – 4.5 mm, anthers c. 0.3 mm, sacs parallel, connective gland conspicuous; style 1 – 3 mm, ovules 20 – 30 per locule, irregularly radiating. **Fruit** dark purplish to blackish (in vivo), obloid to globose, 0.8 – 1 × 0.6 – 1 cm, surface smooth, calyx ring with smooth rim; seed 1 – 2, ovoid, 1 × 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: China (Fujian, Guangdong, Guangxi and Hainan), Cambodia, Laos, Thailand and Vietnam.

ECOLOGY OR HABITAT. Primary and secondary forest, and along rivers.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: March - October. Fruiting: November - April.

VERNACULAR NAME(S). Cambodia: Hong tuk, Pring teuk (Kampong Spoe). Vietnam: Phen den, Tram, Tram cuulong.

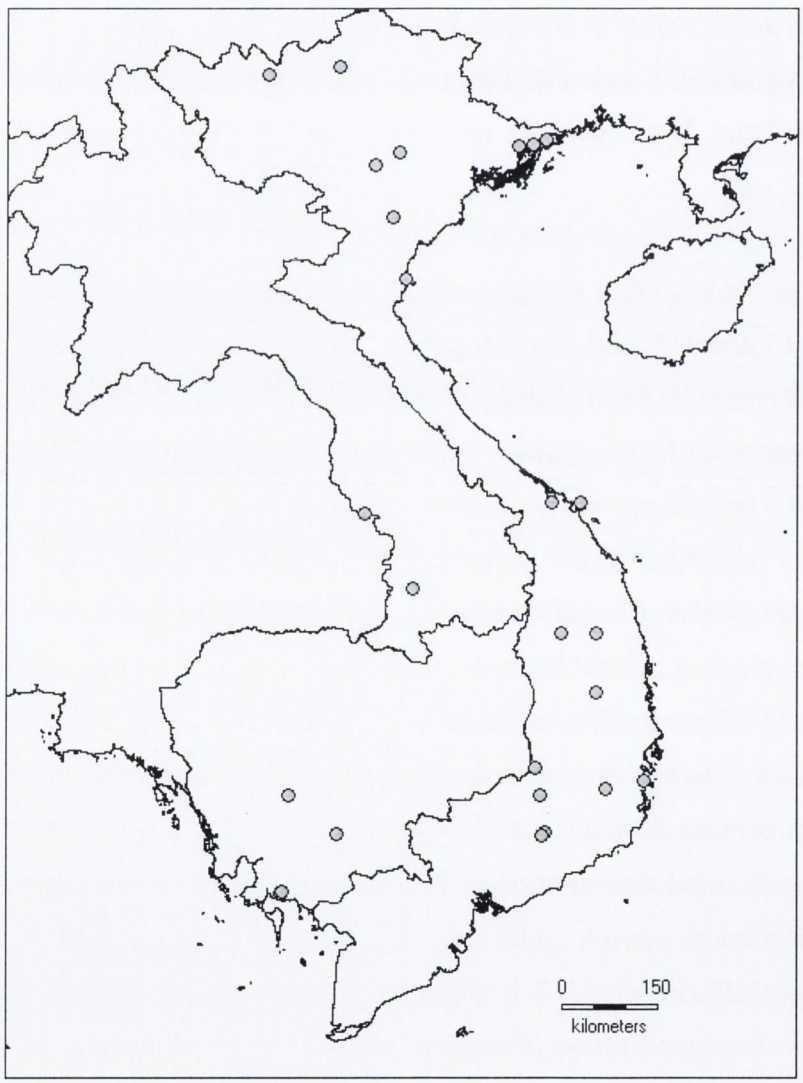
USES. Fruit edible.

NOTES.

1. This is a highly variable species. *Syzygium bonii*, *S. campylocarpum*, *S. hancei*, *S. mekongense*, *S. petelotii* and *S. szemoanse* are similar in their short inflorescences with persistent bracts, small obconic hypanthium, coherent petals, subcoriaceous to coriaceous leaves, dark greenish brown leaf blade and faint venation. *Syzygium campylocarpum* and *S. bonii* deviate from the typical form in having whiter twigs. In addition to this, *S. campylocarpum* also has thinner leaves (*Anon. 574*, *Lien 252* , *Schmid s.n.* [Daa Lao, 16 May 1953]). Gagnepain (1917) acknowledged the similarities between *S. mekongense* and *S. hancei*, but considered them as different species on the basis of the leaf and flower bud size. Since the last revision, there have been new specimens of *S. mekongense* and *S. hancei* collected in continental Southeast Asia and China. Based on the current herbarium collections, I find the variation of leaf size and flower are continuous without clear disjunction.

2. In the protologue, *Harmand 1257* is the only specimen number cited by Gagnepain, however lectotypification is required as there are five potential type sheets at **P**. In the protologue Gagnepain gave a description of the fruit and inflorescence but not the flower. The lectotype chosen here is the fruiting specimen used in his description, two of the isotypes are specimens with few

attached flowers at late anthesis and maturing into fruit. The other two isotypes are from *Harmand 1237* in *Herb. Pierre 3189*, dated Mar. 1877, giving the tree height information of '8 – 10 m'. In the protologue Gagnepain mentioned that this information was possibly communicated to Pierre by Harmand but this information was missing on the original Harmand's ticket. This implies that the two sheets of *Harmand 1237* were used by Gagnepain for his species description in the protologue and furthermore I assume Gagnepain considered these two sheets the same as *Harmand 1257*. I believe that, but cannot prove that there was a typographical error in copying the collection number from Harmand's label to Pierre's label and that the number should be 1257.



Map 26. Distribution of *Syzygium hancei* Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

SPECIMENS EXAMINED.

CAMBODIA. *Gourgand s.n.* (**P**) – Kampong Spoe: Phnum Aural, 8 March 2001, *K.Enghourt, M.Sophal & S.Kosal MoE Herb. Cat. 670* (**K**) – Kampot: Mt. Bokor, Popok Vil waterfall, 8 March 2001, *D.Middleton & M.Monyrak 623* (**P**); Mt. Bokor, Popok Vil waterfall, 11 December 2000, *S.Hul* et al. *954* (**P**) – Kandal: Phnom Penh, *Gourgand s.n.* (**P**).

LAOS. [Thailand] between Ubon and Kemmarat, Ubon river, *Thorel s.n.* (**P**); Attapeu: Bolaven plateau [Attopeu plateau], March 1877, *Harmand 1257* (**P**).

VIETNAM. Cochinchina: October 1866, *Pierre s.n.* (**P**) – Da Nang: Son Tra, 9 July 1986, *Anon. LX – VN 2768* (**HN**) – Dac Lak: Dak Nang, Dao Nghia, 17 May 1979, *Phuong 925* (**HN**); Duc Minh, 9 December 1979, *Anon. 574* (**HN**) – Dong Nai: Mt. Dinh, *Pierre s.n.* (**BM**, **E**) – Gia Lai: Ayun Pa, 21 April 1988, *Bien 764* (**HN**); K'bang, 20 November 2005, *N.Q.Binh & D.D.Cuong VN 1620* (**HN**) – Ha Giang: Bac Quong, 14 July 2001, *N.Q.Binh, D.D.Cuong & V.Schnitzler VN 848* (**HN**) – Ha Tay: Mt. Ba Vi, *Petelot 2596* (A) – Khanh Hoa: Nha Trang, June 1909, *d'Alleizette s.n.* (**L**) – Kon Tum: 30 November 1978, *H.H.Dung 383* (**HN**) – Lam Dong: Bao Loc, *Lien 252* (**HN**); Da Chay, 16 April 1997, *Averyanov & N.Q.Binh VH 3988* (**HN**); Daa Lao, 16 May 1953, *Schmid s.n.* (**P**) – Lao Cai: Chapa, July 1931, *Petelot 4678* (A) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 8 August 1999, *N.M.Cuong, H.L.Quyen & M.V.Xinh NMC 402* (**CPNP**); Nho Quan, Cuc Phuong National Park, 17 September 1999, *N.M.Cuong, H.L.Quyen & M.V.Xinh NMC 523* (**CPNP**); Nho Quan, Cuc Phuong National Park, 24 July 2000, *N.M.Cuong, H.L.Quyen & M.V.Xinh NMC 877* (**CPNP**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, , *W.T.Tsang 30068* (**E**, P); Dam Ha, Sai Vong Mo Leng, July 1940, *W.T.Tsang 30383* (**K**, **P**); Dam Ha, Sai Vong Mo Leng, July 1940, *W.T.Tsang 30417* (A, K, P); Ha Coi, Tsai Wong Mo Shan and vicinity, November 1936, *W.T.Tsang 27247* (**K**, **P**); Tien Yen, Kau Nga Shan and vicinity, January 1937, *W.T.Tsang 27485* (**K**, **P**); Tien Yen, Kau Nga Shan and vicinity, December 1936, *W.T.Tsang 27389* (**K**, **P**) – Than – hoa: *Bon 5808* (**P**); Cua Bang, 17 August 1903, *Bon 5603* (**P**) – Thua Thien-Hue: Bach Ma, *Nham 559* (**HN**) – Vinh Phuc: Me Linh, Ngoc Thanh, 27 June 2000, *Phuong 3049* (**HN**).



Plate 5.19. Holotype of *Syzygium hancei* Merr. & L.M.Perry.

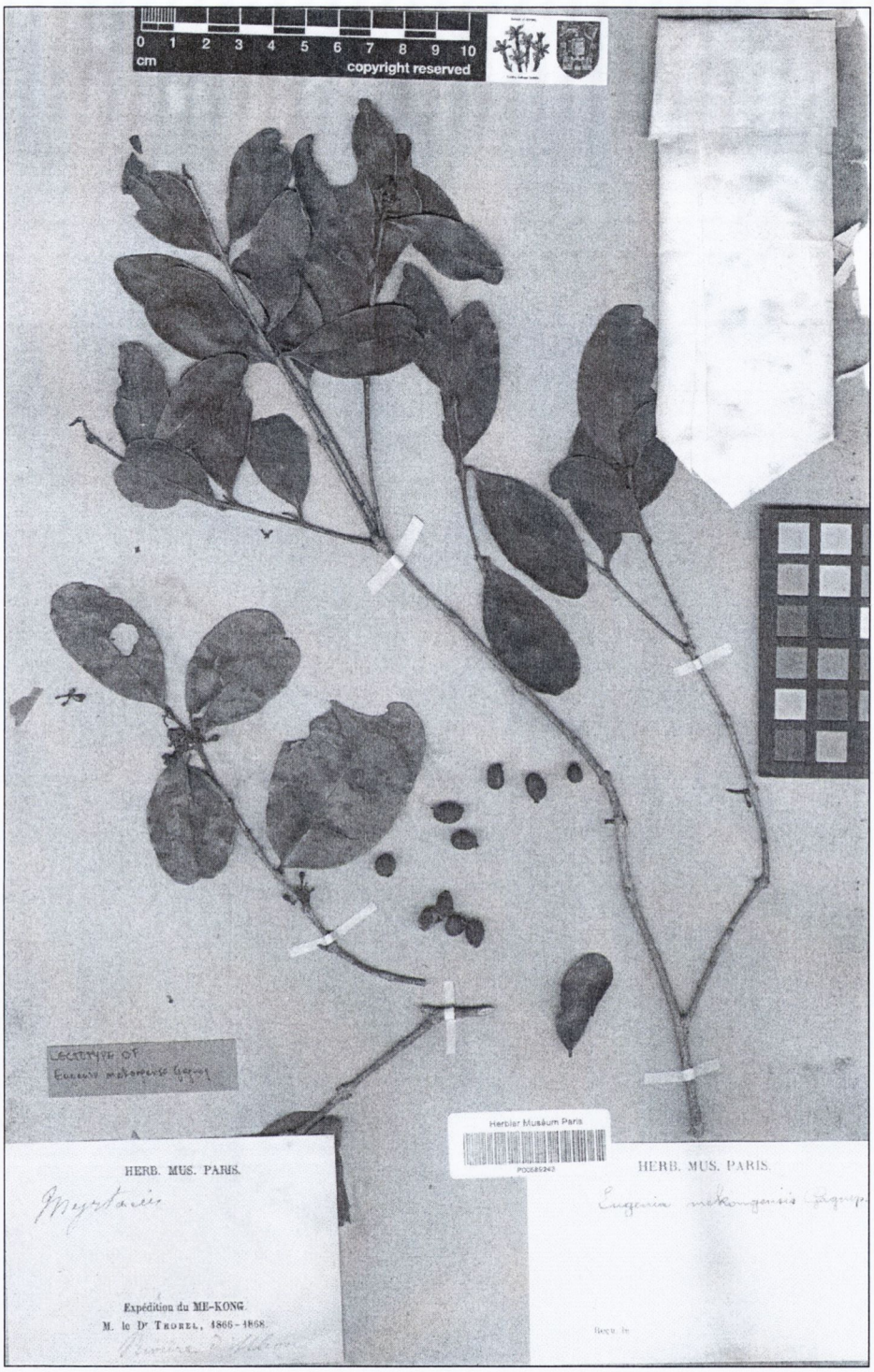


Plate 5.20. Lectotype of *Syzygium mekongense* (Gagnep.) Merr. & L.M.Perry.

29. *Syzygium harmandii* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 115 (1938); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 905 (2003) – *Eugenia harmandii* Gagnep. Not. Syst. 3: 325 (1918), et in Lecomte, Fl. Gén. Indo-Chine 2: 840, f. 89 (1921); M.F.Newman et al., Checkl. Vas. Pl. Laos: 245

(2007). **Type**: Laos, around Bassac, fl., Mar. 1877, *Harmand 1169* (lectotype **P**!, in *Herb. Pierre 3207*, barcode P00589208, with a drawing by Delpy dated Feb. 1900 attached, here designated; isolectotypes **P**! [2 sheets, barcodes P00589206 & P00589207]). (see note 1)

Shrub. Glabrous on all parts. **Twig** angular (4-angled) and winged, 4 – 5 mm diameter, stout, surface smooth, brownish, not contrastin to leaf colour. **Leaves** in whorls of three, 11 – 18 × 1.5 – 2.5 cm, 7 to 12 times as long as wide, linear lanceolate, base cordate or rounded, margin flat, apex acute, without acumen, blade coriaceous, dark greenish; midrib sunken above, raised below; secondary veins (Type A.II) 12 – 14 per side per blade, 10 mm apart, 30 – 40 degrees from midrib, prominent and sunken above, prominent below; tertiaries faint, reticulate; inner intramarginal veins prominent, c. 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.2 – 0.5 cm, 1/40 – 1/85 of blade length, 4 mm diameter, stout, dark brownish, not contrasting to blade colour. **Inflorescence** lateral-axillary in axil of fallen leaves, c. 5 cm long, racemose, flower few, c. 5; axes 0.8 cm long, angular; bract and bracteoles persistent, triangular, both 1 × 1 mm. **Flowers** large, with long pedicel, 1 – 2 cm long, hypanthium not glaucous, not fibrous, 1.5 – 1.75 × 1 – 1.5 cm, pyriform, pseudostalk distinct, c. 0.5 – 1 cm; sepals 4, free, unequal, outer sepals 4 – 5 × 8 – 10 mm, inner sepals 8 – 10 × 11 – 13 mm, semiorbicular; petals 8, free, unequal, outer 4 petals 8 × 8 mm, inner 4 petals 13 × 10 mm, orbicular; outer stamens c. 2 cm long, anthers 1.75 – 2 mm long, sacs parallel, connective gland inconspicuous; style c. 10 long, ovules 18 – 20 per locule, irregularly radiating. **Fruit** not seen.

DISTRIBUTION: Cambodia and Laos.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: March and Novermber.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

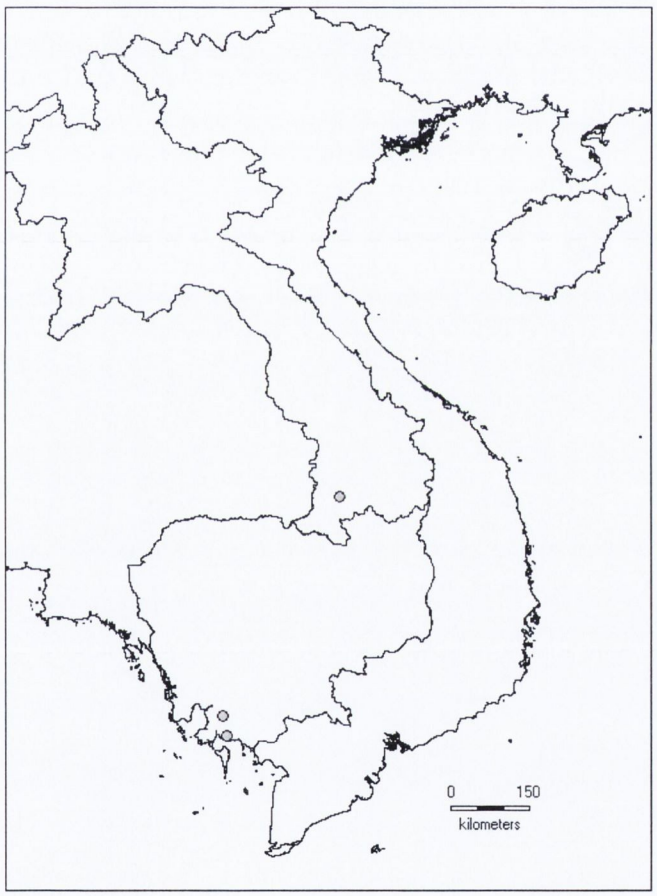
NOTES.

1. This species is morphologically and anatomically very similar to *S. diospyrifolium* and *S. formosum*. It is similar with these two species in having verticillate leaves arranged at the end of twigs, cordate to subcordate leaf bases, racemose inflorescences and big flowers. Anatomically it shares the same circular midrib vascular bundle.

SPECIMENS EXAMINED.

LAOS. Champassak: Bassac, March 1877, *Harmand 1169* (**P**).

CAMBODIA. S. loc. *Hanh 53* (**P**) – Kampot: Mt. Bokor, 20 November 1999, *S.Hul et, al. 732* (**P**).



Map 27. Distribution of *Syzygium harmandii* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

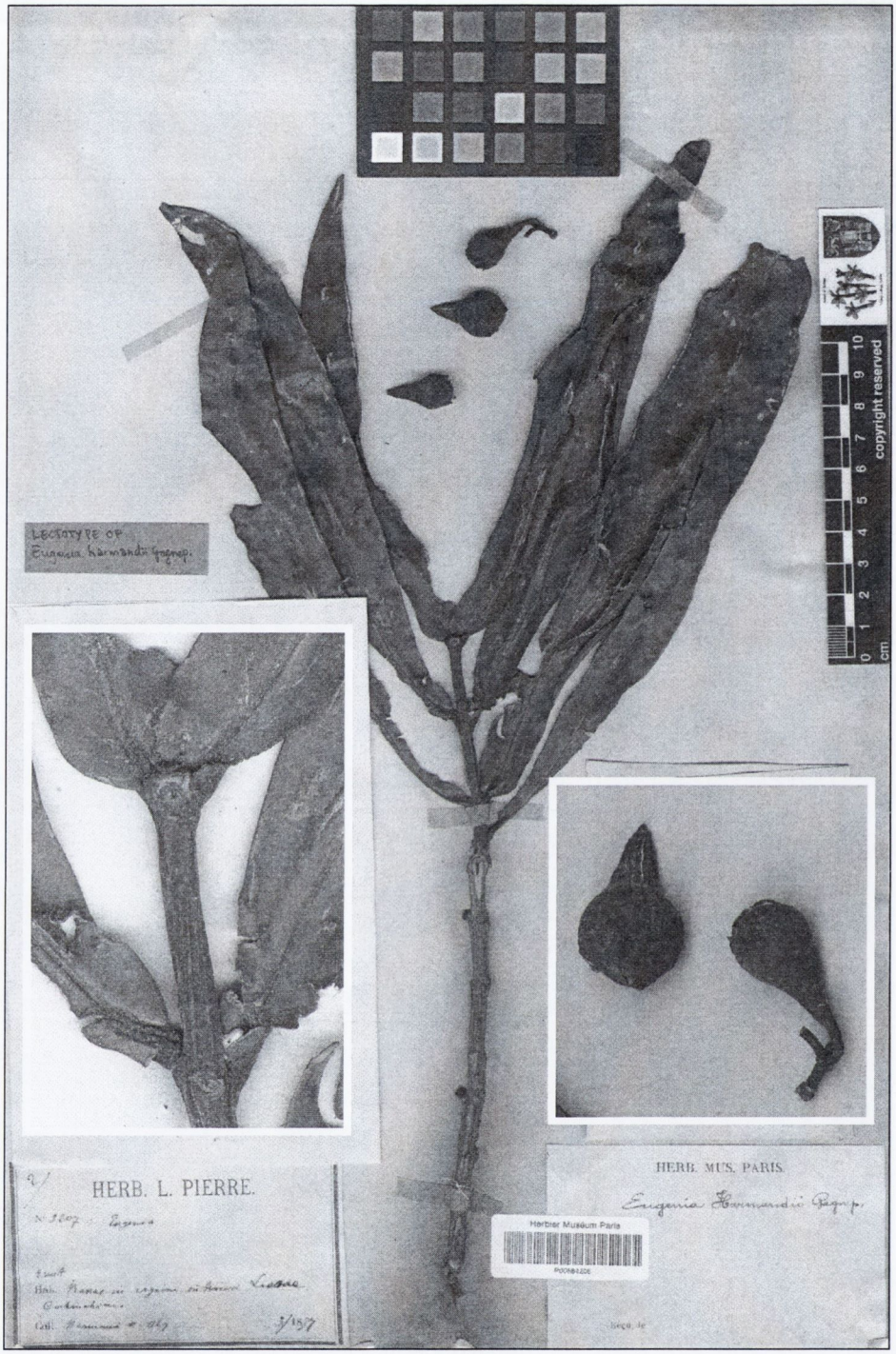


Plate 5.21. Lectotype of *Syzygium harmandii* (Gagnep.) Merr. & L.M.Perry.

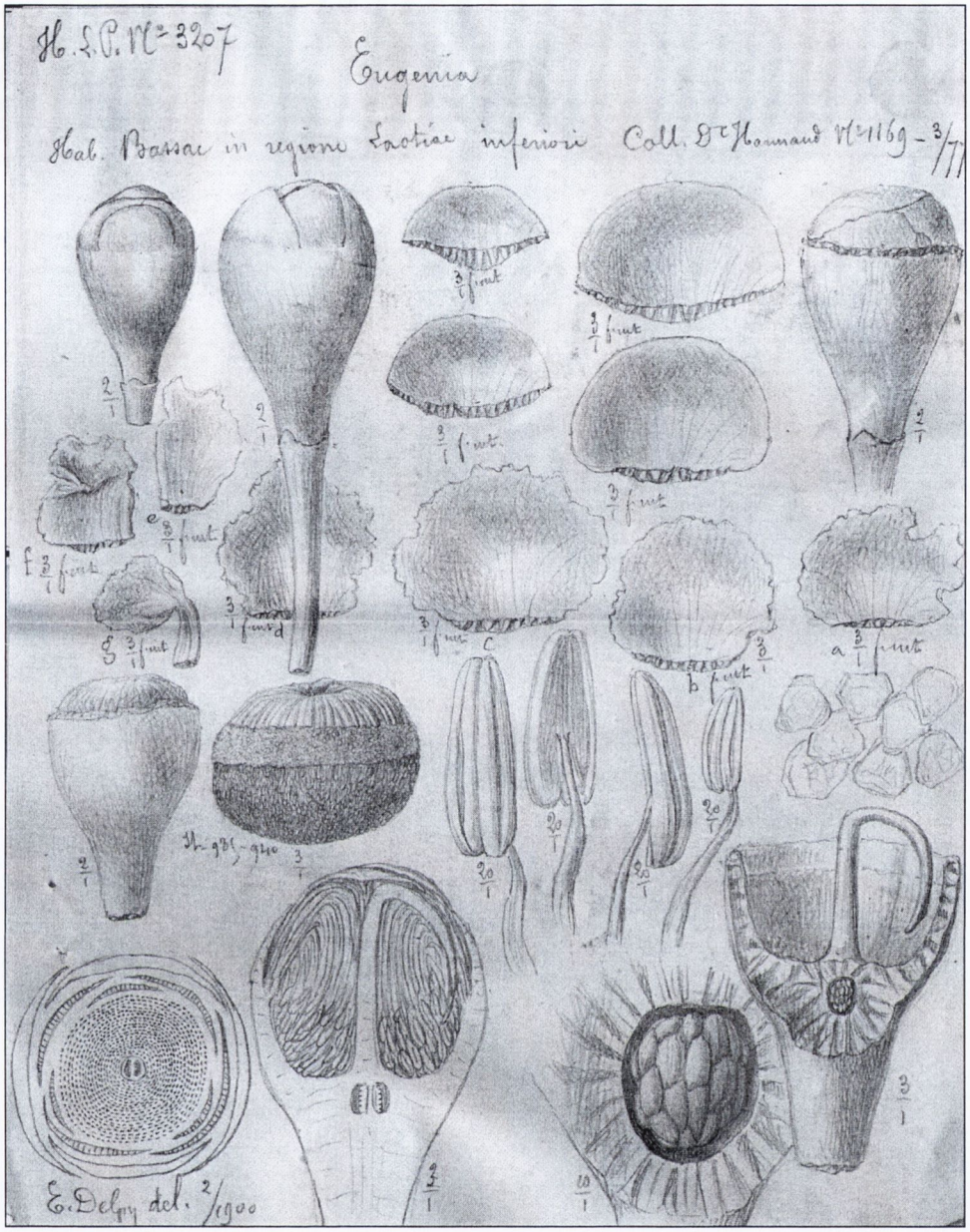


Plate 5.22. Delpy's drawing on the lectotype of *Syzygium harmandii* (Gagnep.) Merr. & L.M.Perry.

30. *Syzygium hemisphericum* (Wight) Alston, in Trimen, Handb. Fl. Ceylon 6, Suppl. (1931) 115; Kosterm., Quat. J. Taiwan Mus. 34: 140 (1981); P.S. Ashton in Dassan. & Fosberg, Fl. Ceylon 2: 430 (1981) – *Eugenia hemispherica* Wight, Ill. Ind. Bot. 2: 14 (1841), Wight, Icon. Pl. Ind. Orient. 2: t. 525 (1843); Duthie in Hook.f., Fl. Brit. Ind. 2: 477 (1878); Trimen, Handb. Fl. Ceylon 2: 170 (1894) – *Jambosa hemisphaerica* (Wight) Walp., Repert. Bot. Syst. 2: 191 (1843); Gamble, Fl. Pres. Madras 1: 474 (1919) – *Strongylocalyx hemisphaericus* (Wight) Blume,

Mus. Bot. 1: 89 (1850); Thwaites & Hook.f., Enum. Pl. Zeyl.: 116 (1864). **Neotype**: Sri Lanka, Moray Estate, Maskeliya, garden of Superintendant's Bungalow, December, *Kostermans 27242*, (neotype **L**! [HLB no. 457086] here selected; isotype PDA n.v.). (see note 1)

– *Eugenia chanlos* Gagnep., Notul. Syst. (Paris) 3: 320 (1917) – *Syzygium chanlos* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 109 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 49, fig. 3732 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 902 (2003). **Type**: Cochinchina [Vietnam], Mt. Dinh, Mar. 1867, fl., *Herb. Pierre s.n.*, (lectotype **P**! [barcode P00589354] with a drawing by Delpy dated Jan. 1900 attached; isolectotype **P**!). Remaining former syntypes: Cambodia, Kompong chuang, fl., 16 April 1909, *Magnien, Gourgand & Châtillon s.n.* (**P**! [barcode P00589290]); Cochinchina [Vietnam], Muxoai, Mar. 1867, fl., tree 12 – 18 m, 300m alt., *Herb. Pierre s.n.* (**P**!, 3 sheets); Cochinchina [Vietnam], Mt. Dinh, May. 1866, fl, *Herb. Pierre s.n.* (**P**! [2 sheets]), **syn. nov.** (see note 2)

Tree to 12 – 18 m tall, to 30 – 41 cm dbh. Bark smooth, greyish to brownish; slash bark brownish. Glabrous on all parts. **Twig** terete, c. 2 mm diameter, smooth, brownish, not contrasting to leaf colour. **Leaves** opposite to subopposite, 9 – 13 cm×3 – 5 cm, 2 to 3 times as long as wide, elliptic to oblong – elliptic, base attenuate, c. 40 degrees from midrib, margin flat, apex acuminate, with distinct acumen, acumen c. 0.5, 1/10 – 1/25 of blade length, blade chartaceous, greenish; midrib sunken above, raised below; secondary veins (Type B) 10 – 12 per side per blade, broadly spaced, 7 – 15 mm apart, spreading, c. 70 degrees ascending from midrib, prominent and raised on both surfaces, slender, 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate; tertiaries prominent, reticulate; inner intramarginal c. 2 mm, looped, outer intramarginal veins faint; petiole 1 – 1.5 cm long, 1/8 – 1/9 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** usually terminal, sometimes axillary on leafy twig, 3 – 6 cm long, paniculate, first order branching, spreading, flowers 9 to 16 ;axes 2.5 – 5.5 cm, angular, flaky; bract and bracteoles caducous, triangular, bract 1.2 × 0.6 mm, bracteoles 1 × 0.5 mm. **Flower** pedicellate, pedicel 3 – 4 mm long, hypanthium not glaucous, not fibrous, 5 – 6 ×

3 – 4 mm, pyriform, pseudostalk distinct, c. 2 mm; sepals 4, free, 0.6 – 1 × 1.5 mm, triangular; petals 4, free, 2.5 – 4 × 2.5 – 3 mm, orbicular; outer stamens 5 – 10 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style 7 – 8 mm, ovules 10 – 15 per locule, irregularly radiating. **Fruit** ovoid, 3 × 2.5 cm, surface smooth, calyx ring with persistent sepal lobes; seed 1, subglobose, 2 × 1.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: India, Sri Lanka, Thailand, Cambodia, Laos and Vietnam.
ECOLOGY OR HABITAT. Primary and secondary forest, to 300 – 600 m alt.
CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).
PHENOLOGY. Flowering: March, April, May and June. Fruiting: May.
VERNACULAR NAME(S). Cambodia: Pring chan (Siem Reap), Pring Sratoap (Kampong Thum & Kampong Chhnang). Vietnam: Tram sung, Tram trang.
USES. Not documented
NOTES.

1. I concur with Noltie (2005), after having examined the specimens at **E**, **K**, **BM**, **L** and **P** herbarium, that there are no possible types available for typification. The specimens seen by Wight may be lost and there is no indication in the protologue what specimen he had used. In the protogue, the epithet is based on the hemispherical shape of the flower bud which Wight stated as distinctive for this species. The illustration in Wight's Icones clearly potrays the hemispherical flower bud, the inflorescence type and leaf shape. However, the illustration fails to show other important diagnostic characters such as the leaf venation and flower pedicel. This is important because this species does not have a typical *Syzygium* venation with intramarginal veins but rather a pinnate-like venation and a pedicellate flower. Furthermore, a hemispherical or globular flower bud is insufficient to represent this species because this character also occurs in other *Syzygium* species (*e.g. S. tokinense*). I have examined a number of specimens cited by Kostermans (1981) in his revision of Ceylonese *Syzygium* and I have decided to choose *Kostermans 27242* (**L**) as the neotype because it is a well preserve flowering specimen that shows the floral type and leaf venation.
2. *Syzygium hemipshericum* is easily identified by its distinctive pinnate-like leaf venation, pedicellate flower and terminal paniculate inflorescence. *Syzgium*

chanlos is conspecific with *S. hemisphericum* in having the same morphological characters.

SPECIMENS EXAMINED.

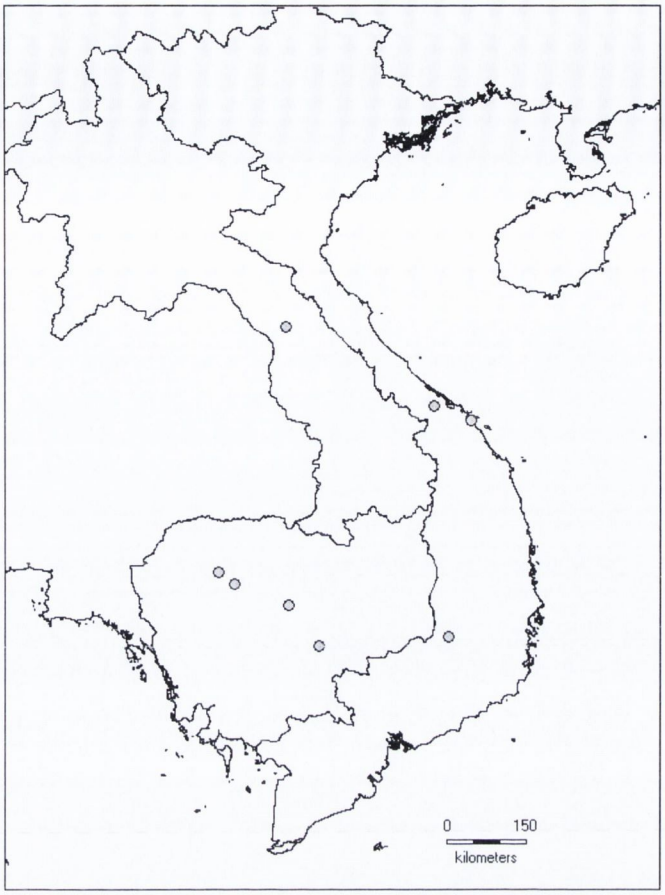
CAMBODIA. Kampong Chhnang: *Bejaud 567* (**P**) – Kampong Thum: Prasat Sambour, 27 May 2001, *K.Eanghourt & M.Monyrak 859* (**K**) – Siem Reap: Angkor Thom, June 1909, *d'Alleizette s.n.* (**L**); Banteay Srei, Khnar Sanday, 26 April 1924, *Diffon 509* (**P**).

LAOS. Khammouan: Nakai, 23 May 2006, *Nanthavong, K. & C.E.Ridsdale BT 489* (**E**).

VIETNAM. Cochinchina: s. loc. *Pierre s.n.* (**A**, **P**) ; Mu xoai, March 1867, *Pierre s.n.* (**P**) – Da Nang: Tourane and vicinity, May 1927, *J. & M.S. Clemens 4155* (**K**) – Dac Lak: Krong No , 9 April 1954, *Schmid s.n.* (**P**) – Dong Nai: Mt. Dinh, March 1867, *Pierre s.n.* (**P**); Mt. Dinh, May 1866, *Pierre s.n.* (**P**) – Thua Thien – Hue: Mt. Bach Ma, 16 June 1944, *Vidal 796 A* (**P**).

ADDITIONAL SPECIMENS EXAMINED.

SRI LANKA. Deltota, May 1856, *C.P. 2450* (**BM**); Kandy district, Moray Estate, Maskeliya, December, *Kostermans 27242* (**L**); Kandy district, Moray Estate, 22 November 1974, *Davidese et. al. 8679* (**L**); Botanical Garden Peradeniya, July, *Kostermans 277732* & *277733* (**L**); Botanical Garden Peradeniya, April, *Kostermans 27504* (**L**).



Map 28. Distribution of *Syzygium hemisphericum* (Wight) Alston in Cambodia, Laos and Vietnam.

31. *Syzygium imitans* Merr. & L.M.Perry, J. Arnold Arbor. 19: 113 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 52, fig. 3741 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 905 (2003); J. Chen & Craven, Fl. China 13: 346 (2007). **Type**: Vietnam, Tonkin, Chapa, *Petelot 6147* (holotype **A** n.v. [barcode 69427]).

Tree 3 – 6 m tall. Glabrous on all parts. **Twig** terete and compressed, 2.5 – 3 mm diameter, stout, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite to subopposite, 10 – 18 × 5 – 7.5 cm, 2 to 3 times as long as wide, elliptic to oblong – elliptic, base cuneate to slightly attenuate, c. 45 degrees from midrib, margin flat, apex acuminate, acumen (0.3 –)0.7 – 1cm, 1/15 – 1/35 of blade length, blade chartaceous, greenish; midrib sunken above, raised below; secondary veins (Type B) slender, 10 – 15 per side per blade, 15 – 20 mm apart,

c. 70 degrees ascending from midrib, prominent and raised on both surfaces, 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate to form the outer intramarginal veins; tertiaries prominent, subscalariform; inner intramarginal veins 2 – 3 mm from leaf margin, looped, outer intramarginal veins faint; petiole 1 – 2 cm, 1/10 – 1/14 of blade length, 2 – 2.5 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal, 8 – 10 cm long, paniculate, second to third order branching, spreading, flowers many, to 60; axes 7.5 – 9.5 cm, angular; bract and bracteoles caducous. **Flower** whitish, pedicellate, pedicel 1 – 2 mm, hypanthium not glaucous, not fibrous, 5 – 7 × 4 – 6 mm, pyriform, pseudostalk distinct, 1.5 – 2 mm; sepals 4, free, 1.5 – 2.5 × 4 – 4.5 mm, semiorbicular; petals 4, coherent, 4 – 5 × 5 – 6 mm, orbicular; outer stamens 6 – 10 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style c. 6 mm, ovules 20 – 25 per locule, irregularly radiating. **Fruit** depressed globose, 1.3 – 1.5 × 1.2 – 1.3 cm, surface smooth, calyx ring with persistent sepal lobes; seed 1, depressed globose, 0.6 × 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: South China (Guangxi and Guangdong) and Vietnam (North-Central).

ECOLOGY OR HABITAT. In open vegetation.

CONSERVATION STATUS. IUCN Global Status: Data Deficient (DD); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: July – September. Fruiting: November.

VERNACULAR NAME(S). Tram sao (Vietnam).

USES. Not documented.

NOTES.

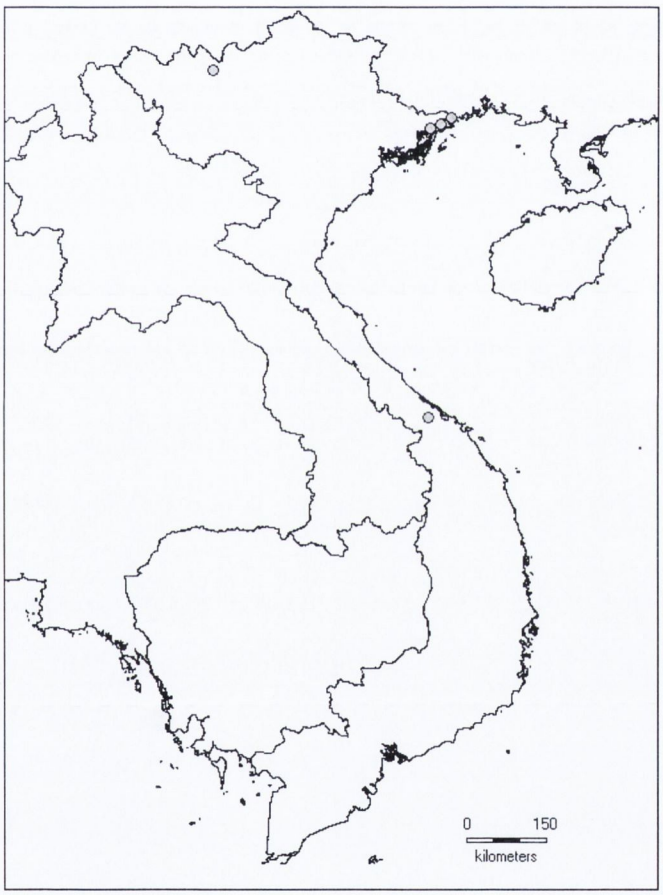
1. This species is vegetatively quite similar to *S. globliflorum* except the basal secondary veins (2 – 3) tend to be acrodromous, *i.e.* not connected at margin to form intramarginal venation but arcuate. Both species have the same floral type (flower bud globular and pedicellate) but the inflorescence of *S. imitans* differs from *S. globiflorum* in having second order branching (versus first order branching), more flowers (versus few flowers) and shorter pedicel (versus longer pedicel).

SPECIMENS EXAMINED.

VIETNAM. Lao Cai: Sa Pa, *Petelot 6143* (**A** n.v.) , *Petelot 6144* (**A** n.v.), *Petelot 6147* (**A** n.v.) – Quang Ninh: Mon Cay, September 1939, *W.T.Tsang 26890* (**E**, K); Dam Ha, Sai Vong Mo Leng and vicinity, 18 July - 9 September 1940, *W.T.Tsang 30415* (**A**, **K**); Ha Coi, Tsai Wong Mo Shan and vicinity, November 1936, *W.T.Tsang 27232* (**E**, K) – Thua Thien-Hue: Mt. Bach Ma, *T.D.Dai 313* (**HN**).

ADDITIONAL SPECIMENS EXAMINED.

CHINA. Guang Dong: Taan Fan, *W.T.Tsang 26698* (**P**).



Map 29. Distribution of *Syzygium imitans* Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

32. *Syzygium jambos* (L.) Alston, in Trimen, Handb. Fl. Ceylon 6 (Suppl.): 115 (1931); Merr. & L.M.Perry, J. Arnold Arbor. 19: 114 & 217 (1938), in Mem. Amer. Acad. Arts 18: 165 (1939); Merr., Philipp. J. Sci. 79: 397 (1950); Backer &

Bakh.f., Fl. Java 1; 344 (1963); Kosterm., Quat. J. Taiwan Mus. 34: 141 (1981); P.S. Ashton in Dassan. & Fosberg, Fl. Ceylon 2: 427 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 397 (1985); Whistler, J. Arn. Arb. 69: 183 (1988); D.G. Long & Rae in Gierson & D.G. Long, Fl. Bhutan 2: 280 (1991); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 44, fig. 3718 (1992); W.M. Verheij & R.E. Coronel (eds.), Prosea 2, Edible Fruit: 296-298 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 77 (1994); M.C.Le & T.H.Le Forest Plants (Thực vật rừng): 312 (2000); P.Dy Phon, Plants used in Cambodia: 378 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 868 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 905 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 430 (2004) [incl. *S. zimmermannii*]; V.S.Hoang, N.Khamseng & P.J.A. Kessler, Blumea 49: 315 (2004), pro parte; J. Chen & Craven, Fl. China 13: 344 (2007) [excl. var. *tripinnatum*] – *Eugenia jambos* L. Sp. Pl. 470 (1753)]; Lour. Fl. Cochinch. 307. 1790; Roxb., [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed. 2, 2: 494 (1832); Wight, Ill. Ind. Bot. 2: 14 (1841); Kurz, Forest Fl. Burma 1: 495 (1877), in J. Asiat. Soc. Bengal 46: 82 (1877); Duthie in Hooker f. Fl. Brit. Ind. 2: 474. (1878); King, J. Asiat. Soc. Bengal 70: 82 (1901), in Mat. Fl. Malays Penins. 12: 512 (1901); Brandis, Ind. Trees: 318 (1906); Gagnep. in Lecomte, Fl. Gén. Indo – Chine 2: 834 (1920) [excl. var. *sylvatica* Gagnep.]; Ridl., Fl. Malay. Penins. 1: 724 (1922); Craib, Fl. Siam. Enum. 1: 647. 1931; Corner, Wayside Trees Mal. 1: 499, plate 150 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 62, fig. 11b (1949); Kochummen in Ng, Tree Fl. Mal. 3: 247 (1978); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 245 (2007) – *Myrtus jambos* (L.) HBK, Nov. Gen. Sp. 6: 144 (1823); Blume, Bijdr.: 1085 (1826) – *Jambosa vulgaris* DC., Prodr. 3: 286 (1828) – Blume, Mus. Bot. 1: 93 (1849); Wight & Arn., Prodr. Fl. Ind. Orient.: 332 (1834); Wight, Icon. Pl. Ind. Orient. 2: t. 435 (1843); Miq., Fl. Ind. Bat. 1: 425 (1855); Gamble, Fl. Pres. Madras 1: 474 (1919); A.M.Cowan & Cowan, Tree N. Bengal: 66 (1929) – *Eugenia vulgaris* (DC.) Baill., Hist. Pl. 6: 345 (1876) – *Jambosa jambos* (L.) Millsp., Publ. Field Columb. Mus., Bot. Ser. 2: 80 (1900); – *Plinia jambos* (L.) M.Gómez, Fl. Haban.: 292 (1914). **Type**: Sri Lanka, *Herb. Hermann 2: 220, no. 188* (lectotype **BM**! [barcode BM000621575 & BM000621576] designated by Fawcett & Rendle (1926: 352)).

– [*Eugenia malaccensis* sensu Lour. Fl. Cochinch. 306. 1790, non L.] (fide Merr., Comm. Fl. cochinch. Trans Amer. Philos. Soc. 24: 285 (1935))

– [*Eugenia malaccensis* Blanco, Fl. Filip. (ed. 2): 290 (1845), nom. illeg. non L.] (fide Merr., Sp. Blancoan.: 290 (1918))

– *Jambosa palembanica* Blume, Mus. Bot. 1: 93 (1850). **Type**: Sumatra, Palembang, *Blume s.n.* (**L** n.v.). (fide Miq., Fl. Ind. Bat. 1: 425 (1855))

– *Eugenia monantha* Merr., J. Straits Branch Roy. Asiat. Soc. 79: 22 (1918) – *Syzygium monanthum* (Merr.) Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 163 (1939) – *Syzygium merrillii* Masam., Enum. Phan. Born.: 534 (1942), nom. superfl. **Type**: Sarawak, Rejang, Belaga, *Haviland 2146* (holotype **K**!), **syn. nov.**

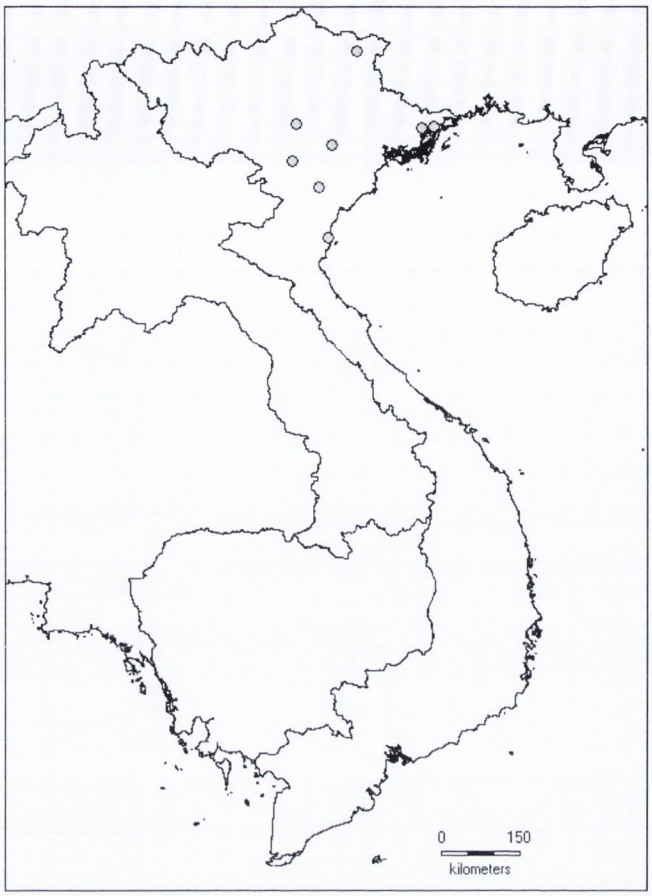
– *Syzygium jambos* var. *linearilimbum* H.T.Chang & R.H.Miao, Acta Bot. Yunnan. 4: 17 (1982); . **Type**: China, Yunnan, *Zhiat Z.H. 1146* (holotype **KUN** n.v.). (fide J. Chen & Craven, Fl. China 13: 344 (2007))

Tree to 1 m. Glabrous on all parts. **Twig** terete, 2 – 3 mm diameter, stout, slightly fissured, brownish, not contrasting to leaf colour. **Leaves** opposite, 11 – 18 × 1.5 – 4.5, 3.5 to 7 times as long as wide, lanceolate or elliptic, base attenuate to slightly cuneate, c. 45 degrees from midrib, margin flat, apex acute, tapering gradually into narrow point, acumen absent, blade subcoriaceous, greenish; midrib sunken above, raised below; secondary veins (Type A.II) 12 – 20 per side per blade, broadly spaced, 7 – 17 mm apart, c. 35 – 45 degrees from midrib, prominent and raised above, prominent below; tertiaries prominent, reticulate; inner intramarginal veins c. 0.5 mm from leaf margin, straight or slightly scalloped, outer intramarginal veins faint; petiole, 0.3 – 1 cm, 1/20 – 1/40 of blade length, 1 – 2 mm diameter, stout, dark brownish, not contrasting to blade lenght. **Inflorescence** terminal, to 4 cm long, racemose, flowers few, one to five, not compact; axes c. 3 cm long, angular to terete; bracts and bracteoles caducous. **Flower** white, pedicellate, pedicel c. 1 cm, hypanthium not glaucous, not fibrous, 10 – 20× 7 – 10 mm, pyriform, pseudostalk distinct, 5–10 mm long; sepals 4, free, unequal, outer lobes c. 1 × 1 mm, triangular; petals 4, free, unequal, , outer lobes 4 × 6 – 7 mm,inner lobes 5 – 6 × 7 – 8 mm, semiorbicular; outer stamens 25 – 30 mm long, anther c. 1 mm, sacs parallel, connective gland inconspicuous; style 35 – 40 mm, ovules c. 30 per locule, radiating. **Fruit** globose, 5 × 5 cm, surface

smooth, calyx ring with persistent sepal lobes, pericarp c. 6 – 10 mm thick; seed 1 – 3, ovoid, 3 × 2 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread from India to Borneo. In Indochina found in Laos and Vietnam. Possibly it occurs in Cambodia but has not yet been collected.
ECOLOGY OR HABITAT. In forest or planted in villages.
CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).
PHENOLOGY. Flowering: January, April. Fruiting: May.
VERNACULAR NAME(S): Cambodia: Chumpu. Vietnam: Bodao, Cay doi (Phu Tho), Gioi, Ly , Roi.
USES. Fruit is edible. The tree is planted on roadsides. The liquid of the boiled leaves is used to treat fever and the pulverised leaves are rubbed on the body to treat small pox (P.Dy Phon, 2000; W.M. Verheij & R.E. Coronel, 1992)). (For further detail see Verheij & Coronel (1992))
NOTES.
1. This species is closely resemble *S. siamense*. (see notes on *S. siamense* for detail).

SPECIMENS EXAMINED.
LAOS. Cahn Trap?, *Spire 1025* (**P**).
VIETNAM. s. loc. May 1887, *Pierre 1962* (**P**) – Cao Bang: April – May, *Pierre s.n.* (**P**) – Hanoi City: *Demange s.n.* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, *CPNP 4001* (**P**), *CPNP 4000* (**CPNP**), *CPNP 3994* (**CPNP**), *CPNP 3990* (**CPNP**), *CPNP 3988* (**CPNP**) – Phu Tho: Chan Moung forest reserve, 21 April 1914, *Chevalier 30092* (**P**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, May-July 1940, *W.T.Tsang 29926* (**A**, **E**, K); Tien Yen, January 1937, *W.T.Tsang 27482* (**E**, K) – Sontay – Tu Chap: Baa Tai valley, 12 April 1888, *Balansa 2861* (**P**) – Thanh Hoa: Cho Bo, Black river, 1887, *Balansa 2862* (**K**, **P**); Nhu Xuan, Xuan Quy, 24 April 1996, *N.T.Ninh & V.Dumontet VN 95* (**HN**) – Tonkin: *Bon 4607* (**P**).



Map 30. Distribution of *Syzygium jambos* (L.) Alston in Cambodia, Laos and Vietnam.

33. *Syzygium levinei* (Merr.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 110 & 227 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 53, fig. 3745 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 431 (2004) [pro parte] − J. Chen & Craven, Fl. China 13: 358 (2007) − *Eugenia levinei* Merr. Lingnan Sci. Jour. 13: 39 (1934). **Type**: China, Kwangtung, Lofoushan, *Merrill 10713* (holotype **PNH** †; isotype **A** n.v. [barcode 69406])

− *Eugenia millettiana* sensu Dunn & Tutcher, Kew Bull. Add. Ser. 10: 105 (1912),; Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 823 (1920; McClure, Lingan Univ. Sci. Bull. 3: 30 (1931); non Hemsl. (fide Merr. Lingnan Sci. Jour. 13: 39 (1934)) (see note 2)

Tree to 8 m tall. Glandulary hairy only on the inflorescence. **Twig** terete, 1.0 – 2.0 mm diameter, slender, smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 5 – 9 × 2.5 – 3.5 cm, 2 – 3 times as long as wide, elliptic to obovate, base cuneate to attenuate, 25 – 30 degrees from midrib, margin flat, apex acuminate with distinct acumen, acumen 0.5 – 1 cm, 1/6 – 1/9 of blade length, dark to pale brownish; midrib sunken above, raised below; secondary veins (Type A.1) slender, 20 – 25 per side per blade, narrowly spaced, (1 –)2 – 3 mm apart, ascending 60 – 70 degrees from midrib, prominent and raised above, prominent below; tertiaries faint, reticulate; inner intramarginal veins 0.5 – 1.0 mm, straight, outer intramarginal veins absent or faint; petiole 5 – 7 mm, 1/10 – 1/18 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** mostly terminal, sometimes axillary near leafy twig apex, 4 – 8 cm long, paniculate, first to second order branching, flowers many, 29 – 47; axes 3.5 – 7.5 cm, angular hairy; bract and bracteoles caducous, triangular, bract 0.7 × 0.5 mm, bracteoles 0.5 × 0.2 mm. **Flower** white (in vivo), sessile, hypanthium not glaucous, not fibrous, 3.0 – 4.0 × 3.0 – 4.0 mm, obconic, pseudostalk distinct, 1.0 – 2.0 mm; sepals 4, free, 1.5 × 0.5 mm, triangular; petals 4, coherent, orbicular; outer stamens c. 5 mm, anthers 0.5 mm, sacs parallel, connective gland conspicuous; style 6 – 6.5 mm, ovules 16 – 18 per locule, arrange irregularly and radiating. **Fruit** dark brown, ovoid, 0.8 × 0.7 cm, surface smooth, calyx ring with smooth rim, pericarp c. 0.1 mm thick; seed 1, ovoid, c. 0.8 × 0.7 mm, cotyledon free, intercotyledonary intrusion absent.

DISTRIBUTION: South China (Guangdong, Guangxi, Hainan and Hong Kong), Cambodia and Vietnam.

ECOLOGY OR HABITAT. In forest.

CONSERVATION STATUS. IUCN Global Status: Data Deficient (DD); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: June, August, September, October. Fruiting: January, March, October, December.

VERNACULAR NAME(S). Vietnam: Sam (Long An), Tram nui.

USES. Not documented.

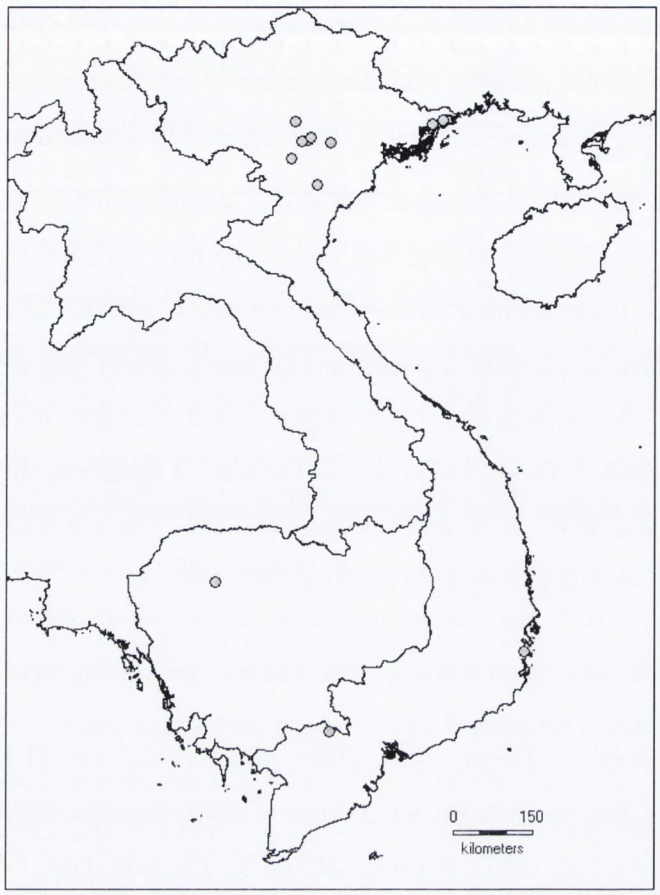
NOTES.

1. This species is distinctive in having a hairy inflorescence and leaves with dark brownish colour that contrast highly to the whitish twig. This seems to be a widespread species within its distribution range and is possibly undercollected.

2. Hemsley (1887) published *Eugenia millettiana* without a description but he cited a few specimens and this name was intended as a new name for *Opa odorata* because the epithet for *Eugenia* is pre-empted by *Eugenia odorata* Wight (Ill. Ind. Bot. 2: 16 (1841)). However two taxon were mounted on the same sheet (*Vachell s.n.*, China, May 1829, (**K**!)), one is glabrous (*Opa. odorata*) and the other taxa has a hairy inflorescence (*S. levinei*). Therefore, based on Hemsley's intention, the binomial of *Eugenia milletiana* goes with the Loreiro species, *Opa odorata*. Merrill (1934) effectively published the hairy taxa as *Eugenia levinei.*

SPECIMENS EXAMINED.

CAMBODIA. Siem Reap: Angkor Thom, June 1909, *d'Alleizette s.n.* (**L**). **VIETNAM**. Hill between Son Tay and Mt. Ba Vi, 3 August 1886, *Balansa 2891* (**K**, **P**) – Ha Tay: Son Tay, August 1887, *Balansa 2894* (**K**, **P**); Son Tay, 27 October 1938, *Petelot 2124* (A); Son Tay, March 1885, *Balansa 2888* (**K**, **P**); Thu Phap, August 1887, *Balansa 2887* (**K**, **P**) – Hanoi City: Ninh Thai?, 14 March 1890, *Bon 4297* (**P**) – Khanh Hoa: Nha Trang, June 1909, *d'Alleizette s.n.* (**L**) - Long An: Ben Tram, 15 September 1905, *Prades 702* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 2 October 1970, *Quynh 29* (**CPNP**); 12 August 1966, , *Anon. 121 D* (**CPNP**) – Phu Tho: Phu Ho, September 1923, *Petelot 1510* (A) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, 18 July-9 Sept, 1940, *W.T.Tsang 30405* (**P**); Ha Coi, Tsai Wong Mo Shan and vicinity, November 1936, *W.T.Tsang 27216* (**P**) – Thanh Hoa: Black river, January 1932, *Petelot 4319* (**P**) – Tonkin: *Bon 5056* (**P**).



Map 31. Distribution of *Syzygium levinei* (Merr.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

34. *Syzygium lineatum* (DC.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 109 (1938); Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 172 (1939); Amshoff, Blumea 5: 499 (1945) [excl. in syn. *Syzygium cerasiforme* (Blume) Merr. & L.M.Perry]; Airy Shaw, Bull. Misc. Inform. Kew 1949: 121 (1949); Backer & Bakh.f., Fl. Java 1: 343 (1963); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 53, fig. 3746 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 83 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 873 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 245 (2007) – *Myrtus lineata* Blume, Bijdr. 17: 1087 (1827), nom. illeg.., non Sw. (1788). – *Jambosa lineata* DC., Prodr. 3: 287 (1828); Miq., Fl. Ind. Bat. 1: 428 (1855) – *Clavimyrtus lineata* (DC.) Blume, Mus. Bot. 1: 113, t. 116 (1850), incl. var. *procera*, *membranacea* &

varingifolia – *Eugenia lineata* (Blume) Duthie in Hook.f., Fl. Brit. Ind. 2: 487 (1878), nom. illeg., non DC. [excl. *Eugenia corymbosa* Wallich, *Wallich Numer. list No. 3566F* (**K-W**!), nom. nud.]; King, J. Asiat. Soc. Bengal 70: 99 (1901); King, in Mater. Fl. Malay Penins. 12: 529 (1901); Brandis, Ind. Trees: 321 (1906); Ridl., Fl. Malay. Penins. 1: 738 (1922). **Type**: Java, in sylvis montanis, *Blume 1498* (holotype **L**! [HLB no. *944.234-470,-471,* 2 sheets marked as belonging together]; isotype G n.v.). (see note 2)

– *Clavimyrtus lineata* (DC.) Blume var. *membranacea* Blume, Mus. Bot. 1: 113. 1850. Type: Java, *Herb. Blume s.n.* (lectotype **L**! [HLB no. 898.203-482] here designated; isolectotypes **L**! [3 sheets: HLB no. 898-203-481, -483, 908.1510-5], **K**!).

– *Clavimyrtus lineata* (DC.) Blume var. *procera* Blume, Mus. Bot. 1: 113. 1850. Type: Java, 'in monte Murio', Nogosaren, *Waitz s.n. in Herb. Blume* (holotype **L**! [HLB no. 898.203-477]).

– *Clavimyrtus lineata* (DC.) Blume var. *varingifolia* Blume, Mus. Bot. 1: 113. 1850 ('*varingaefolia*'). Type: Borneo, *Blume s.n.* (holotype **L**! [HLB no. 908.151-12]; isotype **K**!).

– *Syzygium longiflorum* K.Presl, Abh. Königl. Böhm. Ges. Wiss., 5, 3: 500 (1845); Merr., Philipp. J. Sci. 79: 398 (1950); P.Dy Phon, Plants used in Cambodia: 579 (2000) – *Eugenia longiflora* (K.Presl) Fern.-Villar, in Blanco , Fl. Philipp. Ed. 3, 4(13A):86 (1880); C.B.Robinson Philipp. J. Sci. 4: 336 (1909); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 822 (1920); Craib, Fl. Siam. Enum. 1: 649 (1931); Corner, Wayside Trees Mal. 1: plate 151, fig. 168 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 159, figs. 30e,f (1949); Kochummen in Ng, Tree Fl. Mal. 3: 201 (1978). **Type**: The Philippines, Cagayan Province, Luzon, 1841, *Cuming 1296* (holotype **BM**!; isotype **L**! [barcode L0009641]).

– *Clavimyrtus latifolia* Blume, Mus. Bot. 1: 117 (1850) – *Jambosa latifolia* (Blume) Miq., Fl. Ind. Bat. 1: 429 (1855). **Type**: Borneo, *Herb. Korthal* (**L** n.v.). (fide Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 172 (1939))

– *Clavimyrtus symphytocarpa* Blume, Mus. Bot. 1: 113 (1850) – *Jambosa symphytocarpa* (Blume) Korth. ex Miq. Fl. Ind. Bat. 1: 430 (1855). **Type**:, Sumatra, *Herb. Korthal* (**L** n.v.). (fide Govaerts et. al. (2010)).

– *Jambosa rubricaule* Miq. Fl. Ind. Bat. 1: 432 (1855) – *Eugenia rubricaulis* (Miq.) Duthie in Hook.f., Fl. Brit. Ind. 2: 487 (1878). **Type**: Java, Dieng, *Junghunh s.n.* (holotype **U**! [sheet no. 255732B]).

– *Jambosa teysmannii* Miq. Fl. Ind. Bat. 1: 429 (1855) – *Eugenia teysmannii* (Miq.) Koord. & Valeton Koord. & Valeton, Med. 40: 164 (1900) – *Syzygium teysmannii* (Miq.) Masam. Enum. Phan. Born.: 540 (1942). **Type**: Java, Anon. *s.n.* [possibly Teysman] (holotype **L**! [barcode L0009642]; isotype **K**! [annotated by Miquel: '*Jambosa* teysmannii']).

– *Eugenia marivelesensis* Merr. (1906: 106). **Type**: The Philippines, Luzon, Bataan Privince Lamao river, Borden 618 (lectotype **K**! selected by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 84 (1994)).

– *Eugenia miquelii* Elmer (1912: 1441). **Type**: The Philippines, Mindanoa, District of Davao, Todaya (Mt. Apo), *Elmer 11240* (holotype **PNH**†; isotypes **A** n.v. [barcode 69750], **GH** n.v. [barcode 69751], **NY**! [barcode 00118062]).

– *Eugenia longicalyx* Ridl. (1930: 11). *Syzygium longicalyx* (Ridl.) Masam. (1942: 533). **Type**: British North Borneo, July 1896, *Creagh s.n.* (holotype **K**!; isotype **SING** n.v.).

– [excluding *Syzygium zippelianum* Miq., Fl. Ned. Ind. 1(1): 449 (1855) – *Eugenia zippeliana* (Miq.) Koord. & Valeton, Meded. Lands Plantentuin 40: 142 (1900). **Syntypes**: Java, Mabalar, Pengalengang *Herb. Junghunh s.n.* (**L**! [HLB 898,203-742]); Java, Gede, *Herb. Zippelius* (**L** n.v.)] (see note 3)

Tree to 10 m tall. Bark flaky. Glabrous on all parts. **Twig** terete, 2 – 3 mm diameter, slender, surface smooth or fissured, whitish to brownish, contrasting or not to leaf colour. **Leaves** opposite, 6 – 9 × 2.2 – 4.5 cm, 2 to 3.5 times as long as wide, elliptic, oblong – elliptic or ovate, base cuneate, slightly attenuate, c. 45 degrees from midrib, margin wavy, apex acuminate, acumen distinct, 0.5 – 1.3 cm, 1/6 – 1/16 of blade length, blade chartaceous to subcoriaceous, light to yellowish to greenish brown; midrib sunken above, raised below; secondary veins (Type A.I) very slender, 20 – 30 per side per blade, narrowly spaced, 1 – 2(– 3) mm apart, 60 – 70 degrees from midrib, inconspicuous and raised above, prominent below; tertiaries faint, reticulate; outer intramarginal veins c. 1 mm, straight, outer intramarginal veins faint or absent; petiole 0.6 – 0.8 cm, 1/9 – 1/15 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade

colour. **Inflorescence** terminal and axillary near apex of leafy twig, to 12 cm long, paniculate, second order branching, flowers 9 to 21; axes c. 11 cm, angular; bract and bracteoles persistent, triangular, bract 1.5 × 0.8 mm, bracteoles 1.2 × 0.5 mm. **Flower** whitish, pedicellate, pedicel c. 1 mm, hypanthium not glaucous, not fibrous, 5 – 7 × 3 – 4 mm, pyriform, pseudostalk distinct, 2 – 4 mm; sepals 4, free, 2 – 3 × 3 mm, semiorbicular; petals 4, free, 3 × 3 mm, orbicular; outer stamens 0.9 – 1 cm, anthers c. 0.5 m, sacs parallel, connective gland conspicuous; ovary at hypanthium apex, style c. 5 – 10 mm, ovules 10 – 15 per locule, irregularly radiating. **Fruit** globose, 0.9 × 0.9 cm, surface smooth, calyx ring with persistent sepal lobes; seed 1, globose, 0.7 × 0.7 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread, occurring in China (Guangxi), Myanmar, Thailand, Cambodia, Laos, Vietnam, Peninsular Malaysia, Sumatra, Borneo, Jawa and The Philippines.

ECOLOGY OR HABITAT. Primary or secondary forest, along roadside, stunted forest, savannah, river banks, limestone hill, to 850 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: December-June. Fruiting: January, March.

VERNACULAR NAME(S). Cambodia: Pring , Pring bay chom (Kandal), Pring chan (Kampot, Koh Kong), Pring chom (Kandal), Pring kbal khmum (Kandal), Pring phnom (Koh Kong), Pring sambak salp (Kandal), Smach teuk (Kampong Spoe). Vietnam: Tram hang (Dong Nai), Tram hoa dai, Tram ba vo.

USES. Fruits is edible, consumed fresh or cooked. Wood is used in construction.

NOTES.

1. *Syzygium lineatum* is a widespread species and it is quite distinctive. The venation is slender and narrowly spaced (*Callophyllum*-like) and the inflorescence is paniculate with pedicellate flowers.

2. Blume's *Myrtus lineata* is illegitimate and de Candolle having seen the dried specimen of the type communicated by Blume, made a new combination: *Jambosa lineata*. Therefore it can be safely presumed that *Myrtus lineata* and *Jambosa lineata* are homotypic. In the same publication, de Candolle made new

combination of *Myrtus lineata* Sw. from the Carribean as *Eugenia lineata* (Sw.) DC, a name which Duthie apparently was not aware of and which preempted *E. lineata* (Blume) Duthie. Amshoff (1945) included *S. cerasiforme* in *S. lineatum* without referring to the type because it was not found in **L** at the time. A specimen in **L** (barcode L00941), annotated by Blume as '*Myrtus cerasiformis*', is the type of *Myrtus cerasiformis* and it does not conform morphologically with *S. lineatum* but in my opinion is conspecific to *S. racemosum* (Blume) DC. The latter species is found in Thailand but to date not in Indochina. It differs from *S. lineatum* in having a shorter inflorescence, sessile flowers and darker leaf colour that is highly contrasting to the whitish twig.

3. *Syzygium zippelianum* which was included as a synonym in the *World Checklist of Myrtaceae* (Govaerts et. al., 2010) is not conspecific to *S. lineatum*.

SPECIMENS EXAMINED.

CAMBODIA. 1963, *Guinet 172* (**P**) – Kampong Spoe: Phnum Aural, 3 March 2001, *K.Enghourt, M.Sophal & S.Kosal MoE Herb. 584* (**K**) – Kampong Thum: Kampong Svay [Kampong Soai], February 1875, *Harmand 375* (**L**) – Kampot: Mt. Bokor, 8 March 2001, *D.Middleton & M.Monyrak 605* (**A**, **K**); Mt. Bokor, 6 May 1999, *M.Monyrak 25* (**K**); Phnom Kamchay, 19 April 1914, 15-19 March 1914, *Chevalier 30066* (**P**) – Kandal: Phnom Penh, June 1909, *d'Alleizette s.n.* (**L**); Phnom Penh, *Magnen, Gourgand & Chatillion s.n.* (**P**); Phnom Penh, 5 April 1933, *Bejaud 560* (**P**); Phnom Penh, *Bejaud 554* (**P**) – Koh Kong: Botum Sakor, Prolean, 3 December 1968, *M.A.Martin 1085* (**P**); Thma Bang, Ta Tey Leu, 29 January 1970, *M.A.Martin 1676* (**P**) – Kompong Speu: Samraong Tong, April 1870, *Pierre 986* (**P**) – Preah Vihear: Mlu Prey, January 1876, *Pierre 3091* (**P**); Mlu Prey, January 1876, *Pierre 3091 (Harmand252)* (**L**) – Siem Reap: Phnom Koulen, 17 December 2000, *S.Hul* et al. *1004* (**P**)

LAOS. *Harmand 466* (**P**) – Khammouan: Ban Mak Phueang, 12 February 2005, *M.F.Newman, P.I.Thomas, K.E.Armstrong, K.Sengdala & V.Lamxay LAO 159* (**E**)

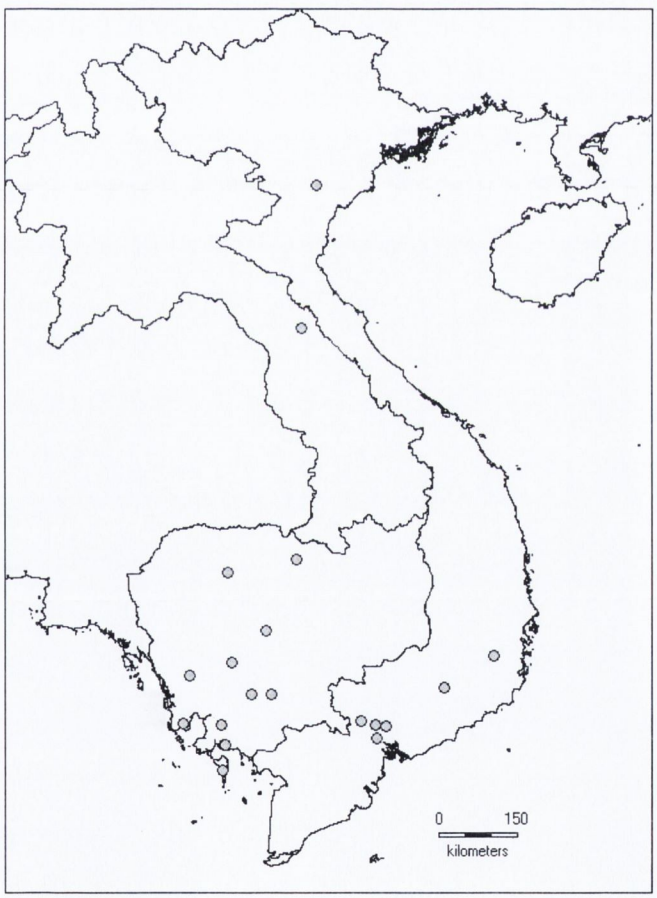
VIETNAM. Lang-than, *Thorel s.n.* (**P**) – Binh Duong: Thu Dau Mot, 1862-1866, *Thorel 1011* (**P**) – Cochinchina: , 1868, *Talmy s.n.* (**P**) – Dong Nai: Bien Hoa, 10 May 1967, *Vu Van Cuong 452* (**P**); Bien Hoa, 10 May 1967, *Vu Van Cuong 452* (**P**) – Ho Chi Minh City: , 1 January 1966, *Vidal 4974* (**P**) – Ken Giang: Phu

Quoc Is., 20 January 1874, *Pierre s.n.* (**P**); Phu Quoc Is., 20 January 1874, *Pierre s.n.* (**P**) – Lam Dong: , Mt. Gia Rich, *Averyanov* et al. *VH 4540* (**HN**); Minrong Sekang, 26 February 1953, *M.Schmid, s.n.* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 25 May 2000, *D.D.Soejarto & N.M.Cuong 11642* (**GH**) – South Vietnam: , 9 March 1971, *Vu Van Cuong 1640* (**P**) – Tay Ninh: Cai Cong, April 1866, *Pierre s.n.* (**P**).

ADDITIONAL SPECIMENS EXAMINED.

Syzygium cerasiforme (Blume) Merr. & L.M.Perry: Java, annotated by Blume as '*Myrtus cerasiformis*', *Blume s.n.*, (holotype **L**! [barcode L009410].

Syzygium racemosum (Blume) DC.: Java, annotated by Blume as 'Calyptranthes racemosa, 1266, Java', *Blume s.n.* (holotype **L**! [barcode L0329986]).



Map 32. Distribution of *Syzygium lineatum* (DC.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

35. ***Syzygium malaccense*** (L.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 215 (1938); Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 154 (1939); Backer & Bakh.f., Fl. Java 1: 343 (1963); T.G. Hartley & L.M.Perry, J. Arnold Arbor. 54: 40 (1973); Kosterm., Quat. J. Taiwan Mus. 34: 123 (1981); P.S. Ashton, in Dassan. dan Fosberg, Fl. Ceylon 2: 428 (1981); Whistler, J. Arn. Arb. 69: 181 (1988); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 44, fig. 3717 (1992); W.M. Verheij & R.E. Coronel (eds.), Prosea 2, Edible Fruit: 292-294 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 85 (1994); P.Dy Phon, Plants used in Cambodia: 579 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 875 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003) – *Eugenia malaccensis* L., Sp. Pl.: 470 (1753); Roxb., [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed.: 483 (1832); Wight, Ill. Ind. Bot. 2: 14 (1841); Kurz, J. Asiat. Soc. Bengal 46: 68 (1877), in Forest Fl. Burma 1: 493 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 471 (1878); Koord. & Valeton, Med. 40: 55 (1900); King, J. Asiat. Soc. Bengal 70: 82 (1901); Brandis, Ind. Trees: 319 (1906); Merr., Philip. J. Sci. 9: 121 (1914); Merr. Interpr. Herb. Amboin. 398 (1917); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 839 (1920); Ridl., Fl. Malay. Penins. 1: 1922 (1922); Craib, Fl. Siam. Enum. 1: 651 (1931); Corner, Wayside Trees Mal. 1: 499 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 46, fig 1a-b & 6a (1949); Kochummen in Ng, Tree Fl. Mal. 3: 247 (1978) – *Caryophyllus malaccensis* (L.) Stokes, Bot. Mat. Med. 3: 72 (1812) – *Myrtus malaccensis* (L.) Spreng., Syst. Veg. 2: 484 (1825) – *Jambosa malaccensis* (L.) DC., Prodr. 3: 286 (1828); Wight & Arn., Prodr. Fl. Ind. Orient.: 332 (1834); Wight, Ill. Ind. Bot. 2: t. 98 (1841). **Type**: Icon, van Rheede, Hort. Malab. 1: 29, t. 18 (1678) (lectotype here designated). (see note 1)

– *Eugenia macrophylla* Lam., Encycl. 3: 196 (1789) – *Myrtus macrophylla* (Lam.) Spreng., Syst. Veg. 2: 483 (1825), nom. illeg., non J.St.-Hil. – *Jambosa macrophylla* (Lam.) DC., Prodr. 3: 286 (1828). **Type**: *Sonnerat s.n.* in *Herb. Lamark* (lectotype **P-LA**! [barcode P00297788] here designated; isolectotype **P-LA**! [P00297789]).

– *Jambosa domestica* Rumph., Herb. Amboin. I: 121, t. 37 (1741), incl. forma *minor*, *rosacea*, *calapparia*; DC., Prodr. 3: 288 (1828); Blume, Mus. Bot. 1: 91 (1849). **Type**: Icon, Rumph., Herb. Amboin. I: 121, t. 37 (1741). Representative

specimen: *Robinson Pl. Rumph. Amb. 194* (n.v.). (fide Merr. Interpr. Herb. Amboin. 398 (1917))

– *E. purpurea* Roxb. [Hort. Beng. (1814) 37, nom. nud.] Fl. Ind. ii. 483 (1832) – *Jambosa purpurascens* DC., Prodr. 3 (1828) 286 – *Jambosa purpurea* (Roxb.) Wight & Arn., Prodr. Fl. Ind. Orient.: 333 (1834); Wight, Ic. 2: t. 549 (1843) – *Jambosa* domestica var. purpurea (Roxb.) Blume, Mus. Bot. 1: 92 (1849) – *E. malaccensis var. purpurea* Duthie *in* Hook. *f.* , Fl. Brit. Ind. 2 (1878) 472. (*Wallich 3610*, **K**!, **K-W**!). **Type**: Ic. Roxb. No. 1438, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.))

Tree to 8 m tall. Glabrous on all parts. **Twig** angular (4-angled) or terete and compressed, c. 4 mm diameter, stout, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, 15 – 30 × 8 – 12 cm, 2 to 3.5 times as long as wide, elliptic, oblanceolate or obovate, base strongly attenuate, c. 25 – 30 degrees ascending from midrib, margin flat to wavy, apex mostly acuminate, acumen if present, 0.5 – 1 cm, 1/20 – 1/28 of blade length, blade chartaceous, pale brownish; midrib sunken above, raised below; secondary veins (Type B) 8 – 12 per side per blade, broadly spaced, 10 – 15 mm apart, c. 45 degrees ascending from midrib, prominent to faint and raised above, prominent and raised below, 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate, extend from base to half way or near leaf apex (forming outer intramarginal veins); tertiaries prominent, reticulate; inner intramarginal veins extend from well above the leaf base (after basal secondary veins) to leaf apex, looped, c. 5 mm from margin; petiole 1 – 1.5 cm, 1/14 – 1/28 of blade length, c. 2 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** lateral-axillary in axil of fallen leaves, 3 – 4 cm long, racemose, flowers few, 3 to 15; axes 1.5 – 2.5 cm, angular; bract and bracteoles caducous. **Flower** pedicellate, pedicel 0.3 – 0.5 cm, hypanthium 1.3 – 1.5 × 0.7 – 0.8 cm, pyriform, pseudostalk distinct, 5 – 7 mm; sepals 4, free, unequal, outer lobe 3 – 3.2 × 5 mm, inner lobes 5 – 6 × 7 mm, semiorbicular; petals 4, free, 6 – 7 × 7 – 8 mm, orbicular; outer stamens c. 1.5 cm, anthers c. 1.5 mm, sacs parallel, connective gland conspicuous; style 1.9 – 2 mm, ovules 10 – 15 per locule, irregularly radiating. **Fruit** oblong to subglobose, 7 × 5 cm, surface smooth, calyx ring with persistent sepal lobes, seed 1, globose, 2 × 2 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Mainland Southeast Asia to Southwestern Pacific. In Indochina occur in Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. Cultivated. Possibly originate from Malesia.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

VERNACULAR NAME(S). Cambodia: Chumpu, Kraham. Laos: Kieng (Xaignabouli). Vietnam: Dieu do

USES. Cultivated as a fruit tree. In Cambodia, the fruit, seed and leaves are used to treat fever while the root is diuretic (P.Dy Phon, 2000). (For further detail see W.M. Verheij & R.E. Coronel (eds.), Prosea 2, Edible Fruit: 292-294 (1992))

NOTES.

1. For the purpose of typification, Rheede's icon is chosen as the lectotype because the drawing of the floral parts, fruit and leaves is better represented *S. malaccense* than Herman's icon (Herb. Hermann 5: 241, No. 187 (**BM**!)). (see Plate 5.22)

SPECIMENS EXAMINED.

CAMBODIA. s. loc., November 1875, *Pierre Harmand 48 3201* (**P**). **LAOS**. Xaignabouli: 30 October 1965, *Vidal 4178* (**P**). **VIETNAM**. Cochinchina: *Thorel 371* (**P**) – Dong Nai: Mt. Dinh, 20 March 1918, *Chevalier 36807* (**P**) – Hanoi City: *Petelot 3387* (**P**).

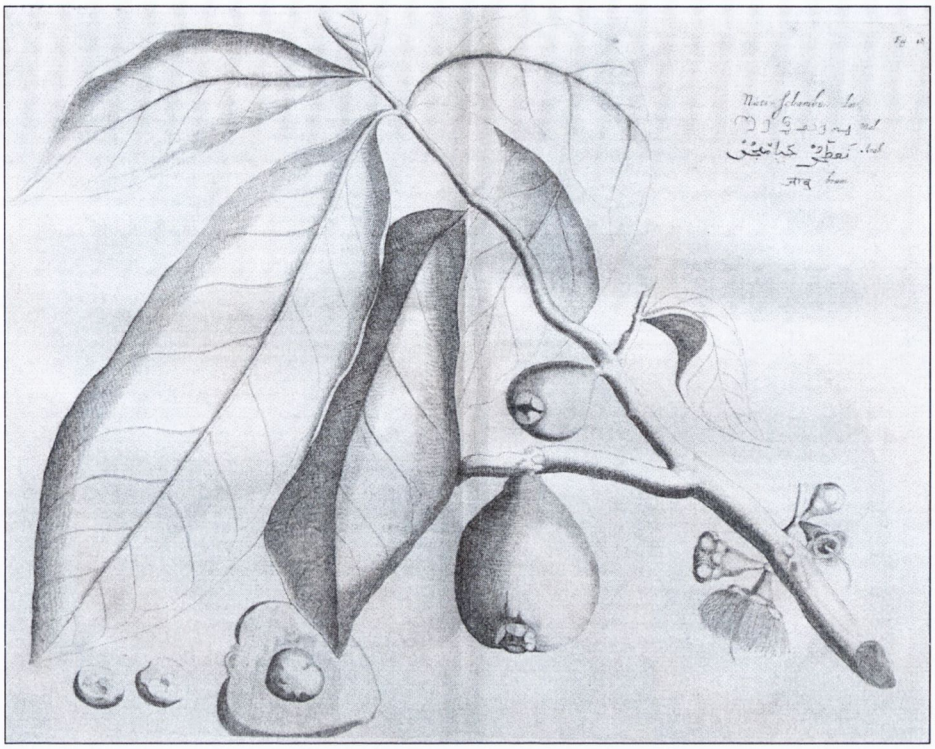


Plate 5.23. Icon of *Syzygium malaccense* (L.) Merr. & L.M.Perry from Rheede's *Hortus Indicus Malabaricus* (1678).

36. *Syzygium megacarpum* (Craib) Rathakr. & N.C.Nair, J. Econ. Taxon. Bot. 4: 287 (1983); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 86 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 875, plate XXX,1 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); J.Chen & Craven, Fl. China 13: 345 (2007) – *Eugenia macrocarpa* Roxb., (Hort. Bengal. 37 (1814)) Fl. Ind. ed. 1832, 2: 497 (1832), nom. illeg., non Schlecht. & Cham.; Wight, Icon. Pl. Ind. Orient. 2: t.: t. 612 (1843); Kurz, J. Asiat. Soc. Bengal 46: 68 (1877); Kurz, Forest Fl. Burma 1: 492 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 474 (1878) – *Jambosa macrocarpa* Miq., Fl. Ned. Ind. 1: 417 (1855) – *Eugenia megacarpa* Craib, Fl. Siam. 1: 652 (1931) – *Syzygium macrocarpum* (Miq.) Bahadur & R.C.Gaur, Indian J. Forest. 1: 349 (1978) – *Syzygium macrocarpum* (Roxb.) N.P. Balakrishnan, Fl. Jowai 1: 201 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 387 (1985). **Type**: Ic. Roxb. No. 2260 ined. (lectotype **K**! [downloaded from Royal Botanic Gardens, Kew (2006)] here designated, **C** n.v.)

– *Jambosa coarctata* Blume, Mus. Bot. 1: 99 (1850). **Type**: *Blume s.n.* (**L** n.v.) (fide P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 86 (1994))

– *Eugenia latilimba* Merr., Lingnan Sci. J. 13: 64 (1934) – *Syzygium latilimbum* (Merr.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 216 (1938); M.C.Le & T.H.Le Forest Plants (Thực vật rừng): 312 (2000). **Type**: China, Hainan, Chim Shan, Fan Maan Ts'uen, 4 -20 May 1932, *McClure 20098*, (holotype **PNH**†; isotypes **A** n.v. [barcode 29405], **BM**!, **K**!, **P**!).

– *Eugenia malayana* Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 838 (1920), nom. nov., sphalm. non *Jambosa confusa* Bl. & *Jambosa lanceolata* Korth.; M.R.Henderson, Gard. Bull. Sing. 12: 202 (1949 – *Syzygium malayanum* (Gagnep.) I.M.Turner, J. Singapore Natl. Acad. Sci. 22-24: 21 (1996); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 431 (2004). **Voucher**: see all the specimens examined in Laos. (see note 1)

Tree to 10 m tall, to 20 cm dbh. Bark brownish, slash bark dark greyish. Glabrous on all parts. **Twig** terete or subangular,3 – 4 mm diameter, stout, surface smooth, greyish or pale brownish, not contrasting to leaf colour. **Leaves** opposite, 23 – 28(– 50) × 7.5 – 9 cm, 3 to 4 times as long as wide, oblong – elliptic , base cordate, sometimes rounded, margin flat, apex acute or acuminate, acumen if present c. 1 cm, 1/28 of blade length, blade coriaceous, greenish; midrib sunken above, raised below; secondary veins (Type A.II) c. 10 per side per blade, broadly spaced, 5 – 7 mm apart, 60 – 70 degrees from midrib, faint and raised above, prominent and raised below; tertiaries prominent, scalariform to subscalariform; inner intramarginal veins c. 5 mm from leaf margin, straight, outer intramarginal veins faint; petiole c. 1 cm, 1/25 – 1/28 of blade length, 2 – 3 mm diameter, stout, wrinkled, dark brownish to blackish, contrasting to blade colour. **Inflorescence** terminal, 4 – 6 cm long, racemose, flowers few, 3 to 9; axes 1.5 – 3.5 cm, angular, stout; bract and bracteoles caducous. **Flower** pedicellate, pedicel c. 1 cm, hypanthium not glaucous, not fibrous, 15 – 20 × 15 – 20 mm, pyriform, pseudostalk distinct, c. 5 mm; sepals pinkish, 4, free, unequal, semiorbicular, outer lobes 5 × 10 mm, inner lobes 8 – 10 × 15 – 18 mm; petals whitish, 4, free, 15 – 17 × 17 mm, suborbicular; outer stamens whitish, 25 – 30 mm, anthers c.

1.25 mm, sacs parallel, connective gland conspicuous; style 20 – 25 mm, ovules 20 – 30 per locule, irregularly radiating. **Fruit** (immature) globose, 2 × 29 cm, surface smooth, calyx ring with undulating rim; seed 1 – 3, ovoid, 1 × 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: India (Assam), Bangladesh, China (Hainan, Guangxi and Yunnan), Myanmar, Thailand, Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: May, December. Fruiting: not documented.

VERNACULAR NAME(S). Laos: Kiem nam (Louang Phabang). Vietnam: Roi rung, Gioi rung.

NOTES.

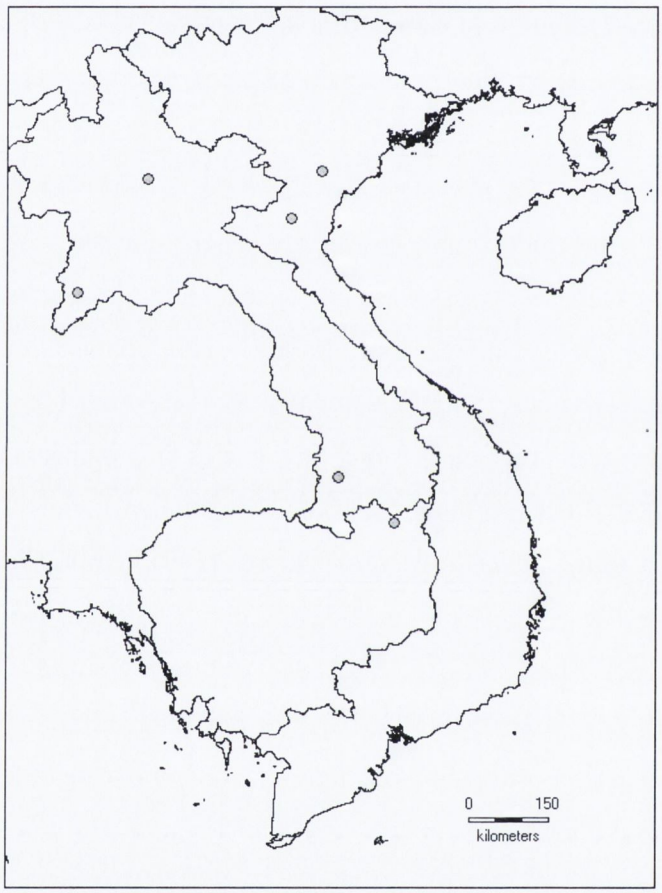
1. Gagnepain (1920) referred to the Indochinese specimens as conspecific with *Jambosa confusa* Bl. and partly with *Jambosa lanceolata* Korth. He proposed the new name *Eugenia malayana* upon realising that the new combination for *Eugenia* was pre-empted by *Eugenia confusa* DC. and *Eugenia lanceolata* Lam. (1789). Henderson (1949) later used this new name for species in Peninsular Malaysia (*FMS 33413* [**K**!, **KEP**!]) but cautioned that he did not see any original material of *E. malayana*, *J. confusa* or *J. lanceolata*. Turner (1997), followed Henderson in adopting the specific epithet and changed the genus to *Syzygium*. The leaves of *J. confusa* (type: *Blume s.n.*, **L**! [barcode L0009609]) and *J. lanceolata* (type: *Korthal s.n.*, **L**! [barcode L0009610]) are brownish in colour and narrower than *S. megacarpum* and in my opinion do not resemble Indochinese specimens. I am also doubtful about the identity of *E. malayana* from Peninsular Malaysia (*FMS 33413* [**K**!, **KEP**!] & *FRI 13528* [**KEP**!]) which resembles *S. tekuense* (M.R.Hend.) I.M.Turner as the leaves are much longer, tapering gradually toward apex and dark brownish in colour in dried state.

SPECIMENS EXAMINED.

CAMBODIA. Ratanikiri: Virachey National Park, O Tayak river, 11 December 2005, P.*Thomas, K.Teah, K.Sokhon, S.Teng, S.Sokhon, Y.Bounsoeung 14* (**E**).

LAOS. sin. loc. 4 October 1913, *Dussaud s.n.* (**P**) – Attapeu: , Bolaven plateau [Attopeu plateau], March 1877, , *Harmand 1314* (**P**) – 'Louang Phabang: base of Phou Phung, 31 December 1953, *Vidal 2577* (**P**) – Xaignabouli: Pak Lay, *Thorel s.n.* (**P**).

VIETNAM. s. loc., *Anon. LX-VN 267* (**HN**) – Nghe An: Quy Chau, 10 February 2004, *N.Q.Binh & D.D.Cuong VN 1261* (**HN**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, *Anon. NMC 1685* (**CPNP**), 25 May 1992, *Anon. NMC 149* (**CPNP**).



Map 33. Distribution of *Syzygium megacarpum* (Craib) Rathakr. & N.C.Nair in Cambodia, Laos and Vietnam.

37. *Syzygium nervosum* A.Cunn. ex DC., Prodr. 3: 260 (1828) – *Cleistocalyx operculatus* (Roxb.) Merr. & L.M.Perry, J. Arnold Arbor. 18: 337 (1937) [excl. *Syzygium angkolanum* Miq.], nom. nov. pro *Syzygium nervosum* DC.; Kosterm., Quat. J. Taiwan Mus. 34: 121 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya:

388 (1985); V.D.Nguyen, Medicinal plants of Vietnam, Cambodia and Laos: 282 (1993) – *Cleistocalyx nervosus* (A.Cunn. ex DC.) Kosterm., Bull. Bot. Surv. India 29: 17 (1987 publ. 1989), non (Lour.) Blume, sphalm. nervosum, comb. illeg.; P.Chantaranothai & J.Parn., Fl. Thailand 7: 785 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 311 (2003) – *Cleistocalyx nervosum* (A.Cunn. ex DC.) P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 63, fig. 3776 (1992). **Type**: *Roxburgh s.n.* in *Herb. Lambert 1816* (holotype G-DC [microfich**E**!]). (see Panigrahi & Mishra, Taxon 34: 298-299 (1985) & I.M.Turner Gard. Bull. Singapore 57: 26 (2005) for detailed discussions on the typification; see note 1 for discussion on *S. angkolanum*)

– *Eugenia operculata* Roxb. [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed. 1832, 2: 486 (1832), nom. superfl., nom. illeg..; Wight, Icon. Pl. Ind. Orient. 2: t. 552 (1843); Kurz, J. Asiat. Soc. Bengal 46: 66 (1877); Kurz, Forest Fl. Burma 1: 482 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 498 (1879); Koord. & Valeton, Med. 40: 148 (1900); King, J. Asiat. Soc. Bengal 70: 129 (1901); King, in Mater. Fl. Malay Penins. 12:: 599 (1901); Brandis, Ind. Trees: 322 (1906); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 817 (1920); Ridl., Fl. Malay. Penins. 1: 754 (1922); Craib, Fl. Siam. Enum. 1: 653 (1931); M.R.Henderson, Gard. Bull. Sing. 12: 264, figs. 51b & c, (1949); Kochummen in Ng, Tree Fl. Mal. 3: 205 (1978) – *Syzygium operculatum* (Roxb.) Nied. in H.G.A.Engler & K.A.E.Prantl, Nat. Pflanzenfam. 3(7): 85 (1893), nom. illeg.; D.G. Long & Rae in Grierson & D.G. Long, Fl. Bhutan 2: (1911); Gamble, Fl. Pres. Madras 1: (1919); A.M.Cowan & Cowan, Tree N. Bengal: 67 (1929); P.S. Ashton, in Dassan. dan Fosberg, Fl. Ceylon 2: (1981); B.Hyland, Austral. J. Bot., Suppl. ser. 9: 108, fig. 50 (1983). **Type**: *Roxburgh s.n.* in *Herb. Lambert*, 1816 (lectotype G-DC! [microfiche] designated by Panigrahi & Mishra, Taxon 34: 298-299 (1985)).

– *Eugenia paniala* Roxb. [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed. 1832, 2: 489 (1832); Wight, Icon. Pl. Ind. Orient. 2: t. 616 (1843); Kurz, J. Asiat. Soc. Bengal 46: 66 (1877); Kurz, Forest Fl. Burma 1: 483 (1877); Craib, Fl. Siam. Enum. 1: 655 (1931) – *Eugenia* operculatus var. paniala (Roxb.) Duthie in Hook.f., Fl. Brit. Ind. 2: 498 (1879), comb. Illegit.; King, J. Asiat. Soc. Bengal 70: 130 (1901); King, in Mater. Fl. Malay Penins. 12:: 560 (1901) – *Cleistocalyx operculatus* var. *paniala* (Roxb.) Chantaranothai & J.Parn., Kew Bull. 48: 591 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 20 (1994), nom.

illeg. – *Cleistocalyx nervosus* var. *paniala* (Roxb.) J.Parn. & Chantaranothai, Novon 6: 201 (1996); P.Chantaranothai & J.Parn., Fl. Thailand 7: 788 (2002) – *Cleistocalyx cerasoides* var. *paniala* (Roxb.) I.M.Turner, Gard. Bull. Singapore 57: 26 (2005) – *Syzygium nervosum* var. *paniala* (Roxb.) Craven & Biffin, Blumea 51: 138 (2006). **Type**: Ic. Roxb. No. 2255 (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)] designated by Chantaranothai & J.Parn., Kew Bull. 48: 591 (1993)). (see note 2)

– *Calyptranthes makal* sensu Blanco, Fl. Filip.: 419 (1837), non Raeusch. Representative specimen: The Philippines, Antipolo, Rizal Province, Luzon, *Merrill Sp. Blancoan. 978* (**US** n.v. [barcode 00689276]). (fide Merr. Sp. Blancoan. : 288 (1918); Merr. & L.M.Perry, J. Arnold Arbor. 18: 337 (1937) [as synonym of *Cleistocalyx operculatus* (Roxb.) Merr. & L.M.Perry)

– *Calyptranthes zuzygium* Blanco, Fl. Filip., ed. 2: 293 (1845) non Sw., nom. illeg.; Merr. Sp. Blancoan. : 288 (1918) [as syn. of *Eugenia clausa* C.B.Rob]. (fide Merr. & L.M.Perry, J. Arnold Arbor. 18: 337 (1937) [as syn. of *Cleistocalyx operculatus* (Roxb.) Merr. & L.M.Perry])

– *Syzygium wallichianum* K.Presl, Abh. Königl. Böhm. Ges. Wiss., 5, 3: 500 (1845). (fide Govaerts et. al. (2010)).

– *Eugenia cerasoides* Roxb., Fl. Ind. ed. 1832, 2: 488 (1832) – *Syzygium cerasoides* (Roxb.) Raizada, Indian Forester 84: 478 (1958) – *Syzygium cerasoides* Raizada, Indian Forester 93: 755 (1967), nom. illeg. – *Cleistocalyx cerasoides* (Roxb.) I.M.Turner, Gard. Bull. Singapore 57: 26 (2005). **Type**: : Ic. Roxb. No. 2256, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)] designated by I.M.Turner, Gard. Bull. Singapore 57: 25 (2005); **C** n.v.))

– *Calyptranthes mangiferifolia* Hance ex Walp., Ann. Bot. Syst. 2: 629 (1852). (fide Merr. & L.M.Perry, J. Arnold Arbor. 18: 337 (1937))

– *Syzygium nodosum* Miq., Fl. Ned. Ind. 1(1): 447 (1855). **Type**: Indonesia, Java, Palengang, *Junghuhn s.n.* (lectotype **L**! [barcode U0004982] here designated; isolectotype [barcode L0012413]).

– *Eugenia operculata* var. *obovata* Kurz, Forest Fl. Burma 1: 482 (1877) – [*Syzygium obovatum Wall Wallich Numer. List 3552A & B* (1831), nom. nud.] – *Syzygium nervosum* var. *obovatum* (Kurz) A.Kumar, J. Econ. Taxon. Bot. 7: 664 (1985 publ. 1986). **Type**: Bangladesh, Sillet, *F.de Silva s.n., Wallich Numer. List 3552A* (1831) (lectotype **K-W**! here designated; isolectotypes **E**!, **P**!).

– *Eugenia holtziana* F.Muell., Australas. J. Pharm. 1: 199 (1886), sphalm. *holtzei*, in Syst. Census Austral. Pl. 2: 101 (1889). **Type**: Australia, *Moritz Holtze 44* (holotype **MEL** n.v.). (fide B.Hyland, Austral. J. Bot., Suppl. Ser. 9: 108 (1983))

– *Eugenia gigantea* Ridl., J. Straits Branch Roy. Asiat. Soc. 45: 192 (1906). (fide Govaerts et. al. (2010))

– *Eugenia clausa* C.B.Rob., Philipp. J. Sci., C 4: 380 (1909); . **Type**: The Philippines, Luzon, Province of Rizal, Bosoboso, *Bur. Sci. 6760* (*Robinson*) (holotype K n.v.). (fide Merr. & L.M.Perry, J. Arnold Arbor. 18: 337 (1937))

– *Eugenia divaricatocymosa* Hayata, Icon. Pl. Formosan. 3: 118 (1913). **Type**: n.v. (fide Merr. & L.M.Perry, J. Arnold Arbor. 18: 337 (1937))

– *Eugenia suavis* Ridl. J. Fed. Malay. States Mus. 5: 160 (1915). **Type**: Peninsular Malaysia, May 1913, *H.C.Rohinson 5730* (**K**!), **syn. nov.** (see note)

– [*Calyptranthes cuneata* Buch.-Ham. ex Wall., *Wallich Numer. List 3557B* (1831), nom. nud (**E**!, **K-W**!).]

– [*Calyptranthes grandis* Buch.-Ham. ex Wall., *Wallich Numer. List 3554* (1831), nom. nud. (**E**!, **K-W**!).]

– [*Calyptranthes tatna* Buch.-Ham. ex Wall., *Wallich Numer. List 3555* (1831), nom. nud. (**E**!, **K-W**!).]

– [*Calyptranthes costata* Buch.-Ham. ex Wallich, *Wallich Numer. List 3556* (1831), nom. nud. (**E**!, **K-W**!).]

– [*Syzygium panealla* Wallich, *Wallich Numer. List 3557A* (1831) (**K-W**!, **E**!), nom. nud.]

– [*Syzygium polyanthum* auct. non Wight: Thwaites, Enum. Pl. Zeyl.: 116 (1859), spec. *C.P. 2801* (**PDA** n.v.). (fide Kosterm., Quat. J. Taiwan Mus. 34: 121 (1981))]

Tree to 15 m tall. Bark greyish or brownish. Glabrous on all parts. **Twig** terete and sometimes compressed, 2 – 3 mm diameter, stout, smooth, whitish to pale brownish, contrasting or not to leaf colour. **Leaves** opposite, 10 – 18 × 6.5 – 7 cm, 2 – 3 times as long as wide, elliptic to obovate, base cuneate, slightly attenuate, 50 – 60 degrees ascending from midrib, margin flat, apex blunt, acute or acuminate, acumen if present 1/15 – 1/20 of blade length, blade chartaceous, pale greenish; midrib sunken above, raised below; secondary veins (Type C.I) 10 to 13 per side per blade, broadly spaced, 15 – 20 mm apart, ascending c. 60

degrees from midrib, prominent and raised above, prominent below; tertiaries prominent, subscalariform; intramarginal veins absent, secondary veins looped near margin, pinnate-like, 3 – 5 mm from leaf margin; petiole 2 – 3 cm long, 1/6 – 1/7 of blade length, c. 2 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** lateral-axillary in axil of fallen leaf, 5 – 10 long, paniculate, second order branching, flowers many, 45 – 63, compact; axes 5 – 10 cm long, angular; bract and bracteoles caducous, bract triangular, 1×1 mm, bracteoles triangular, 0.5×0.5 mm. **Flowers** white, pedicellate, pedicel short, 0.5 – 2 mm long, hypanthium not glaucous, not fibrous, 3 – 4 mm long, obconic, pseudostalk indistinct, very short, 1 mm or less; sepals calyptrate, dome shaped, 1 – 2 × 2 – 3 mm, apex apiculate; petals 4, detached together with calyptrate calyx; outer stamens 5 – 6 mm long, anther c. 0.2 mm long, sacs parallel, connective gland conspicuous; style 5 – 7 mm long, ovules 12 – 15 per locule, irregularly radiating. **Fruit** globose, 1×1 cm, surface smooth, calyx ring with smooth rim; seed 1, globose, 0.85×0.85 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread from Nepal to North Australia. In Indochina only documented in Vietnam and possibly not yet collected in Cambodia and Laos.

ECOLOGY OR HABITAT. In forest and cultivated.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: March, April, July, November, December.

VERNACULAR NAME(S). Vietnam: Diang (Dong Nai), Voi (Ninh Binh & Thanh Hoa), Voi (Vietnam).

USES. The fruit is edible. Leaves are used as a beverage and are believe to be stomachic. A decoction of the leaves and flower buds is used as an antiseptic for washing boils and ulcers (Nguyen, 1993). The wood is used for house building (Lemmens et al., 1995).

NOTES.

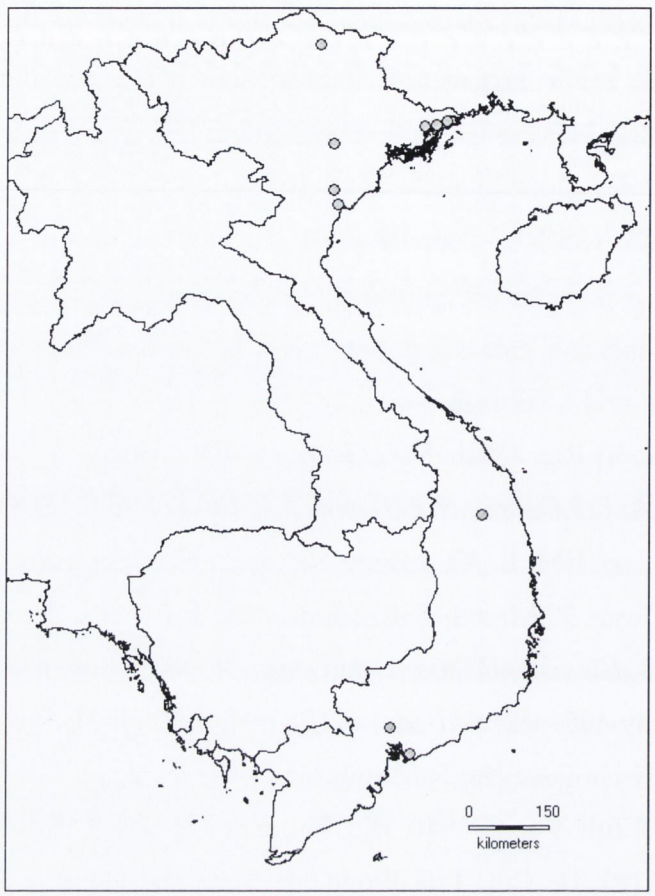
1. Merrill & Perry (1937) regarded *Syzygium angkolanum* as conspecific with the *S. nervosum* but acknowledged the peculiarity in the type specimens (*Junghuhn 100* [**U**!, barcode U005201] & *Junghuhn s.n.* [**U**!, barcode U0005201]) in having terminal and axillary inflorescences near the twig apex. I believe these are

different species altogether because *S. angkolanum* not only differs in the inflorescence position but also in the presence of intramarginal veins and the absence of calyptrate sepals which never occur in *S. nervosum*.

2. *S. nervosum* is found in the wild and cultivated. The cultivated form is formally recognised as var. *paniala* and it differs from the wild form in having larger flowers and fruits.

SPECIMENS EXAMINED.

VIETNAM. Ba Ria-Vung Tau: Ba Ria, April 1861, *Pierre s.n.* (**P**) – Bac Kan: Ba Be National Park, 12 July 2004, *E.A.Daniel, N.T.HIep & P.V.The DA 4752* (**HN**) – Cochinchina: s. loc., *Pierre s.n.* (**BM**, **E**, **K**) – Dong Nai: Bien Hoa, September 1865, *Pierre 56* (**P**) – Hanoi City: , 30 March 1888, *Balansa 2871* (**P**) – Kontum: Kon Plong, 16 November 1988, *Hien 366* (**HN**) – Lam Dong: 14 December 1952, *Schmid, M. s.n.* (**P**); 27 February 1953, *Schmid, M. s.n.* (**P**) – Ninh Binh: 21 April 1882, *Bon 1515* (**P**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, 18 May -5 July 1940, *W.T.Tsang 29997* (**P**); 18 July-9 sept, 1940, *W.T.Tsang 30343* (**P**); 8 May-5 July, 1940, *W.T.Tsang 30053* (**P**); Ha Coi, Tsai Wong Mo Shan and vicinity, 5 May-22 June, 1939, *W.T.Tsang 29208* (**P**); Tien Yen, Hong Du forest reserve, July 1918, 30 Jun-3rd July 1918, *Chevalier Fleury 37911* (**P**) – Thanh Hoa: Cu Phach, 1885-1889, *Balansa 2872* (**BM**, **K**, **L**, **P**).



Map 34. Distribution of *Syzygium nervosum* A.Cunn. ex DC. in Cambodia, Laos and Vietnam.

38. *Syzygium nigrans* (Gagnep.) Craven & Biffin, Blumea 51: 138 (2006) – *Eugenia nigrans* Gagnep., Notul. Syst. (Paris) 3: 329 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 814 (1920) – *Cleistocalyx nigrans* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 18: 336 (1937); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 63, fig. 3775 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 17 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 788, fig. 4 (2002). **Type**: Cochinchina [Vietnam], Cai-cong, fl., in *Herb. Pierre s.n.* (cited as *Pierre 1934* in the protologue) ([first-step] lectotype **P**!, first designated by Merrill & Perry op. cit. 1937; [second-step] lectotype **P**! [barcode P00589224] here designated; isolectotype **P**! [barcode P00589223] **BM**!). Remaining former syntypes: Cochinchina [Vietnam], Thu-dau-mot, fl., *Thorel s.n.* (**P**! [barcodes P00589193 & P00589194]); Cambodia, fr., 24 Dec. 1896, *Hanh* 116 (**P**! [barcode P00589225]). (see note 1)

– *Syzygium stictanthum* Merr. & L.M.Perry, J. Arnold Arbor. 19: 116 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 58, fig. 3759 (1992); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 242 (2007). **Type**: Laos, Province of Cammon [Khammouan], Xa Ngom, *Pételot 4675* (*Colani*) (holotype **A** n.v. [barcode 71337]; isotype **NY**! [barcode 00405596], **US**! [barcode 00118293]), **syn**, **nov**. (see note 2)

Tree to 6 m tall. Glabrous on all parts. **Twig** terete, c. 2 mm diameter, stout, surface smooth, brownish, contrasting to leaf colour. **Leaves** opposite, 7.5 – 9.2 × 2.8 – 4 cm, 2 to 3 times as long as wide, obovate, elliptic, base attenuate, c. 45 degrees ascending from midrib, apex mostly acuminate, acute or rounded, acumen 0.4 – 0.5 cm, 1/18 – 1/20 of blade length, margin flat, blade subcoriaceous, dark brownish, shiny above; midrib sunken above, raised below; secondary veins 12 – 18 per side per blade, narrowly spaced, 2 – 5 mm apart, ascending c. 45 degrees from midrib, slender, faint on both sides; tertiaries faint, reticulate; inner intramarginal veins faint, 0.5 – 1 mm from leaf margin, straight; petiole 0.7 – 1 cm, 1/9 – 1/13 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, 5 – 6 cm long, paniculate, second to third order branching, flowers many, c.100; axes 5 – 6 cm long, angular; bracts and bracteoles caducous. **Flowers** sessile, hypanthium not glaucous, not fibrous, 4 – 5 × 2.5 – 3 mm, obconic, pseudostalk indistinct, very short, 1 – 1.5 mm; sepals calyptrate, apex blunt, dome-shaped, 1.5 – 2 × 2.5 – 3 mm; outer stamens 6 – 7 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style 6 – 7 mm, ovules 8 – 10 per locule, irregularly radiating. **Fruit** subglobose, 1.4 – 1.6 × 1.3 – 1.4 cm, surface smooth, calyx ring with smooth rim; seed 1, subglobose, 1.1 × 1.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: In continental Southeast Asia in Thailand, Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. Forest.

CONSERVATION STATUS. IUCN Global Status: Near Threatened (NT); IUCN Regional (Indochina) Status: Near Threatened (NT).

PHENOLOGY. Flowering: March, October, December. Fruiting: July, December.

VERNACULAR NAME(S). Vietnam: Tram hoa co dom, Tram la den.

USES. Not documented.

NOTES.

1. Merrill & Perry (1937) designated *Pierre 1934* as the lectotype. Pierre's specimen numbered *1934* from Cay Cong was cited in the protologue, however I found two sheets in **P** of unnumbered Pierre's specimens and annotated by him with the locality 'Cay cong'. I believe these are the specimens that Gagnepain referred to as *Pierre 1934* and which were used in his description. Second step lectotypification is required as there are two undifferentiated sheets of Pierre's specimens.

2. *Syzygium stictanthum* was described by Merrill (1938) from the duplicates in **A** and **NY** whereby the flowers on these specimens are without a corolla. Although Merrill noted that vegetatively this species is similar to *Cleistocalyx nigrans*, he ascribed the specimens to *Syzygium* on the assumption that the flowers are not calyptrate. The duplicate in **US** which was overlooked by Merrill, clearly showed that the flowers are calyptrate. Evidently in my opinion, *C. nigrans* and *S. stictanthum* are conspecific.

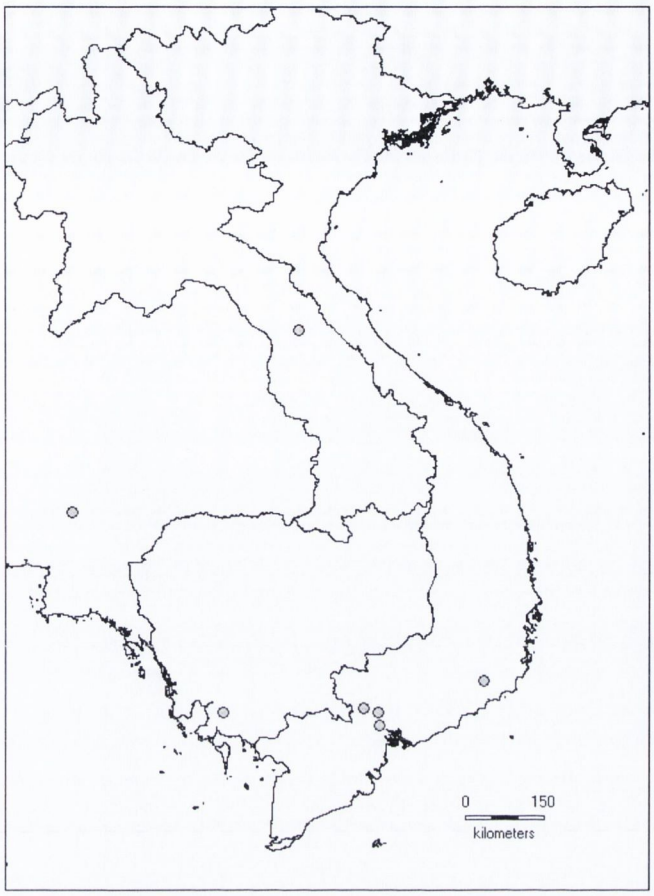
SPECIMENS EXAMINED.

CAMBODIA. Kampot?, 24 December 1896, , *Hanh 116* (**P**).

LAOS. Khammouan: Xa Ngom, December 1930, *Petelot 4675* (**US**).

THAILAND. Nakhon Ratchasima: Mt. Khao Yai, 2 October 1984, , *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan 37145 & 37150* (**BKF**).

VIETNAM. s. loc., 1862-1866, *Thorel 396* (**P**) – Binh Duong: Thu Dau Mot, 862-1866, *Thorel s.n.* (**P**); Cochinchina: *Pierre s.n.* (**P**) – Ho Chi Minh City: 19 July 1873, *Pierre s.n.* (**P**) – Lam Dong: Ma Sra, 1 March 1955, *Schmid s.n.* (**P**) – Tay Ninh: Cai Cong, *Pierre s.n.* (**BM**, **P**).



Map 35. Distribution of *Syzygium nigrans* (Gagnep.) Craven & Biffin in Cambodia, Laos and Vietnam.

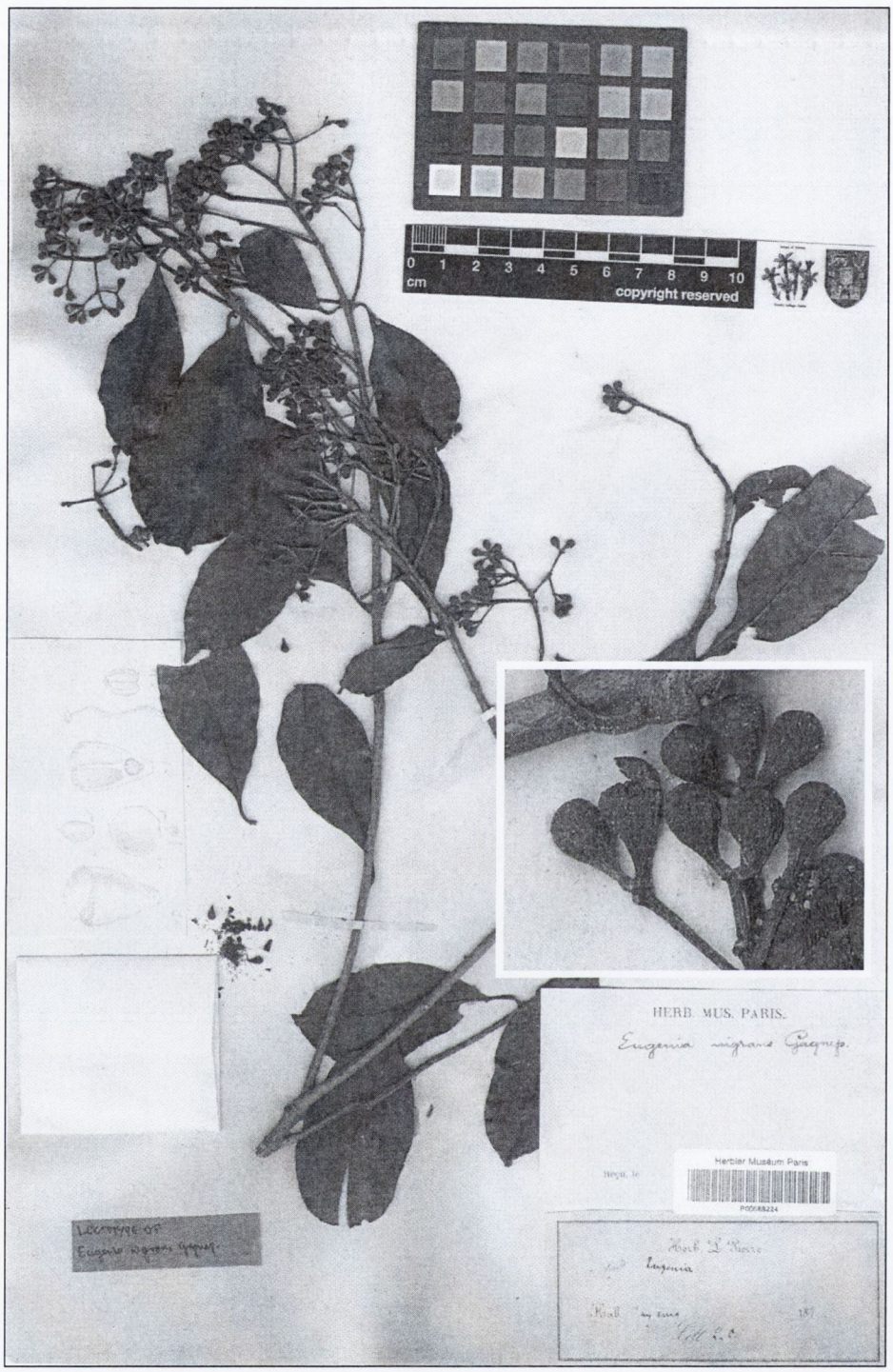


Plate 5.24. Lectotype of *Syzygium nigrans* (Gagnep.) Craven & Biffin.

39. *Syzygium oblatum* (Roxb.) Wallich ex Steudel, Nomencl Bot. ed., 2 (1841) 657; A.M & J.M. Cowan,Trees N. Bengal 68 (1929); Merr. & L.M.Perry, J. Arnold Arbor. 19: 101 (1938); Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 187 (1939); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 54, fig. 3748 (1992);

P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 90 (1994); Turner, Gard. Bull. Singapore 47: 47 (1995); P.Chantaranothai & J.Parn.,Thailand 7: 879, fig. 22 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 314 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003) – *Eugenia oblata* Roxb., [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed.: 493 (1832); Wight, Ill. Ind. Bot. 2: 15 (1841); Wight, Icon. Pl. Ind. Orient. 2: t. 622 (1843); Kurz, J. Asiat. Soc. Bengal 46: 67 (1877), in Forest Fl. Burma 1: 488 (1877); King, J. Asiat. Soc. Bengal 70: 114 (1901), in Mater. Fl. Malay Penins. 12: 544 (1901); Merr., J . Straits Branch Roy. Asiat. Soc. 77: 225 (1917), in En. Born.: 431 (1921); Ridl., Fl. Malay. Penins. 1: 749 (1922), pro parte; Ridl., in J. Bot. 68: 34 (1930); Craib, Fl. Siam. Enum. 1: 652 (1931); M.R.Henderson, Gard. Bull. Sing. 12: 136, fig. 28d (1949); Kochummen in Ng, Tree Fl. Mal. 3: 204 (1978) – [*Syzygium oblatum* Wallich, *Wallich Numer. List 3569* (1831) (**K-W**!), nom. nud.] – *Acmena oblata* (Roxb.) Walp., Repert. Bot. Syst. 2: 181 (1843) – *Strongylocalyx oblatus* (Roxb.) Blume, Mus. Bot. 1: 89 (1850). **Type**: Chittagong, *Roxburgh s.n.*, (lectotype **BM**! here designated, a ticket with Wallich's handwriting '*Eugenia* oblata, 3107'; isolectotypes **P**!, Ic. Roxb. No. 2262, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)]; **C** n.v.))

– *Syzygium pulchellum* (Roxb.) Wallich ex Govaerts in R.H.A.Govaerts et. al., World Checklist Myrtaceae: 410 (2008) – *Eugenia pulchella* Roxb., [Hort. Bengal. (1814) 37, nom. nud.] Fl. Ind. ed. 2, 2: 496 (1832) – [*Syzygium pulchellum* Wallich, *Wallich Numer. List 3566A,B* (1831) (**K-W**!), nom. nud.] – *Jambosa pulchella* Miq., Fl. Ned. Ind. 1(1): 422 (1855). **Type**: Ic. Roxb. No. 2506, ined. (**K**! [downloaded from Royal Botanic Gardens, Kew (2006)], **C** n.v.)).

– *Eugenia laevicaulis* Duthie in J.D.Hooker, Fl. Brit. India 2: 492 (1878); King, J. Asiat. Soc. Bengal 70: 116 (1901); M.R.Henderson, Gard. Bull. Sing. 12: 138, fig. 28e (1949); Kochummen in Ng, Tree Fl. Mal. 3: 199 (1978) non Ridl.; *Syzygium laevicaule* (Duthie) Masam., Enum. Phan. Born.: 531 (1942) – ***Syzygium oblatum*** var. ***laevicaule*** (Duthie) P.Chantaranothai & J.Parn., Kew Bull. 48: 607 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 91 (1994), in Fl. Thailand 7: 879 (2002). **Type**: Malaysia, Malacca, *Maingayi 753* (holotype **K**!; isotype **K**!).

– *Eugenia limnoea* Ridl., J. Straits Branch Roy. Asiat. Soc. 79: 64 (1918), in Fl. Malay. Penins. 1: 729 (1922). **Type**: Malaysia, *Ridley 9378a*, 1898 (lectotype **K**!, here designated; isolectotype **SING!**).

– *Eugenia laxiuscula* Ridl., J. Fed. Malay States Mus. 10: 133 (1920). **Type**: Malaysia, Langkawi, Pulau Butang, *Curtis 973* [in protologue as *Curtis 975*] (holotype **K**!; **SING** n.v.).

– *Eugenia compongensis* Gagnep., Notul. Syst. (Paris) 3: 323 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 828 (1920) – *Syzygium compongense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 112 (1938). **Type**: Cambodia, Kompong-soai, fl., feb. 1876, *Harmand s.n.* (lectotype **P**! barcode P00589284; isolectotypes **P**! [2 sheets] barcodes P00589283 & P00589285, **K**! barcode K000276207), **syn. nov.** (see note 1)

– *Eugenia limnaea* Ridl. var. *gracilior* Craib, Fl. Siam. Enum. 1: 650 (1931). **Type**: Thailand, Trat, Koh Chang, Kalwng Mayom, *Kerr 6843* (lectotype **BM**! , designated by P.Chantaranothai & J.Parn., Fl. Thailand 7: 881 (2002): isolectotypes **ABD** n.v., **K**!).

– *Eugenia brantiana* M.R.Hend., Gard. Bull. Singapore 11: 313 (1947). **Type**: Malaysia, Johor, Sg. Pontian Besar, 12 Nov 1939, *SFN 36754 (Henderson)* (lectotype **K**!, here designated; isolectotypes **K**!, **SING!**).

– *Eugenia oblongifolia* var. *robusta* King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 70: 112 (1901). **Type**: Malaysia, Perak, *Scortechini 216* (holotype **K**!).

– [*Eugenia comosa* Wallich, *Wallich Numer. List 3566C,D* (1831) (**K-W**!), nom. nud.]

– [*Eugenia chlorantha* auct. non Duthie: Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 806 (1920); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 49, fig. 3733 (1992) [as *Syzygium chloranthum*]; K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 903 (2003) [as *Syzygium chloranthum*]. (fide type of *Eugenia chlorantha*: *Wallich Numer. List 3581* (**K-W**!)). **Voucher**: Thailand, Chiengmai, *Kerr 1785* (**BKF**!, **K**!, **P**!); Nghe An, Co-ba forest reserve, *Chevalier 32362* (**P**! **L**!).]

Tree to 10 m tall, to 25 cm dbh. Bark greyish, slash bark purplish-brown. Glabrous on all parts. **Twig** terete, c. 3 mm diameter, stout, surface smooth or flaky, pale brownish, not contrasting to leaf colour. **Leaves** opposite, 10 – 17 × 4

– 7 cm, 1.5 – 3.5 times as long as wide, elliptic, oblong-ovate or oblong-elliptic, base cuneate, c. 60 degrees ascending from midrib, slightly attenuate, margin flat, apex acute or acuminate, acumen if present 0.8 – 1.5 cm, 1/13 – 1/30 of blade length, blade coriaceous to subcoriaceous, upper surface with raised pustulation or not, yellowish brown; midrib sunken above, raised below; secondary veins (Type A.II) slender, 24 – 30 per side per blade, broadly spaced, 5 – 7 mm apart, c. 60 degrees from midrib, prominent and raised on both surfaces; tertiaries prominent, reticulate; inner intramarginal veins 1 – 1.5 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.7 – 1.5 cm, 1/10 – 1/25 of blade length, c. 2 mm diameter, stout, brownish to blackish, contrasting or not to blade colour. **Inflorescence** terminal and axillary near leafy twig apex, 5 – 6.5 cm long, paniculate, second to third order branching, flowers many, to 300; axes c. 10 cm, angular, stout; bract and bracteoles caducous. **Flower** sessile, hypanthium not glaucous, not fibrous, 5 – 6 × 3 – 4 mm, obconic, pseudostalk distinct, very short, c. 1 mm; sepals 4 – 5, free, 1 – 1.5 × 3 mm, semiorbicular; petals 4 – 5, coherent, 4 – 6 × 4 – 6 mm, orbicular; outer stamens 1 – 1.3 cm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style 8 – 10 mm, ovules 15 – 20 per locule, irregularly radiating. **Fruit** (immature) globose, 2.2 × 1.7 cm, surface smooth, calyx ring with undulating rim; seed 1, subglobose, 1.7 × 1.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: India, South China, continental Southeast Asia to Borneo. In Indochina occur Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. in primary and secondary forest from lowland to hill terrain, swamp and along rivers, to 800 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: February - October. Fruiting: April, May.

VERNACULAR NAME(S). Cambodia: Pring Kbal Komprak (Siem reap), Kbal Ta (Siem reap), Pring Chan (Koh Kong), Pring Santoap (Koh Kong), Pring Kbal Ta (Kampong Thum). Vietnam: Cay tram (Thanh Hoa), Tram hang (Dong Nai), Tram hoa xanh (Vietnam), Tram la den (Vietnam), Tram rong (Vietnam).

USES. The fruit is edible and the wood is used for house building (Lemmens et al., 1995).

NOTES.

1. Gagnepain (1920) grouped *S. oblatum* and *S. compongense* into section II and III respectively based on the petals coherent in *S. oblatum* and free in *S. compongense*. However, the flowers in the type of *S. compongense* are still in bud with an intact corolla and it is therefore not possible to judge if the petals are coherent or free. The leaf (venation, shape and size), inflorescence and flower type of *S. compongense* are similar to *S. oblatum,* therefore I consider *S. compongense* and *S. oblatum* to be conspecific.

2. *Syzygium oblatum* is a widespread species exhibiting variability in the leaf, inflorescence and flower size. In Thailand, specimens with smaller leaves, less conspicuous venation and shorter inflorescence are formally recognised as var. *laevicaule* (Duthie) P.Chantaranothai & J.Parn.

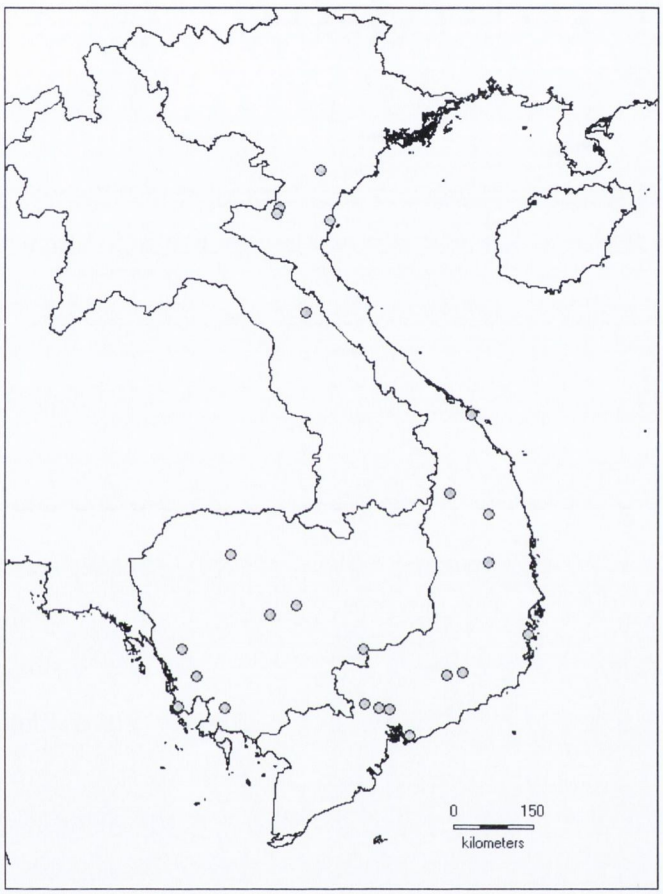
SPECIMENS EXAMINED.

CAMBODIA. Kampong Thum: Kralam forest reserve, 29 May 1909, *Magnen, Gourgand & Chatillion s.n.* (**P**); Kampong Svay, February 1876, , *Harmand s.n.* (**K**, **P**) – Kampot: 10 May 1895, *Hanh s.n.* (**P**); 16 October 1903, *Geoffray 60* (**P**) – Koh Kong: Cardamom Mountains, 10 February 1970, *M.A.Martin 1753* (**P**); 4 April 1969, *M.A.Martin 1567* (**P**); Kiri Sakor, 19 May 1999, *Bansok 64* (**K**) – Siem Reap: 22 February 1924, *Diffon 510* (**P**).

LAOS.Khammouan: Nong Sa Mek, 11 February 2005, *M.F.Newman; Thomas, P.I, Armstrong, K.E; Sengdala, K.; Lamxay, V. LAO 77* (**E**).

VIETNAM. Tram Bam, 13 September 1965, *M.A.Martin 943* (**P**); Saigon river, July 1967, *Vu Van Cuong 1588* (**P**); Binh Quoi-Gia Dinh, July 1959, *Vu Van Cuong 1305* (**P**); Trang Bam, 13 September 1965, *M.A.Martin 943* (**P**) – Ba Ria-Vung Tau: Ba Ria, October 1868, *Talmy s.n.* (**P**) – Binh Duong: Thu Dau Mot, *Pierre s.n.* (**BM**, **E**) – Cochinchina: *Thorel 1203* (**GH**) – Da Nang: Tourane and vicinity, May-July 1927, *J. & M.S. Clemens 3395* (**P**) – Dong Nai: Bien Hoa, 10 May 1967, *Vu Van Cuong 452* (**P**) – Gia Lai: Ayun Pa, *K.Dao 308* (**HN**); K'bang, 24 February 1988, *Phuong 1447* (**HN**) – Khanh Hoa: Nha Trang, June 1909, *d'Alleizette s.n.* (**P**) – Kon Tum: Dak To, 7 April 1988, *Nham 290* (**HN**); Dak To, *K.Dao 226* (**HN**) – Lam Dong: Bao Loc, 18 April 1984, *Anon. 1666* (**HN**); Bao Loc, 22 May 1980, *Lien 196* (**HN**); Di Linh, Ha Nam Ninh, 15 May 1980, *Tue 496* (**HN**) – Nghe An: Co Ba forest reserve, 6 May 1915, *hevalier 32362* (**P**); Ban

Muong, 4 April 1998, *D.D.Soejarto; Ninh, T.N. & P.H.Hoang 10218* (A) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 22 April 1971, *CPNP 3974* (**CPNP**); 23 April 1971, *CPNP 3976* (**CPNP**) – Quang Duc-Lam Dong: 17 March 1953, *Schmid s.n.* (**P**) – Tay Ninh: Cai Cong, *Pierre s.n.* (**P**) – Thanh Hoa: Nhu Xuan, Xuan Quy, 24 April 1996, *N.T.Ninh & V.Dumontet VN 93* (**HN**).



Map 36. Distribution of *Syzygium oblatum* (Roxb.) Wallich ex Steudel in Cambodia, Laos and Vietnam.

40. *Syzygium odoratum* (Lour.) DC. Prodr. 3: 260 (1828); Hook. & Arn. Bot. Beechey's Voy. 187 (1833); Benth. Fl. Hongk. 119 (1861); Merr. & L.M.Perry, J. Arnold Arbor. 19: 102 & 225 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 54, fig. 3749 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 907 (2003); J.Chen & Craven, Fl. China 13: 353 (2007) – *Opa odorata* Lour. Fl. Cochinch. 309 (1790); Moore, Jour. Bot. 63: 283. 1925 – *Eugenia odorata*? Wight, Ill. Ind. Bot. 2: 16 (1841) – *Eugenia millettiana* Hemsl. Jour. Linn. Soc.

Bot. 23: 297 (1887), nom. nov.; Merr. Trans. Amer. Phil. Soc. 24(2): 285 (1935); Lingnan Sci. Jour. 14: 41 (1935); Merrill, E.D. Comm. Fl. Cochinch. Trans Amer. Philos. Soc. 24(2): 285 (1935). **Type**: Cochinchina [Vietnam], *Loureiro s.n.* (holotype **BM**!).

– *Eugenia deckeri* Gangnep. Not. Syst. 3: 323 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 807 (1920). **Type**: Tonkin [China], Kouang-tcheou [Zhanjiang], 20 October 1910, *Decker 15* (holotype **P**! [barcode P00589282]).

Tree to 7 m tall. Glabrous on all parts. **Twig** terete, 1.5 – 2 mm diameter, slender, surface smooth, pale brownish, not contrasting to leaf colour. **Leaves** opposite, 4 – 8 × 1.2 – 3 cm, 2.5 to 3 times as long as wide, elliptic, base cuneate and slightly attenuate, c. 30 degrees from midrib, margin flat, apex acuminate, acumen prominent, 1 – 2 cm, 1/3 – 1/5 times of blade length, subcoriaceous, yellowish brown; midrib sunken above, raised below; secondary veins (Type A.II) slender, 12 – 15 per side per blade, broadly spaced, 2 – 5 mm apart, c. 45 degrees ascending from midrib, faint and raised above, prominent below; tertiaries faint, reticulate; inner intramarginal veins c. 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole c. 3 cm, 1/21 – 1/26 of blade length, c. 1 mm diameter, slender, dark brownish to blackish, contrasting to blade colour. **Inflorescence** terminal and axillary near leafy twig apex, 4.5 – 6 cm long, paniculate, first to second order branching, flowers many, to 100; axes 4 – 5 cm, angular, stout; bract and bracteoles caduceus, lanceolate, c. 1 × 0.5 mm. **Flower** sessile, hypanthium glaucous, not fibrous, c. 5 × *2 mm*, clavate, corrugated, glaucous, purplish, abruptly constrict to distinct pseudostalk, c. 2 mm; sepals 4 – 5, free, c. 0.5 × 1 mm, triangular; petals 4 – 5, coherent, 2 × 2 mm, orbicular; outer stamens c. 0.5 cm, anthers c. 0.4 mm, sacs parallel, connective gland conspicuous; style c. 5 mm, ovules c. 12 per locule, in 2 longitudinal rows. **Fruit** (immature) whitish, globose, 0.4 × 0.4 cm, surface smooth, calyx ring with persistent sepal lobes; seed subglobose, 0.4 × 0.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: China (Guangdong and Hainan) and Vietnam.

ECOLOGY OR HABITAT. In open area, dunes and bushes.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: June, October, November. Fruiting: not documented.

VERNACULAR NAME(S). Tram thom (Vietnam).

USES. Not documented

NOTES.

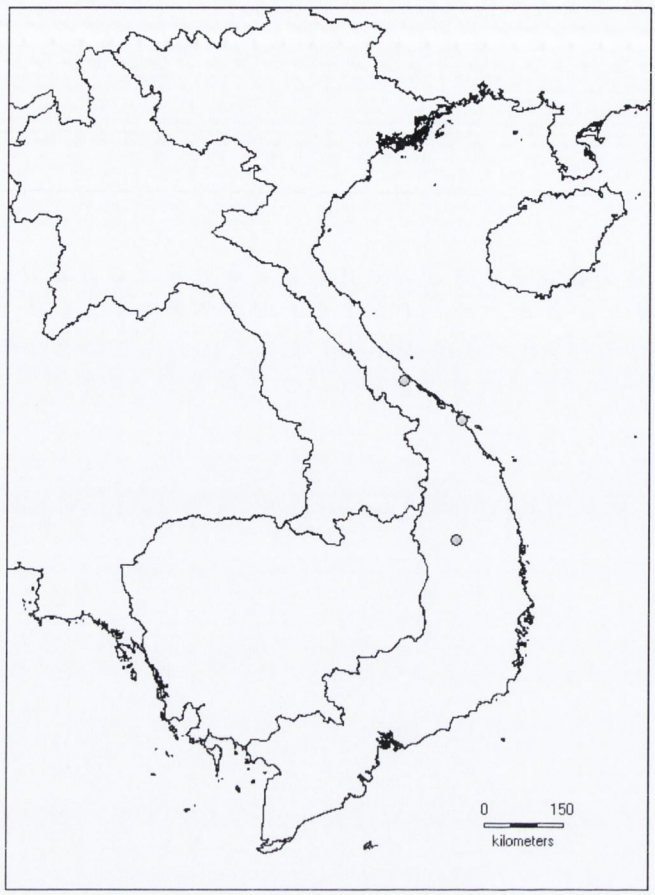
1. *Syzygium odoratum* belongs to subg. *Sequestratum* and morphologically is close to *S. antisepticum* but differs in having distinct leaf acumens and a hypanthium cup that is abruptly constricted to the pseudostalk instead of tapering. The habitat of this species seems to be confined to open vegetation such as dunes and bushes. Whether this is an ecotype of *S. antisepticum* or a distinct species in itself that has diverged from the latter, still requires investigation.

SPECIMENS EXAMINED.

VIETNAM. Da Nang: Tourane and vicinity, 10 August 1927, *J. & M.S. Clemens 4215* (**A**); Tourane and vicinity, 29 June 1927, May-July 1927, *J. & M.S. Clemens 3778* (**A**, **BM**) – Gia Lai: Dak Doa, 30 November 1978, *Hien 606* (**HN**); Dak Doa, 30 November 1978, *Dung 380* (**HN**) – Quang Tri: February 1919, *Chevalier 41231 (de Pirey 67)* (**P**).

ADDITIONAL SPECIMENS EXAMINED.

CHINA. Guangdong: Zhanjiang [Kouang-tcheou], *Decker 15* (**P**); *D.Hooker 141* (**E**); Hoi Kong, 2 June 1929, *Tsiang Ying 2549* (**P**) – Hainan: Ngai, Wong Kam Shan, *S.K.Lau 564* (**BM**).



Map 37. Distribution of *Syzygium odoratum* (Lour.) DC. in Cambodia, Laos and Vietnam.

41. *Syzygium pachysarcum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 110 (1938)); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 55, fig 3751 (1992) [as *Zyzygium pachysarcum*]; P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 93 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 882 (2002); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 907 (2003) – *Eugenia pachysarca* Gagnep. Not. Syst. 3: 329. 1918, in Lecomte, Fl. Gén. Indo-Chine 2: 824 (1920). **Type**: Cambodia, Au Samrong, Mt. Schrall, '10 m tree', fr. & fl., Apr 1870, *Herb. Pierre 987* (lectotype **P**! [barcode P00589190] with attached Delpy drawing dated Jan. 1900, here designated; isolectotypes **P**! [2 sheets, barcodes P00589191 & P00589192], **BM**!, **NY**! [barcode 405069], **E**!). (see note 2)

– *Eugenia tramnion* Gagnep., Notul. Syst. (Paris) 3: 332 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 824 (1920) – *Syzygium tramnion* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 111 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco

Viêtnam) 2: 60, fig. 3765 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 909 (2003). **Type**: Cochinchina [Vietnam], fl. & fr., May 1866, *Herb. Pierre 115* (lectotype **P**! barcode P00589173, with Delpy drawing dated Feb. 1900 attached, here designated; isolectotype **P**! barcode P00589174, with two Delpy drawings of flowers and fruits dated Nov. 1899 attached). Remaining former syntypes: Cochinchina [Vietnam], Cay-cong, fl., Apr. 1866, *Herb. Pierre s.n.* (**P**! [barcode P00589262] with Delpy drawing dated Nov. 1899 attached); Cochinchina [Vietnam], Cay-cong, fl., *Herb. Pierre s.n.* (**P**! [barcode P00589263]); Cochinchina [Vietnam], Mu-xoai, fl., tree 12-18 m, Mar. 1867, *Herb. Pierre s.n.* (cited as *Pierre 115* in the protologue) (**P**! [barcode P00589261], **K**!, **BM**!); Cochinchina [Vietnam], Lap-vo, fl., Aug. 1869, *Herb. Pierre s.n.* (cited as *Pierre 115* in the protologue) (**P**!); Cochinchina [Vietnam], fl., *Thorel s.n.* (**P**! [barcode P00589260]), **syn. nov.** (see note 1 and 3)

– *Eugenia tinctoria* Gagnep., Notul. Syst. (Paris) 3: 334 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 824 (1920) – *Syzygium tinctorium* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 112 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 59, fig. 3763 (1992); P.Dy Phon, Plants used in Cambodia: 580 (2000); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 909 (2003). **Type**: Cambodia, Kompong-chnang, fl., 8-11 March 1914, *Chevalier 30041 (Fleury)* (cited as 31984 in the protologue) (lectotype **P**! [barcode P00589216] here designated; isolectotypes **P**! [2 sheets]). Remaining former syntypes: Cambodia, Pursat, fl., *Chevalier 31984* (cited as 30041 in the protologue) (**P**! [barcode P00589177]); Cambodia, Kompong-chnang, fl., *Chevalier 30041* (cited as 31984 in the protologue) (**P**! barcode P00589216); Cambodia, fl. & fr., Magnien, Gourgand & Châtillon *s.n.* (**P**! [3 sheets, barcodes P00589217, P00589218] & P00589219]); Cochinchina,Bien-hoa, fl., *Vinot 34* (**P**! [barcode P00589215]), **syn. nov.** (see note 1)

– *Eugenia rubicunda* Gagnep., in sched., nom. nud., non (Wight & Arn.) Wight.

Tree to 25 m tall, to 30 cm dbh. Bark greyish, slash bark pale brownish. Glabrous on all parts. **Twig** terete, c. 2 – 3 mm diameter, stout, surface smooth, dark brownish, not contrasting to leaf colour. **Leaves** opposite, crushed leaves aromatic, 8.5 – 11.5 × 3.5 – 5.5 cm, 2 to 3 times as long as wide, elliptic, base cuneate, slightly attenuate, c. 45 degrees ascending from midrib, margin flat, apex

acute or acuminate, acumen if present c. 1 cm long, 1/9 – 1/11 of blade length, blade coriaceous, dark brownish; midrib sunken above, raised below; secondary veins slender (Type A.II), 20 – 25 per side per blade, broadly spaced, 2 – 5 mm apart, c. 60 degrees from midrib, prominent and raised on both surfaces; tertiaries prominent, reticulate; inner intramarginal 2 – 3 mm from leaf margin, straight to looped, outer intramarginal veins prominent; petiole c. 1 cm, 1/9 – 1/11 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade lenght. **Inflorescence** terminal, 3.5 – 6 cm long, paniculate, first to second order branching, flowers many, 21 – 105, flowers cluster together at end of axes forming head, one clump consist of 7 flowers in triplets of, the second order branch is very short, c. 1 mm; axes 3 – 5.5 cm, terete, stout; bract and bracteoles persistent, triangular, bract 2 × 1 mm, bracteoles 1 × 0.7 mm. **Flower** yellowish, sessile, hypanthium not glaucous, not fibrous, 5 – 6 × 3 – 5 *mm*, obconic, pseudostalk distinct or indistinct, very short, 1.5 – 2 mm; sepals 4, free, semiorbicular, unequal, outer sepals c. 2 × 1.5 – 3, inner sepals c. 3 × 2 mm; petals 4, free, 2.5 – 3 × 3 – 4 mm, orbicular; outer stamens 5 mm, anthers c. 0.6 mm, sacs parallel, connective gland conspicuous; style 6 – 7 mm, ovules 7 – 12 per locule, irregularly radiating. **Fruit** (immature) obovoid or ellipsoid, 1.5 – 2 × 0.7 – 1.5 cm, surface smooth, calyx ring with undulatin rim; seed 1, ovoid, 1.2 – 1 × 0.3 – 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Endemic to Continental Southeast Asia and found in Cambodia, Laos, Thailand and Laos.

ECOLOGY OR HABITAT. In primary forest to 300 m.

CONSERVATION STATUS. IUCN Global Status: Near Threathened (NT); IUCN Regional (Indochina) Status: Near Threathened (NT).

PHENOLOGY. Flowering: February, March, April, Jun, August, November. Fruiting: April, May, July, August.

VERNACULAR NAME(S). Cambodia: Pring Kbal (Siem reap), Pring Phnom (Kampong Thum), Pring tasar, Pring thom (Kampong Chhnang & Pursat), Prinh thmar (Kandal). Laos: Mak va (Savannakhet). Vietnam: Tram day, Tram nac day, Tram nion (Tay Ninh), Tram nhuom, Tram rim, Tram sung (Dong Nai).

USES. Fruit edible and wood used in carpentry. Bark is used as yellowish brown dye to colour fabric (Dy Phon, 2000).

NOTES.

1. Gagnepain separated *Eugenia tinctoria* from *E. pachysarca* and *E. tramnion* by the calyx length (> 2 mm in *Eugenia tinctoria* versus ≤ 1.5 mm in *E. pachysarca* and *E. tramnion*). *E. pachysarca* differs from *E. tramnion* in the absence of pustulation on the calyx, acute leaf apex and faint leaf venation, whereas in *E. tramnion* the calyx is pustulate, the leaf apex is acuminate and the leaf venation is prominent. However, I found these characters are not very important for delimiting species in *Syzygium*. I believe all three are the same species because they share the same inflorescence and floral and leaf venation type.

2. *Pierre 987* collected from Mt. Schrall is the only gathering cited in the protologue, lectotypification is required as there are three potential type sheets at **P**. I believe all the duplicates are from the same gathering because they shared the same herbarium information (date and locality) annotated by Pierre even though there are both fruiting and flowering specimens.

3. In the protologue, the collections from Cai-cong, Lap-vo and Mu-xoai were given the same number: *Pierre 115*. This is the species number and not the collector's numbers. Gagnepain gave two names on the labels on all the herbarium sheets: '*Eugenia rubicunda* Gagnep.' and '*Eugenia tramnion* Gagnep.' Gagnepain must have initially annotated the sheets as *Eugenia rubicunda* and later changed the name to *Eugenia tramnion* upon realizing the former name was already used by Wight

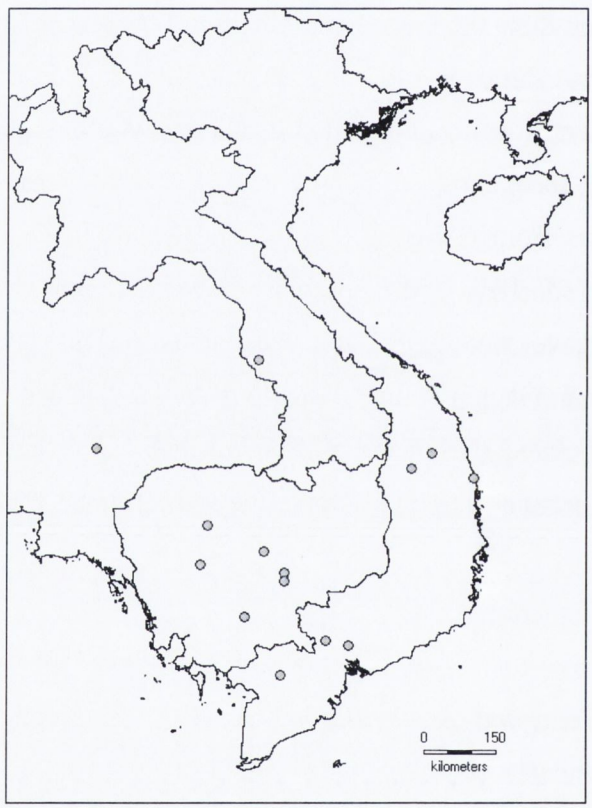
SPECIMENS EXAMINED.

CAMBODIA. s. loc. *Magnen, Gourgand & Chatillion s.n.* (**P**) – Kampong Cham: Stung Trang, *Herbier Forestier du Cambodge 505* (**P**) – Kampong Chhnang: March 1909, *Magnen, Gourgand & Chatillion 2* (**P**); Kralanh forest reserve, March 1914, 8-11 March 1914, *Chevalier Fleury 30041* (**P**) – Kampong Speu: Samraong Tong, Mt. Schrall, April 1870, *Pierre 987* (**BM**, **E**, **NY**, **P**) – Kampong Thum: Kampong Takong, Phnom Barung Reserve, 9 May 1924, *Herbier Forestier du Cambodge 505* (**P**) – Kandal: Phnom Penh, *Bejaud 569* (**P**) – Pursat: 14 March 1914, *Chevalier 31981* (**P**) – Siem Reap: Banteay Srei, Khnar Sanday, 22 February 1924, *Herbier Forestier du Cambodge Diffon19 510* (**P**).

LAOS. Savannakhet: Champone, Ban Phay, 8 August 2000, *D.D.Soejarto; B.H.Southavong; & Samphan 11489* (**GH**).

THAILAND. Nakhon Ratchasima: Pak Thong Chai, 26 March 1968, *S.Phengnaren 593* (**L**).

VIETNAM. An Giang: Lap Vo, , August 1869, *Pierre s.n.* (**P**) – Binh Dinh: Nuoc Ngot, May 1959, *Pham Hoang Ho 5014* (**P**) – Cochinchina: 1862-1866, *Thorel s.n.* (**P**); Mu xoai, March 1867, *Pierre s.n.* (**BM**, **P**) – Dong Nai: Bien Hoa, March 1912, *Vinot 34* (**P**); Bien Hoa, June 1909, *d'Alleizette* (**L**) – Kon Tum: *Bien 709* (**HN**); Kon Plong, 16 July 1978, *K.Dao 268* (**HN**) – Tay Ninh: Cai Cong, , 2 April 1866, *Pierre s.n.* (**BM**, **P**); Cai Cong, May 1866, , *Pierre 115* (**P**); Cai Cong, November 1866, *Pierre s.n.* (**P**).



Map 38. Distribution of *Syzygium pachysarcum* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

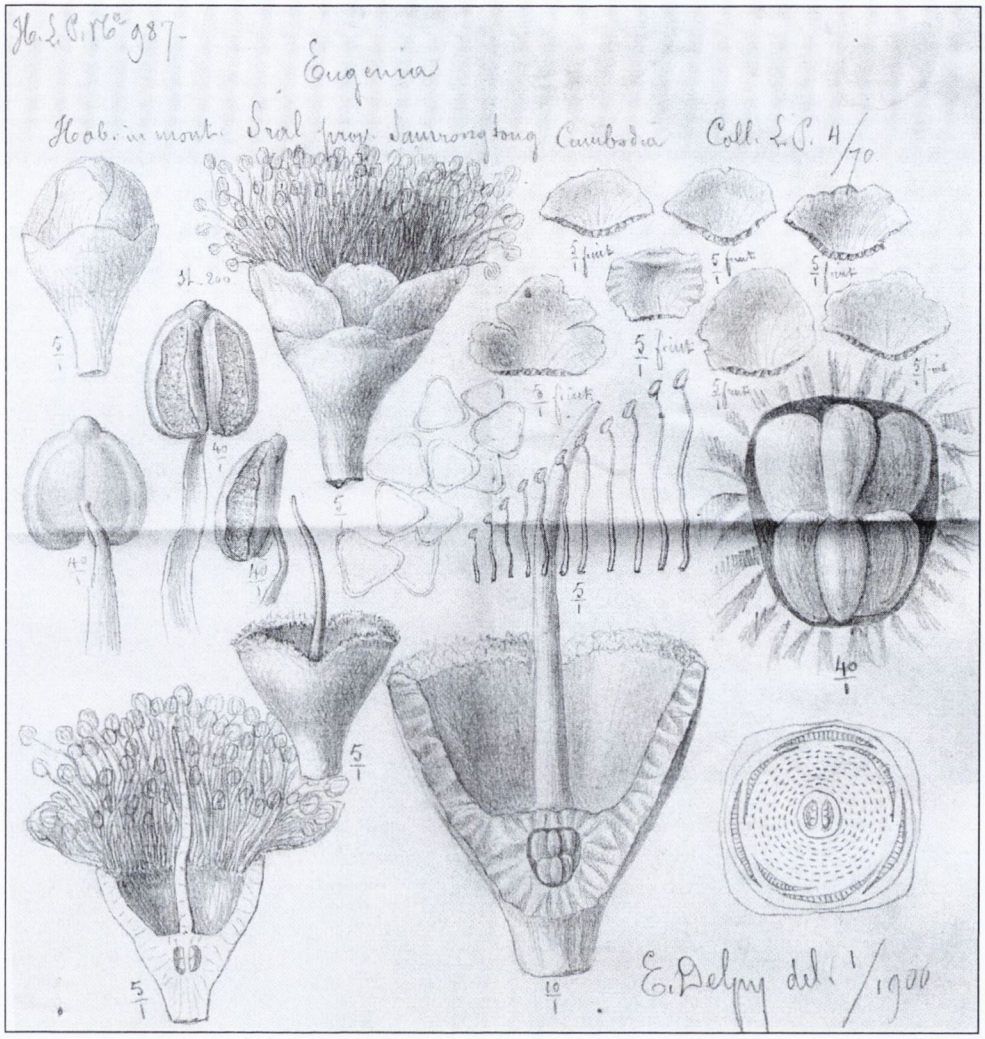


Plate 5.25. Delpy's drawing of the lecotytype of *Syzygium pachysarcum* (Gagnep.) Merr. & L.M.Perry.



Plate 5.26. Lectotype of *Syzygium pachysarcum* (Gagnep.) Merr. & L.M.Perry.

42. *Syzygium pierrei* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 114 (1938); P.H.Hô, Fl. Ill. Viêtnam (Cây co Viêtnam) 2: 56, fig. 3753 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003) – *Eugenia* pierrei Gagnep. Notul. Syst. 3: 330 (1917); Gagnep., in Lecomte, Fl. Gén. Indo-

Chine 2: 836 (1920). **Type**: Cochinchina [Vietnam], near Bao-chiang, fl.,July 1877, *Herb. Pierre 1818* (lectotype **P**!, with attached Delpy drawing dated Mar. 1900, here designated; isolectotypes **P**! [2 sheets, barcodes P00589188 & P00589189]). Remaining former syntype: Cochinchina [Vietnam], Tri-huyen, fl., May 1867, *Herb. Pierre s.n.* (**P**! [barcode P00589425] with attached Delpy drawing dated Mar. 1900, **K**!).

Shrub to 3 m tall. Bark brownish. Glabrous on all parts. **Twig** terete and compressed or subangular, c. 2 mm diameter, stout, surface smooth, greyish to whitish, contrasting to leaf colour. **Leaves** opposite, 8.5 – 10 × 2.5 – 4.5 cm, 2 – 3.5 times as long as wide, elliptic, sometimes obovate, base cuneate, 30 – 40 degrees from midrib, margin flat, apex acute and obtuse, acumen indistinct, blade chartaceous, brownish; midrib flat above, raised below; secondary veins (Type A.II) slender, 6 – 10 per side per blade, 5 – 10 mm apart, 45 – 50 degrees ascending from midrib, prominent and flattish above, prominent and raised below; tertiaries prominent, reticulate; inner intramarginal c. 2 mm from leaf margin, looped, outer secondary intramarginal veins faint; petiole 0.2 – 0.25 cm, 1/30 – 1/50 of blade length, 1 – 2 mm diameter, slender or stout, dark brownish, not contrasting to blade colour . **Inflorescence** terminal or axillary on leafy twig, 3 – 4.5 cm long, racemose, flowers few, 3 to 5, spreading; axes 0.5 – 2 cm, angular, stout; bract and bracteoles caducous. **Flower** pedicellate, pedicel 1 – 1.5 cm, hypanthium not glaucous, not fibrous, 15 – 20 × 6 – 8 mm, pyriform, pseudostalk distinct, c. 7 mm; sepals 4, free, semiorbicular, unequal, inner lobes c. 3 × 5 mm, outer lobes c. 4 – 7 mm; petals 4, free, c. 5 × 6 mm, orbicular; outer stamens c. 10 mm, anthers c. 1 mm, sacs parallel, connective gland conspicuous; style 4.5 mm, ovules 20 – 23 per locule, irregularly radiating. **Fruit** not seen but according to Gagnepain (1920) the young fruit is pyriform and with fleshy crown.

DISTRIBUTION: Found only in Laos and Vietnam.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: April, May, July.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

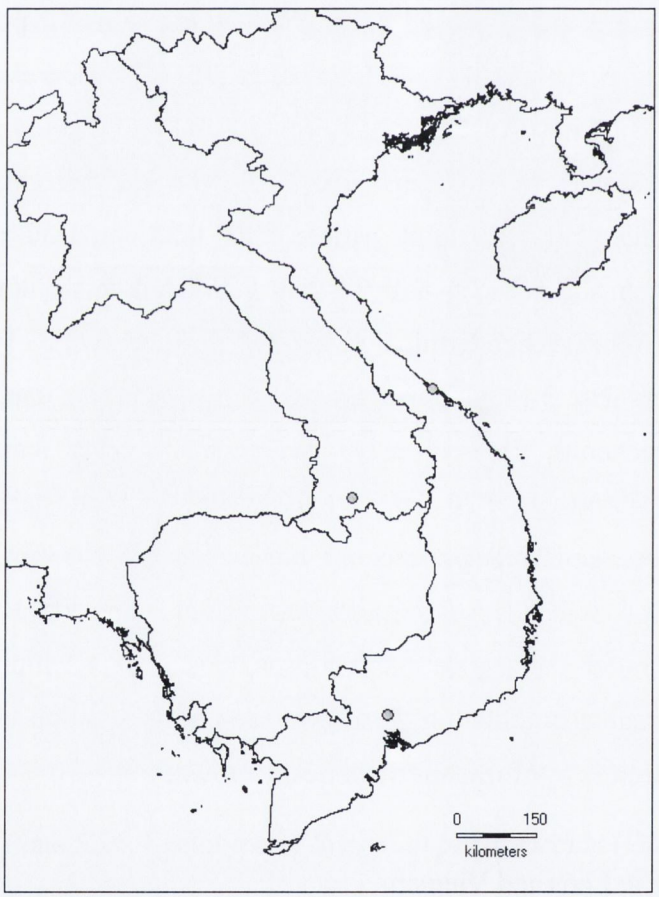
NOTES.

1. *Syzygium pierrei* resembles *S. zimmermannii* but differs in its short petiole and unbranced inflorescence.

SPECIMENS EXAMINED.

LAOS. Champassak: Pathoumphone, Nong Hin, 7 July 2000, *D.Middleton & V.Lamxay 265* (**P**).

VIETNAM. Dong Nai: Bien Hoa, Tri Huyen, April 1869, *Pierre s.n.* (**P**) – Thua Thien-Hue: Bo Giang, July 1877, *Pierre 1818* (**P**) – Cochinchina: Tri Huyen, May 1867, *Pierre s.n.* (**K**, **P**).



Map 39. Distribution of *Syzygium pierrei* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

43. *Syzygium polyanthum* (Wight) Walp., Rep. 2: 180 (1843), non Miq (1855). Merr. & L.M.Perry, J. Arnold Arbor. 19: 108 (1938); Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 155 (1939); Merr., Philipp. J. Sci. 79: 409 (1950); Backer & Bakh.f., Fl. Java 1: 339 (1963); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 56, fig. 3754 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 95 (1994); Turner, Gard. Bull. Singapore 47: 380 (1995); P.Dy Phon, Plants used in Cambodia: 580 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 887 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 907 (2003); Newman; et al., Checkl. Vas. Pl. Lao PDR: 245 (2007) – *Eugenia polyantha* Wight, Ill. Ind. Bot. 2: 17 (1841); Duthie in Hook.f., Fl. Brit. Ind. 2: 496 (1879); Koord. & Valeton, Med. 40: 88 (1900); King, J. Asiat. Soc. Bengal 70: 103 (1901); King, in Mater. Fl. Malay Penins. 12:: 103 (1901); Brandis, Ind. Trees: 322 (1906); Ridl., Fl. Malay. Penins. 1: 742 (1922); Craib, Fl. Siam. Enum. 1: 656 (1931); Corner, Wayside Trees Mal. 1: 501, plate 152 & 153, fig. 168 (1940); M.R.Henderson, Gard. Bull. Sing. 12: 211, fig.40a (1949); Kochummen in Ng, Tree Fl. Mal. 3: 210 (1978). **Type**: Burma '19. Mergui. Arbor.', *Griffith s.n.*, [*Herb.Hooker, Herb. E.I.C. 2394*] (lectotype **K**!, here designated). (fide Noltie (2005: 360)) (see note 1)

– *Eugenia lucidula* Miq., Fl. Ned. Ind. 1: 444 (1855) – *Myrtus cymosa* Blume, Bijdr.: 1086 (1826), nom. illeg, non Spreng (1825) – *Syzygium cymosum* Korth., Ned. Kruidk. Arch. 1: 202 (1847), nom. illeg, non DC (1828). **Type**: Indonesia, Java, *Anon. s.n.*, a ticket bearing Miquel's handwriting '*Eugenia* lucida Miq., Java' (lectotype **L**! [HLB 904.324-22] here designated; isolectotypes **L**! [HLB 898.203-599], **K**! [*Herb. Hooker*]).

– *Eugenia microbotrya* Miq., Anal. Bot. Ind. 1: 27, t. 10 (1850); Merr. En. Born.: 430 (1921) – *Syzygium microbotryum* (Miq.) Masam., Enum. Phan. Born.: 534 (1942). **Type**: Borneo, 'rivier Ariname', *Korthal s.n.* (holotype **L**! [barcode L0600897]).

– *Eugenia pamatensis* Miq., Anal. Bot. Ind. 1: 22, t. 4 (1850). *Syzygium pamatense* (Miq.) Masam., Enum. Phan. Born.: 536 (1942). **Type**: Indonesia, Borneo, Gunung Pammaton, *Korthal s.n.* (holotype **L**! [barcode L0600898]).

– *Eugenia junghuhniana* Miq., Fl. Ned. Ind. 1(1): 444 (1855). **Type**: Indonesia, Java, *herb. Junghuhn*, possible type *Anon. s.n.*, Java (**K**! [*Herb. Hooker*], **L** n.v.).

– *Eugenia nitida* Duthie in J.D.Hooker, Fl. Brit. India 2: 496 (1878), nom. illeg., non Vell. (1829). **Type**: Malay Peninsular, *Maingay 728* (holotype **K**!).

– *Eugenia atropunctata* C.B.Rob., Philipp. J. Sci., C 4: 385 (1909), non Steud (1843), nom. illeg. **Type**: Philipines, Luzon, Cagayan, *Cuming 1308* (lectotype **K**! here designated: isolectotypes **A** n.v. [barcode: 69613], **BM**!, **PNH**†).

– *Eugenia lambii* Elmer, Leafl. Philipp. Bot. 4: 1430 (1912). **Type**: The Philippines, Mt. Pulgar, Palawan, Elmer 13047. Type: (holotype **PNH**†; isotypes **A** n.v. [barcode 69724], **GH** n.v. [69723], **K**!).

– *Eugenia holmanii* Elmer, Leafl. Philipp. Bot. 7: 2354 (1914). **Type**: Elmer 13356, The Philippines, Mt. Urdaneta, Mindanao (**PNH**†; isotypes **A** n.v. [barcode 69708 & 69709]). (fide R.Govaerts et. al. (2010))

– *Eugenia resinosa* Gagnep., Notul. Syst. (Paris) 3: 331 (1918). **Type**: Annam [Vietnam], province of Nghe-an, Co-Ba forest reserve, fl., 15 Mar. 1914, *Herb. Chevalier 30186 (F. Fleury)* (lectotype **P**! [barcode P00589184] here designated; isolectotypes **P**! [2 sheets, barcodes P00589185 & P00589186]). Remaining former syntypes: Cochinchina [Vietnam], Phu-quoc, fl., Jan. 1874, *Herb. Pierre 1416* (cited as *Pierre 1406* in the protologue) (**P**! [3 sheets]); Cochinchina [Vietnam], Mo-cay, fl., Feb. 1867, *Herb. Pierre 424* (**P**! [3 sheets: barcode P00589393, with Delpy drawing dated Dec. 1899 attached; P00589392; one sheet without barcode]); Cochinchina, Thu-dau-mot, fl., *Thorel s.n.* (**P**!); Cochinchina [Vietnam], Ti-tinh, fl., *Thorel s.n.* (**P**!); Cochinchina [Vietnam], Tri-huyen, fl., *Herb. Pierre s.n.* (**P**!); Laos [Thailand], Kemmarat, fl., *Thorel s.n.* (**P**!); Tonkin [Vietnam], Ding-bang, between Hanoi and Sontay, 18 Dec. 1890, *Balansa 4829* (**P**!); Tonkin [Vietnam], D'Along bay, fl., 1911, *Lecomte and Finet 799* (**P**! [2 sheets]); Tonkin [Vietnam], Dap-can, fl., 1909, d*'Alleizette 338* (**P**! [barcode P00589383], **L**! [barcode L0404200]); Tonkin [Vietnam], Ninh-binh, fl. & fr., 16 Aug. 1882, *Bon 1696* (**P**! [2 sheets]); Tonkin [Vietnam], Ninh-binh, fl., 9 Aug. 1882, *Bon 1673* (**P**!); Tonkin [Vietnam], Ninh-binh, fl., *Bon 3655* n.v.; Tonkin [Vietnam], Tralu, fi., Apr. 1914, *Lemarie s.n.* (**P**! [2 sheets]).

– *Eugenia polyantha* var. *sessilis* M.R.Hend., Gard. Bull. Singapore 12: 212 (1949). *Syzygium polyanthum* var. *sessile* (M.R.Hend.) I.M.I.M.Turner, J. Singapore Natl. Acad. Sci. 22 – 24: 23 (1997). **Type**: Malaysia, Johor, Sungai

Kaya, 17 March 1937, *SFN 32413 (Henderson)*. (holotype **SING** n.v.; isotypes **K**!, **L**!).

– [*Syzygium micranthum* Blume ex Miq., Anal. Bot. Ind. 1: 22 (1850) as syn., in sched., nom. nud. **Voucher**: Borneo, Pamatton, *Korthal s.n.*, annotated by Blume as '*Syzygium micranthum* Bl.' (**L**! [barcode L0600900]).]

– [*Eugenia balsamea* auct. non Wight (1841): Ridley, Fl. Malay Penin. 1: 754 (1922). (fide Craib, Fl. Siam. Enum. 1: 656 (1931).]

– [*E. cerasoides* auct. non Roxb. (1832): Miq., Miq., Anal. Bot. Ind. 1: 27 (1850). **Voucher**: s. loc. *Korthal s.n.* (**L**! [barcode L0600879])]

Shrub or tree , to 22 m tall, to 50 cm dbh. Bark greyish brown. Glabrous on all parts. **Twig** terete, 1 – 2 mm diameter, slender, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, 6 – 10 × 3 – 4 cm, 2 to 3 times as long as wide, elliptic or oblong – elliptic, base cuneate, unequal, slightly attenuate, c. 35 – 45 degrees ascending from midrib, margin flat, apex mostly acuminate, sometimes acute, acumen if present 0.5 – 1 cm long, 1/10 – 1/20 of blade length, blade chartaceous, dark brownish; midrib sunken above, raised below; secondary veins (Type B) slender, 7 – 9 per side per blade, broadly spaced, 6 – 10 mm apart, 45 – 60 degrees ascending from midrib, prominent and raised above, prominent below, 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate and extending to form outer intramarginal veins; tertiaries, prominent, reticulate; inner intramarginal veins 1 – 2 mm from margin, looped, outer intramarginal veins prominent; petiole 0.5 – 1 cm, 1/8 – 1/16 of blade length, 1 – 2 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** mostly lateral-axillary in axil of fallen leaves or sometimes on leafy twig, 2 – 4 cm long, paniculate, first to second order branching, flowers many, 27 to 53; axes 1.7 – 3.7 cm, angular, slender; bract and bracteoles persistent, triangular, bract 1 × 0.5 mm, bracteoles 0.5 × 0.2 mm. **Flower** sessile, whitish or yellowish, hypanthium not glaucous, not fibrous, 2 – 2.5 × 2.5 – 3 mm, obconic, flattish, pseudostalk distinct, short, 1 – 1.5 mm; sepals 4, free, 1 × 1 – 1.5 mm, triangular; petals 4, free, 1.7 – 2 × 2 mm, orbicular; outer stamens 3 – 4 mm, anthers c. 0.4 mm, sacs parallel, connective gland conspicuous; style c. 1.5 mm, ovules 9 – 12 per locule, irregularly radiating. **Fruit** (immature) globose, 0.5 – 1 × 0.5 – 1 cm, surface smooth, calyx ring with persistent sepal lobes; seed 1,

globose, 0.45 – 0.95 × 0.45 – 0.95 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: India, Myanmar, Thailand, Cambodia, Laos, Vietnam, Peninsular Malaysia, Sumatra, Borneo, Jawa, The Philippines,..

ECOLOGY OR HABITAT. Secondary forest in sandy-clay soils to 400 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: January, February, March, April, May, August, September, October, December. Fruiting: February, July.

VERNACULAR NAME(S). Cambodia: Pring sratoab, Pring siphlae (Koh Kong). Vietnam: Co phan (Nghe An), San (Ben Tre, Nam Dinh, Nghe An, Ninh Binh), San thuyen.

USES. The fruit is edible. Wood used in construction. In Cambodia, the decoction of wood is used to treat diaorrheas (Dy Phon, 2000). The wood is used for house building (Lemmens et al., 1995).

NOTES.

1. There are four herbarium sheets in **K** that are available for lectotypification. Two of them are annotated 'Mergui, Griffith', one is annotated '19 Hb. Moulmein', the other from Herbarium Griffith and East India Company (E.I.C) No. 2394, with a note bearing number 19 and a short description in Wight's hand writing and the locality 'Mergui' added by anonymous. None of the localities given are of Wight's hand writing or from his herbarium. Therefore, the latter specimen with a note bearing Wight's own description is chosen as lectotype.

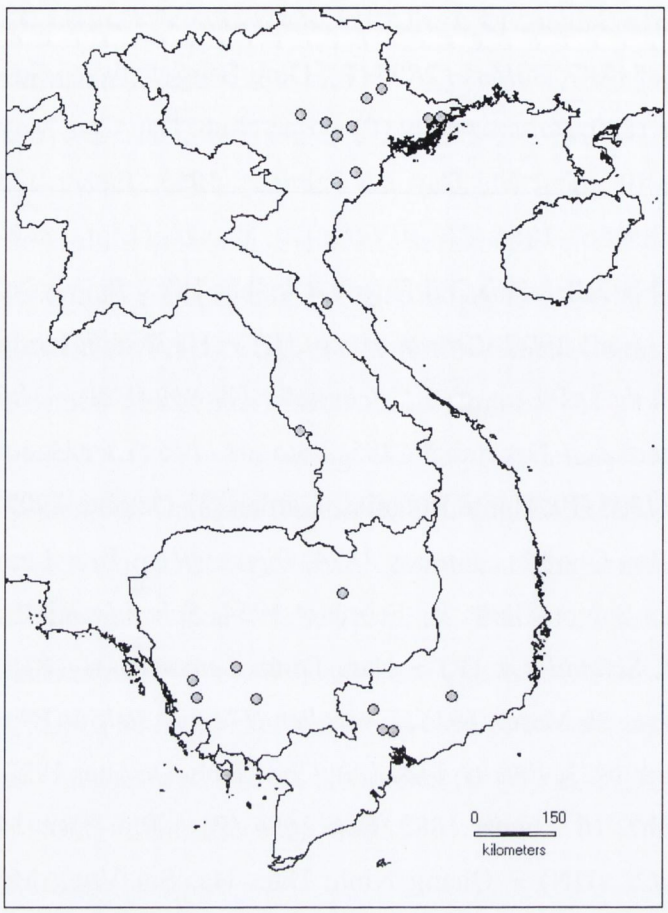
SPECIMENS EXAMINED.

CAMBODIA. Kampong Spoe: Phnum Aural, 19 February 2001, *K.Enghourt, M.Sophal & S.Kosal P.Boyce MoE Herb. Cat. 568* (**K**) – Koh Kong: 22 January 1966, *Vidal 5010* (**P**); Thma Bang, Ta Tey Leu, 28 January 1970, *M.A.Martin 1675* (**P**) – Kompong Speu: Samraong Tong, April 1870, *Pierre 988* (**P**).

THAILAND. Kemmarat (Laos), 1866-1868, *Thorel s.n.* (**P**). (note: This species is widespread in Thailand but only the syntype locality is mapped here)

VIETNAM. Mo Leay?, *Pierre s.n.* (**E**); s. loc., 16 January 1971, *Vu Van Cuong 1587* (**P**); D'Along bay?, 1911, *Lecomte, H. Finet 779* (**P**); s. loc., February 1938,

Petelot 6276 (**P**); Dalat, route to Saigon, 15 April 1953, *de Sigaldy & Dau 86 /TS* (**P**); Son Tay-Tu Phap, October 1887, *Balansa 2895* (**P**); Ding Bang, between Son Tay and Hanoi, 18 December 1890, *Balansa 4829* (**P**) – Bac Ninh: Dap Cau, May 1909, *d'Alleizette 338* (**L**) – Ben Tre: Mo Cay, 25 February 1865, *Pierre 424* (**BM**) – Binh Duong: Thi Tinh, 1862-1866, *Thorel 1184* (**P**); Thu Dau Mot, 1862-1866, *Thorel s.n.* (**P**) – Dong Nai: Bien Hoa, Tri Huyen, October 1872, *Pierre s.n.* (**P**) – Ha Tay: Huong Canh, April 1908, *Chevalier s.n.* (**L**) – Ha Tinh: Huong Khe, 18 August 2001, *N.Q.Binh, D.D.Cuong & V.Schnitzler VN 869* (**HN**) – Hai Phong: Haiphong botanical garden, 1 December 1885, *Balansa 1146* (**L**) – Hanoi City: February 1932, *Petelot 4305* (**P**); Hanoi Botanical Garden, 21 October 1902, *Bois 352* (**P**) – Ken Giang: Phu Quoc Is., January 1874, *Pierre 1416* (**P**) – Lam Dong: 138 km, route between Saigon-Dalat, 21 February 1954, *Schmid s.n.* (**P**); Bao Loc, 27 February 1959, S*chmid s.n.* (**P**) – Nam Dinh: *Lemarie s.n.* (**P**) – Nghe An: Co Ba forest reserve, 15 March 1914, *Chevalier (Fleury) 30186* (**P**) – Ninh Binh: Cho Ganh, October 1923, *Petelot 1481* (A); Cho Ganh, October 1923, *Petelot 1481* (**P**); Ninh Thinh?, 16 August 1882, *Bon 1696* (**P**) – Phu Tho: 14 September 2000, *Phuong 3422* (**HN**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, 18 May 1940, *W.T.Tsang 30136* (**A**, **E**, L); July 1940, *W.T.Tsang 30426* (**A**, **E**, K), May 1940, *W.T.Tsang 30077* (**E**, **K**, **P**), *W.T.Tsang 30181* (**BKF**, **E**, L); 18 July-9 Sept, 1940, *W.T.Tsang 30426* (**A**, **K**); Tien Yen, Kau Nga Shan and vicinity, *W.T.Tsang 27477* (**E**).



Map 40. Distribution of *Syzygium polyanthum* (Wight) Walp. in Cambodia, Laos and Vietnam.

44. *Syzygium praecox* (Roxb.) Rathkr. & N.C. Nair, J. Econ. Taxon. Bot. 4: 288. 1983; D.G. Long & Rae in Gierson & D.G. Long, Fl. Bhutan 2: 282 (1991); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 96 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 888 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003) – *Eugenia praecox* Roxb., Fl. Ind. ed.: 488 (1832); Wight, Ill. Ind. Bot. 2: 17 (1841); Wight, Icon. Pl. Ind. Orient. 2: t.: 619 (1843); Kurz, J. Asiat. Soc. Bengal 46: 66 (1877); Kurz, Forest Fl. Burma 1: 483 (1877); King, J. Asiat. Soc. Bengal 70: 116 (1901); Brandis, Ind. Trees: 320 (1906); Ridl., Fl. Malay. Penins. 1: 750 (1922); Craib, Fl. Siam. Enum. 1: 657 (1931); M.R.Henderson, Gard. Bull. Sing. 12: 133 (1949); Kochummen in Ng, Tree Fl. Mal. 3: 210 (1978) – *Strongylocalyx praecox* (Roxb.) Blume, Mus. Bot. 1: 89 (1850) – *Jambosa praecox* (Roxb.) A.M.Cowan & Cowan, Trees N. Bengal: 67 (1929) – *S. praecoxum* (Roxb.)

Harid. & R.R. Rao, Forest Fl. Meghalaya: 401, fig. 25 (1985). **Type**: Ic. Roxb. No. 2500, ined. (lectotype **K**! [downloaded from Royal Botanic Gardens, Kew (2006)] here designated; isolectotype **C** n.v.))

– *Eugenia lanceifolia* Roxb., Fl. Ind. ed. 1832, 2: 494 (1832) – *Strongylocalyx lanceifolius* (Roxb.) Blume, Mus. Bot. 1: 89 (1850) – *Syzygium roxburghianum* Raizada, Indian Forester 74: 336 (1948). **Type**: Ic. Roxb. No. 2261, ined. (lectotype **K**! [downloaded from Royal Botanic Gardens, Kew (2006)] here designated; isolectotype **C** n.v.))

– *Eugenia wallichii* Wight, Ill. Ind. Bot. 2: 17 (1841), in Icon. Pl. Ind. Orient. 2: t. 536 (1842) – *Syzygium wallichii* (Wight) Walp., Repert. Bot. Syst. 2: 180 (1843).Type: Bangladesh, Silhet, *F. de Silva s.n.* in *Wallich Numer. List 3606* (1831) (lectotype **K-W**! here designated; isolectotypes **E**! [3 sheets], **P**!).

– *Syzygium cathayense* Merr. & L.M.Perry, J. Arnold Arbor. 19: 232 (1938); J. Chen & Craven, Fl. China 13: 347 (2007). **Type**: China, Kwangtung, Fang Cheng, Wu 104 (S.Y.U 67797) (holotype **SYS** n.v.; holotype frag. **A** n.v. [barcode 71308]), **syn. nov.** (see note 1)

Tree to 9 m tall. Glabrous on all parts. **Twig** angular (4-angled) and winged, 2 – 3 mm diameter, stout, surface smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 11 – 15(– 18.5) × 4.5 – 5.5 cm, 2 to 3 times as long as wide, elliptic or oblong-elliptic, base cuneate, 45 – 50 degrees from midrib, margin flat, apex acuminate, acumen to 1.5 cm long, c. 1/9 of blade length, blade chartaceous, dark brownish to blackish, shiny above, contrasting to twig colour; midrib sunken above, raised below; secondary veins (A.III & B) stout, 8 – 12 per side per blade, broadly spaced, 8 – 10 mm apart, 60 – 70 degrees ascending from midrib, prominent and raised on both surfaces; tertiaries prominent, reticulate; inner intramarginal veins 2 – 3 mm from leaf margin, scalloped, prominent, outer intramarginal veins prominent, often the first pair of basal secondary veins arcuate, forming the outer intramarginal veins, extending to the leaf apex; petiole 1 – 1.2 cm, 1/12 – 1/22 of blade length, 0.8 – 1.5 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** axillary on leafy twig, rarely terminal, 4.5 – 5.5 cm long, paniculate, first order branching, flowers few, 17 to 33, spreading; axes 4 – 5 cm, angular, slender; bract and bracteoles caducous. **Flower** whitish (in vivo), fragrant, sessile, hypanthium 5 – 6 × 3 mm, pyriform,

pseudostalk distinct, c. 3 mm; sepals 4, free, 1 – 1.3 × 1.5 mm, semiorbicular; petals 4, free, 2.8 – 3.3 × 3 – 3.5 mm, suborbicular; outer stamens 9 – 10 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style 9 – 10 mm, ovules 8 – 10 per locule, irregularly radiating. **Fruit** (immature) obloid, 1 × 0.5 cm, surface smooth, calyx ring with undulating rim; seed 1, subglobose, 0.8 × 0.45 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread from Nepal to Indochina and South China (Guangdong and Yunnan)

ECOLOGY OR HABITAT. Secondary forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: October, November, December, January. Fruiting: not documented.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

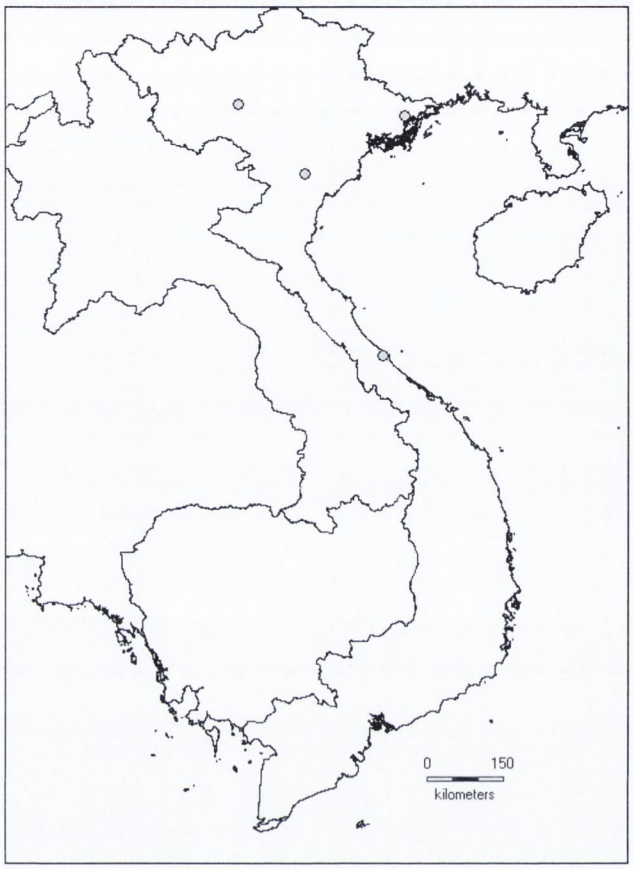
NOTES.

1. Although I have not seen the type of *Syzygium cathayense*, I have examined herbarium materials identified by Merrill as *S. cathayense* (*W.T.Tsang 27481* (**E**, **K**, **P**) & *W.T.Tsang 30757* (**A**, **E**, **K**, **L**, **P**)). The description in the protologue and the herbarium material strongly suggest that all these materials are *S. praecox* in having a distinct whitish winged twig, axillary and short inflorescences and leaves dark brownish with prominent outer intramarginal veins. *Syzygium praecox* is a new record for Vietnam. Its distributional range is previously known from India to Thailand but now this has expanded to Vietnam and South China.

SPECIMENS EXAMINED.

VIETNAM. Lam Dong: *Schmid s.n.* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 13 March 1971, *Anon. D 132* (**CPNP**); Nho Quan, Cuc Phuong National Park, 15 March 1971, *K.Dao D 02* (**HN**) – Quang Ninh: Tien Yen, Ho Yung Shan and vicinity, 13 October 1940, *W.T.Tsang 30757* (A, **E**, K, L, P); Tien Yen, Kau Nga Shan and vicinity, 9 January 1937, *W.T.Tsang 27481* (**E**, **K**, **P**) – Quang Tri: Vinh Linh, 6 December 2003, *N.Q.Binh & D.D.Cuong VN 1236* (**HN**)

– Yen Bai: Tram Tau, 9 March 2001, *N.Q.Binh, D.D.Cuong & V.Schnitzler VN 816* (**HN**).



Map 41. Distribution of *Syzygium praecox* (Roxb.) Rathkr. & N.C. in Cambodia, Laos and Vietnam.

45. *Syzygium ripicola* (Craib) Merr. & L.M.Perry, Brittonia 4: 127 (1941); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 56, fig. 3755 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 104 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 830 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 908 (2003); M.F.Newman et al., Checkl. Vas. Pl. Laos: 245 (2007) – *Eugenia ripicola* Craib, Bull. Misc. Inform. Kew 1915: 428 (1915), Fl. Siam. Enum. 1: 636 (1931). **Type**: Thailand, Nakhon Sawan, Keng Soi, 16 March 1913, *Kerr 2944* (lectotype ABD designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 104 (1994); isolectotypes **BM** n.v., **E**!, **K**!).

– *Eugenia cochinchinensis* Gagnep., Notul. Syst. 3: 322 (1917); in Lecomte, Fl. Gén. Indo-Chine 2: 814 (1920); Craib, Fl. Siam. Enum. 1: 636 (1931) – *Syzygium cochinchinense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 107 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 50, fig. 3735 (1992); P.Dy Phon, Plants used in Cambodia: 378 (2000). **Type**: Cambodia, province of Samrong Tong, fr., April 1870, *Herb. Pierre 527* (lectotype **P**! [barcode P00589286] with a drawing by Delpy dated Dec. 1899 attached, here designated; isolectotypes **P**! [3 sheets, barcodes P00589287, P00589288 & P00589350]). Remaining former syntypes: Laos [Thailand], Kemmarat, fl., *Thorel s.n.* (**P**!); Laos [Thailand], Ubon, fl., *Thorel s.n.* (**P**! [2 sheets]); Laos, Attopeu plateau, Feb. 1877, fl., *Harmand 1170* in *Herb. Pierre 3194* (**P**!, **K**! [barcode K00276201]); Cochinchina [Vietnam], Bien Hoa, fl., May. 1868, fl., *Herb. Pierre s.n.* (**P**! [barcode P00589349]).

– *Syzygium eburneum* (Gagnep.) Merr. & L.M.Perry (1938: 107); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 903 (2003) – *Eugenia eburnea* Gagnep., Notul. Syst. 3: 318 (1917); in Lecomte, Fl. Gén. Indo-Chine 2: 816, fig. 88 (1920). **Type**: Cambodia, plain of Pen-lovier, fl., May 1870, *Herb. Pierre 991* (lectotype **P**! [barcode P00589209] with a drawing by Delpy dated Mar. 1900 attached, here designated; isolectotypes **P**! [2 sheets, barcodes P00589210 & P00589211], **K**! [barcode K000276209], **E**!). **syn. nov.** (see note 1)

Shrub or tree , 3 – 15 m tall, to 20 cm dbh. Glabrous on all parts. **Twig** terete and sometimes compressed, 1 – 2 mm diameter, slender, surface smooth, whitish, contrasting to leaf colour. **Leaves** opposite to subopposite, 6.5 – 11.5 × 2 – 3 cm, 2.5 to 6 times as long as wide, lanceolate or elliptic, base cuneate to attenuate, 20 – 40 degrees from midrib, margin flat, apex acute, without acument, blade chartaceous, pale greenish; midrib sunken above, raised below; secondary veins (Type AI) slender, 20 – 30 per side per blade, narrowly spaced, 1 – 2(– 3) mm apart, 60 degrees ascending from midrib, prominent or faint, raised above, prominent and raised below; tertiaries faint, reticulate; inner intramarginal veins 0.5 – 1 mm from leaf margin, straight, outer intramarginal veins absent or faint; petiole 1 – 1.7 cm, 1/4 – 1/10(– 1/20) of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal and axillary on leafy twig, 3 – 7 cm long, paniculate, first order branching, flowers many, to 30,

compact at branch-end, to 9 flowers; axes c. 3 – 7 cm, angular, slender; bract and bracteoles caducous. **Flower** whitish, sessile, hypanthium 3 – 4 × 2 – 2.5 mm, obconical, pseudostalk indistinct, if distinct, very short, 1 – 1.5 mm; sepals 4, free, 1 – 1.5 × 1 – 1.5 mm, triangular; petals 4, coherent, 1 – 2 × 1 – 2 mm, orbicular; outer stamens 5 – 6 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style 4 – 5 mm, ovules 9 – 12 per locule, irregularly radiating. **Fruit** subglobose, 1 – 1.3 × 0.7 – 0.9 cm, surface smooth, calyx ring with smooth rim; seed 1, subglobose, 0.99 – 1.29 × 0.69 – 0.89 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Endemic to Continental Southeast Asia. Found in Myanmar, Thailand, Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. 100 to 900 m altitude, secondary or primary forest, often along river on rocky terrain.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: February, March, April, June, December. Fruiting: April, June.

VERNACULAR NAME(S). Cambodia: Pring chom (Kandal), Pring khmum, Pring tuk (Pursat). Vietnam: Tram (South Vietnam), Tram nam bo, Tram nga, Tram suoi.

USES. Fruit edible and wood used in carpentry.

NOTES.

1. This is a rheophytic species. Gagnepain (1920) recognised *Eugenia cochinchinense* and *Eugenia eburnea* as distinct species on the basis of the twig colour: greyish or reddish in the former and whitish in the latter species. I consider both of these species to be conspecific to *Syzygium ripicola* having the same leaf venation and inflorescence type. However, the leaves of *S.eburneum* are slightly broader unlike the typical *S. ripicola* which are narrower.

SPECIMENS EXAMINED.

CAMBODIA. Pen Lovier?, May 1870, , *Pierre 991* (**E**, **K**, **P**) – Kandal: Phnom Penh, 10 July 1938, *Bejaud 556* (**P**) – Kompong Speu: Samraong Tong, April

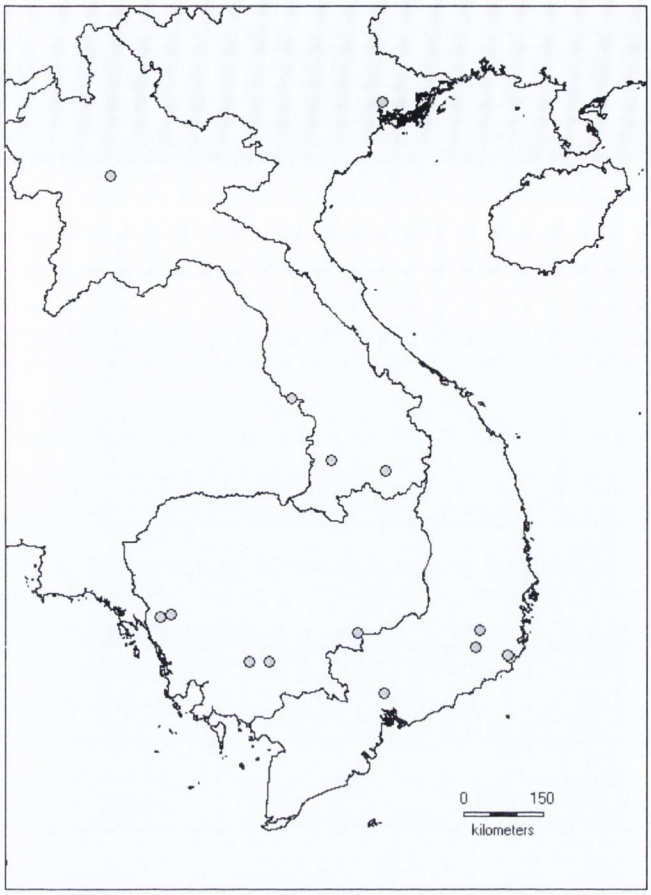
1870, *Pierre 527* (**P**) – Pursat: Peam Prus, 26 December 1968, *M.A.Martin 1379* (**P**); Veal Veng, 15 February 2000, *K.Eanghourt 27* (**TCD**).

LAOS. Route between Luang Prabang and Viangchan, April 1912, *d'Alleizette s.n.* (**L**) – Attapeu: Attapeu basin, *Harmand 1170* (**P**); Bolaven plateau [Attopeu plateau], May 1877, *Pierre 3194* (**K**, **P**).

VIETNAM. route between Ho Chi Minh and Dalat, 133 km, Bao D, 14 April 1953, *Sigaldy de; Dau 70 /TS* (**P**) – Annam: June 1901, *d'Alleizette s.n.* (**L**) – Dong Nai: Bien Hoa, May 1868, , *Pierre s.n.* (**P**); Bien Hoa, March 1868, *Pierre s.n.* (**P**) – Lam Dong: , bank of Daa Uaii?, 27 April 1955, *Schmid s.n.* (**P**); Mt. Lang Bian, 26 April 1919, *Chevalier 40287* (**P**); Dalat, between Lang Ang and Lieng Khan, 12 February 1954, *Schmid s.n.* (**P**); Thac Lien Khuong, 22 March 1967, *Vu Van Cuong 278* (**P**) – Ninh Thuan: Krong Pha-Pham Rang, 25 June 1955, *Schmid s.n.* (**P**); Tour Cham-Krong Pha, 24 April 1964, *Schmid s.n.* (**P**) – Quang Duc-Lam Dong: 2 March 1954, *Schmid s.n.* (**P**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND: Ubon Ratchathani: Kemmarath, *Thorel s.n.* (**P**); Ubon, *Thorel s.n.* (**P**).



Map 42. Distribution of *Syzygium ripicola* (Craib) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

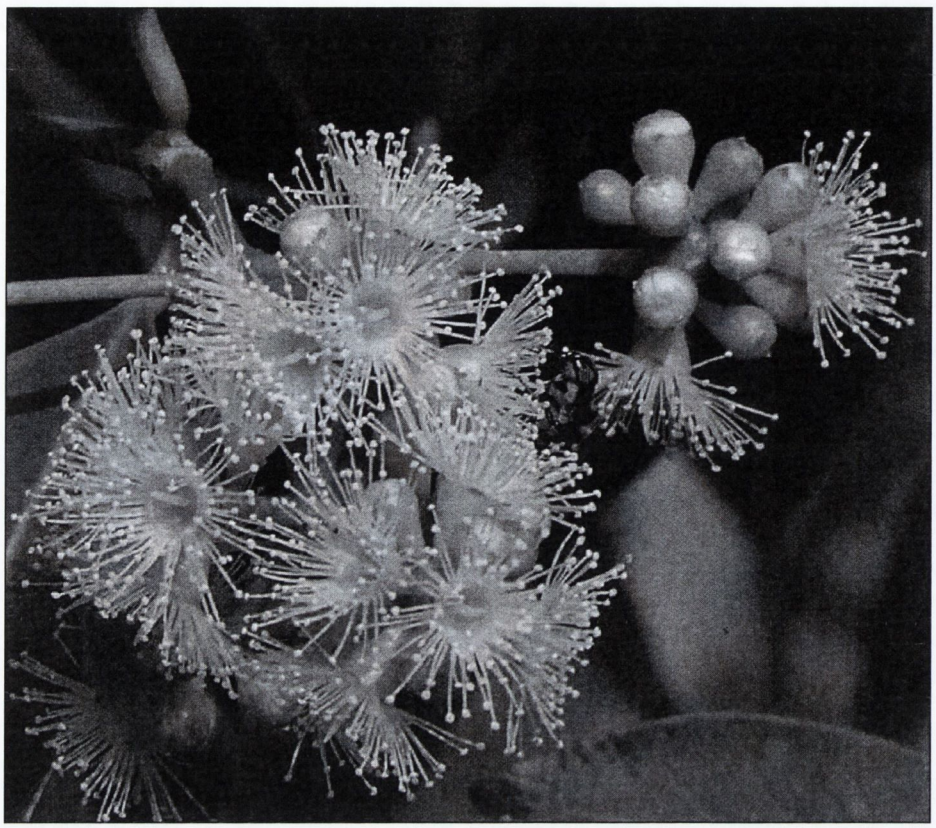


Plate 5.27. Inflorescence of *Syzygium ripicola* (Craib) Merr. & L.M.Perry. Photo courtesy of Pranom Chantaranothai.

46. *Syzygium samarangense* (Blume) Merr. & L.M.Perry, J. Arnold Arb. 19: 115 (1938); Merr. & L.M.Perry, Mem. Amer. Acad. Arts 18: 167 (1939); Merr., Philipp. J. Sci. 79: 414 (1950); Backer & Bakh.f., Fl. Java 1: 345 (1963); T.G. Hartley & L.M.Perry, J. Arnold Arbor. 54: 192 (1973); P.S. Ashton, in Dassan. dan Fosberg, Fl. Ceylon 2: 425 (1981); Whistler, J. Arn. Arb. 69: 180 (1988); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 105, plate V, 7 (1994); P.Dy Phon, Plants used in Cambodia: 580 (2000); P.Chantaranothai & J.Parn., Fl. Thailand 7: 896, fig. 26 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 908 (2003); J. Chen & Craven, Fl. China 13: 345 (2007) − *Myrtus samarangensis* Blume, Bijdr. 17: 1084 (1826) − *Jambosa samarangensis* (Blume) DC., Prodr. 3: 286 (1828) − *Eugenia samarangensis* (Blume) O. Berg in Mart., *Fl. Bras.* 14, 1: 646 (1859), nom. inval., in synon. **Type**: Indonesia, Java, cultivated, *Herb. Blume s.n.* (lectotype: **L**! [sheet no. 898.203-406] designated by N.Snow & J.F.Veldkamp, Blumea XX: XX (2010)).

– *Myrtus obtusissima* Blume, *Bijdr.* 17: 1086 (1826) – *Jambosa ? obtusissima* (Blume) DC., *Prodr.* 3: 287 (1828) – *Jambosa samarangensis* (Blume) DC. var. *obtusissima* (Blume) Blume, *Mus. Bot.* 1: 95 (1850, "1849"). **Type:** Indonesia, Java, Lingajati, *Herb. Blume 1558* (holotype **L**! [sheet no. 898.203-411]).

– *Jambosa ambigua* Blume, *Mus. Bot.* 1: 96 (1850, "1849"). **Type**: Indonesia, Java. *Korthals s.n.* (lectotype **L**! [sheet no. 898.203-402] designated by N.Snow & J.F. Veldkamp, Blumea XX: XX (2010); **K**!).

– *Jambosa samarangensis* (Blume) DC. var.: Blume, *Bijdr.* 17: 1085 (1826) – *Jambosa samarangensis* (Blume) DC. var. *microcarpa* Hassk. ex Blume, *Mus. Bot.* 1: 95 (1850, "1849"). **Type:** 'Archipelagi indici', *Korthals s.n.* (lectotype **L**! [sheet no. 898.203-423] designated by N.Snow & J.F. Veldkamp, Blumea XX: XX (2010)).

– *Eugenia alba* Roxb., Fl. Ind. ed. 1832, 2: 493 (1832) – *Jambosa alba* (Roxb.) G.Don, Gen. Hist. 2: 868 (1832). **Type**: Ic. Roxb. No. 1069, ined. (lectotype **K**! [downloaded from Royal Botanic Gardens, Kew (2006)] designated, **C** n.v.))

– [*Eugenia silvestris alba* Rumph, *Herb. Amboin.* 1: 127, t. 39. 1741, *nom. inval.*]

– *Eugenia alba* Rumph. ex Blume, *Mus. Bot.* 1: 94. 1850 ("1849"), non Roxb. (1832). **Type:** Ambon. *Herb. Amboin. 1: t. 39. 1741*, suggested by Merrill (1917b), here designated – Epitype: Ambon. *Forsten s.n.* [**L**! [sheet no. *898.*203-404] designated by N.Snow & J.F. Veldkamp, Blumea XX: XX (2010); duplicate **L**! [sheet no. 898.203-405]).

– *Myrtus timorensis* Zipp. ex Span., Linnaea 15: 204 (1841) – *Jambosa timorensis* Blume, Mus. Bot. 1: 97 (1850). **Type**: Indonesia, Timor, *Zippelius s.n.* (lectotype **L**! [Sheet no. 893.203-425] here designated; isolectotype **L**! [sheet no. 898.203-424]).

– *Jambosa timorensis* Blume var. *laxiflora* Blume, *Mus. Bot.* 1: 98. 1850 ("1849"). **Type**: Indonesia, Timor, Kupang. *Anon. s.n.* (holotype **L**! [sheet no. 898.203-421).

– *Eugenia mindanaensis* C.B. Rob. in Philip. J. Sci. Bot. 4: 363. 1909. **Type**: Phillipines, Mindanao, district of Davao, Santa Cruz, *William 2752* (holotype P†; isotype **US**! [barcode 00118057]).

– *Eugenia suzukii* Kanehira, *Bot. Mag. (Tokyo)* 45: 335 (1931). **Type:** Belau ("Pelew Islands" on label), Corol, July 1929, *R. Kanehira 361* (holotype TAI; isotype BISH, TAI) (fide N.Snow & J.F. Veldkamp, Blumea XX: XX (2010))

– *Syzygium samarangense* var. *parviflorum* (Craib) P.Chantaranothai & J.Parn., Kew Bull. 48: 609 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 107 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 896 (2002) – *Eugenia javanica* Lam. var. *parviflora* Craib, Fl. Siam. Enum. 1: 647 (1931). Type: Thailand, Khao Kalakiri, *Kerr 7798* (lectotype **BK**!; isotype **ABD** n.v., **BM** n.v., E n.v., **K**!, **TCD**! designated by P.Chantaranothai & J.Parn., Kew Bull. 48: 609 (1993)).

– *Eugenia javanica* auct. non Lam., Encycl. 3: 200 (1789): Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 837 (1920) [excl. var. *balansae* = *Syzygium sp. aff. Syzygium tripinnatum* (Blanco) Merr.]. (see section on incompletely known species)

Possible synonyms:

– *Gelpkea stipularis* Blume, Mus. Bot. 1: 88 (1850) – *Eugenia stipularis* (Blume) Miq., Fl. Ned. Ind. 1(1): 441 (1855).

– *Jambosa calophylla* Miq., Fl. Ned. Ind. 1(1): 423 (1855) – *Eugenia callophylla* (Miq.) Reinw. ex de Vriese, Pl. Ind. Bat. Orient.: 69 (1856).

Tree to 9 m tall, to 20 cm dbh. Bark smooth or flaky, greenish to brownish. Glabrous on all parts. **Twig** terete, 2.5 – 4 mm diameter, stout, surface smooth, pale brownish, not contrasting to leaf colour. **Leaves** opposite, 12 – 20 × 5 – 13.5 cm, 2 times as long as wide, elliptic, oblong-elliptic, ovate to obovate, base rounded to slightly cordate, c. 35-45 degrees from midrib, margin flat, acute or acuminate, blade chartaceous, brownish to greenish; midrib sunken above, raised below; secondary veins (Type A.III or B) 10 – 12 per side per blade, broadly distanced, 10 – 20 mm apart, c. 45 degrees ascending from midrib, prominent and raised above, prominent below, sometimes a pairs of basal secondary veins (acrodromous veins) arcuate and extending to form outer intramarginal veins; tertiaries prominent, reticulate; inner intramarginal 3 – 6 mm from leaf margin, straightly or slightly looped, outer intramarginal veins prominent; petiole 0.4 – 0.8 cm, 1/30 – 1/60 of blade length, 1.5 – 2 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary on leafy twigs or an

axils of fallen leaves, to 8 cm long, racemose, flowers few, 3 to 7; axes to 5 cm, terete to subangular; bract and bracteoles caducous. **Flower** whitish to yellowish, big, pedicellate, pedicel 1 – 2 cm, hypanthium greenish (in vivo), not glaucous, not fibrous, 15 – 20 × 10 – 15 mm, pyriform, apex broad, tapering gradually to pseudostalk, pseudostalk c. 5 mm; sepals reddish-green, 4, free, semiorbicular, 3.5 – 4 × 6 – 8 mm,; petals 4, free, ovate to orbicular, 10 – 13 × 10 – 15 mm; outer stamens 15 – 20 mm, anthers, c. 1.5 – 2 mm, sacs parallel, connective gland conspicuous; style c. 20 – 30 mm, ovules 28 – 30 per locule, irregularly radiating. **Fruit** pyriform to subglobose, whitish, greenish to reddish (in vivo), 4.5 – 6 × 4 – 6 cm, surface smooth, shiny, calyx ring with persistent, inflexed and fleshy sepal lobes; seed 1 to 2, subglobose, c. 1 – 1.5 × 1 – 1.5 cm, cotyledons free, intercotyledonary intrusion absent.

(The description here is based on herbarium specimens and *in situ* observation)

DISTRIBUTION: Widely cultivated in the tropics, including Cambodia, Laos and Vietnam.

ECOLOGY OR HABITAT. Villages and plantation, low land.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

VERNACULAR NAME(S). Wax apple (general). Cambodia: Champuu, Kanlan rehs. Vietnam: Man, Roi.

USES. Important fruit crop.

NOTES.

1. Many cultivars of *S. samarangense* have been clones which differ in fruit colour and taste.

SPECIMENS EXAMINED (no voucher were made from *in situ* observations).

CAMBODIA. Kandal: Kien Svay village, 7 January 2010, *M.Leti & P.Toeng CL1254* (**P**), *CL1255* (**P**), *CL1257* (**P**), *1258* (**P**); Phnom Penh, 6 March 1914, *Chevalier 31706* (**P**); Phnom Penh, 20 January 2010, *M.Leti & P.Toeng CL1259* (**P**), *CL1260* (**P**), *CL1261* (**P**).

VIETNAM. June 1927, *Petelot s.n.* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 25 May 1999, *N.M.Cuong 149* (**GH**); Nho Quan, Cuc Phuong National Park, 16 May 1971, *CPNP 3987* (**CPNP**); Nho Quan, Cuc Phuong

National Park, 16 May 1970, *CPNP 3986* (**CPNP**) – Thua Thien-Hue: Hue, 28 June 1916, *Eberhardt 3300* (**P**).

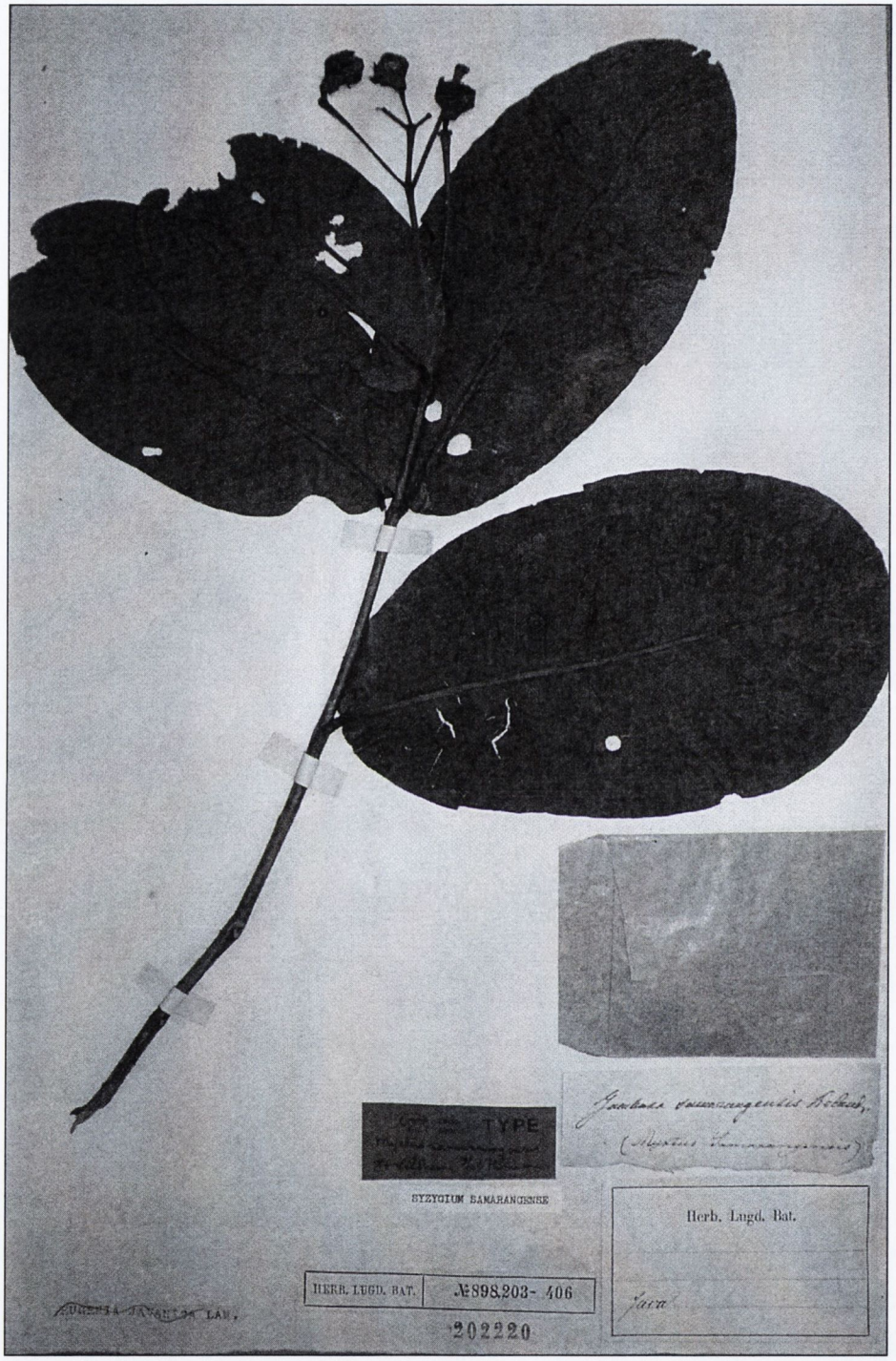


Plate 5.28. Lectotype of *Syzygium samarangense* (Blume) Merr. & L.M.Perry. Photo by the Author with permission from The Nationaal Herbarium Nederland.

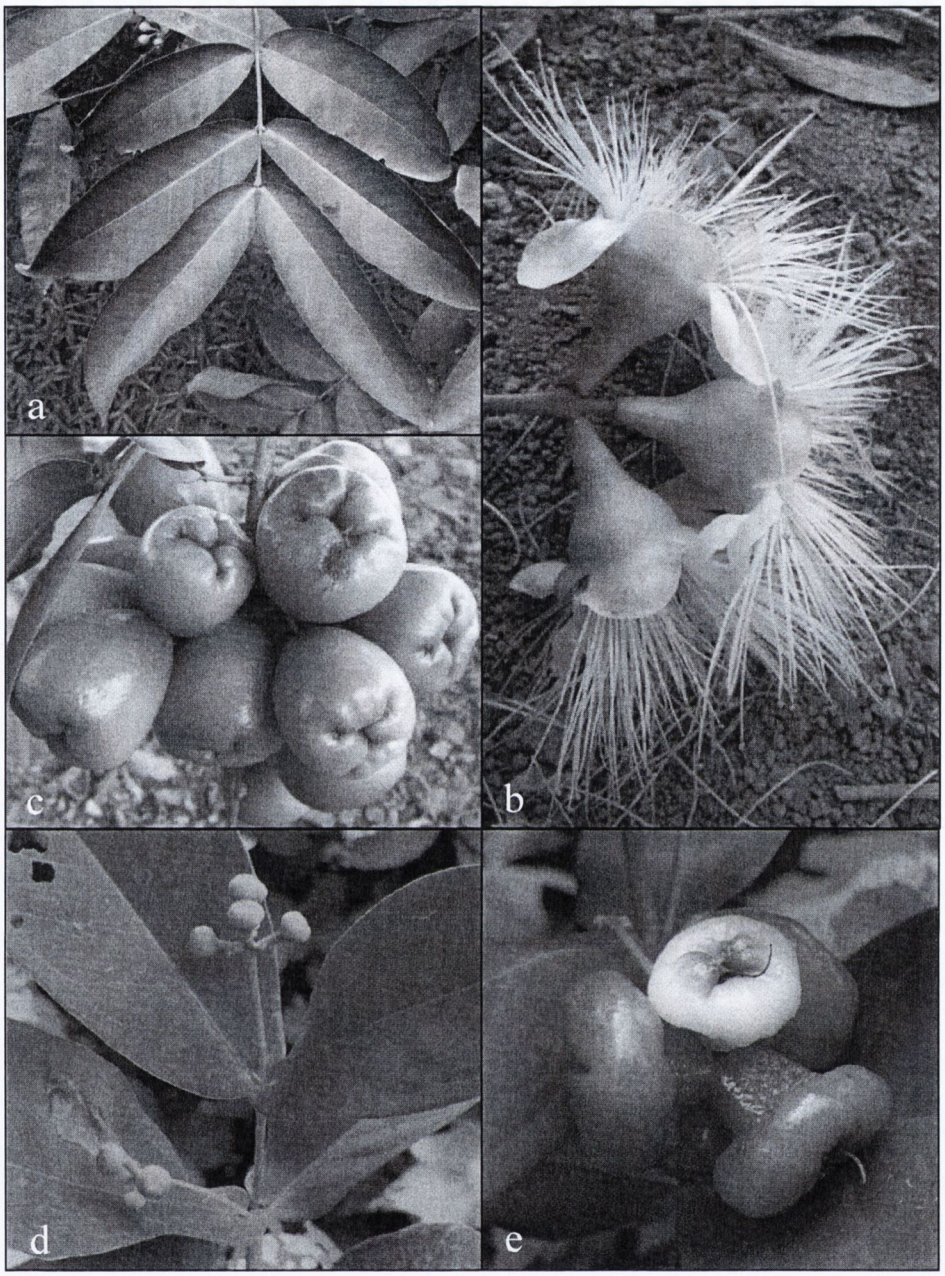


Plate 5.29. *Syzygium samarangense* vegetative and reproductive organs– a. Leaves; b. Flowers; c. Fruits. *Syzygium aqueum* – d. Young inflorescence; e. Fruits. Photos courtesy of Mathieu Leti.

47. *Syzygium siamense* (Craib) P.Chantaranothai & J.Parn., Kew Bull. 48: 609 (1993); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: (1994); Turner, Gard. Bull. Singapore 47: (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003) – *Eugenia siamensis* Craib, Bull. Misc.

Inform. Kew 1912: 153 (1912); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 843 (1920); Ridl., Fl. Malay. Penins. 1: 726 (1922); Craib, Bull. Misc. Inform. Kew 1930: 153 (1930); Craib, Fl. Siam. Enum. 1: 661 (1931); M.R.Henderson, Gard. Bull. Sing. 12: 59, fig. 11a (1949); Kochummen in Ng, Tree Fl. Mal. 3: 217 (1978). **Type**: Thailand, Chonburi, Sriracha, Nawng Kai Plai, 26 Sept 1911, *Kerr 2118* (lectotype **K**! designated by Chantaranothai & J.Parn., Kew Bull. 48: 609 (1993); isotype **BM** n.v.).

– *Eugenia jambos* var. *sylvatica* Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 834 (1920), pro parte majore [excl. spec. *Balansa 1141* (Haipong), *Balansa 1140* (Ounbi), *Geoffray 347* (Kampot), *Eberhardt 3035* (Song valley)]; *Syzygium jambos* var. *sylvaticum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 114 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 45, fig. 3719 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 906 (2003). **Type**: Cochinchina [Vietnam], Bienhoa Province, Mt. Nui-chua-chuang, fl., 10 Jan. 1914, *Chevalier 29923 (Fleury)* (lectotype **P**! [P00589334] here designated; isolectotypes **P**! [2 sheets, P00589245 & P00589248]. Remaining former syntypes: Cambodia, Mt. Chereev, fl., Apr. 1870, *Herb. Pierre 994* (**P**! [P00589341, P00589253, P00589342]; Mekong, fl., Sept. 1878, *Harmand s.n. in Herb. Pierre 1923* (**P**! [P00589337]); Hanoi [Vietnam], Ninh Thai, 14 Dec. 1886, fl. Bon 3312 (**P**! [2 sheets, P00589246 & P00589247]. (See note)

– *Eugenia rubida* Ridl., J. Fed. Malay States Mus. 10: 90, Plate XXX, 3A-B (1920). **Type**: n.v. (fide Craib, Fl. Siam. Enum. 1: 661 (1931))

Tree to 14 m tall, to 20 cm dbh. Bark greyish brown. Glabrous on all parts. **Twig** terete or subangular, 1.5 – 3 mm diameter, stout, surface smooth to slightly fissured, pale brownish, not contrasting to leaf colour. **Leaves** opposite, 12.5 – 17.5 × 3 – 5.6 cm, 2.5 to 4 times as long as wide, elliptic to oblong, base rounded to cuneate, 60 – 70 degrees from midrib, margin flat, apex usually acuminate or sometimes acute, acumen if present 1 – 2 cm long, 1/6 – 1/10 of blade length, blade subcoriaceous to chartaceous, greenish; midrib sunken above, raised below; secondary veins (Type A.II) 6 – 10 per side per blade, broadly distanced, 10 – 20 mm apart, 50 – 60 degrees ascending from midrib, faint and raised above, prominent below; tertiaries prominent, reticulate; inner intramarginal c. 3 – 5 mm from leaf margin, looped, outer intramarginal veins faint; petiole 0.3 – 0.6 cm,

(1/20 –)1/30 – 1/45 of blade length, 1.5 – 2 mm diameter, stout, dark brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary at apex of leafy twig, 3 – 5 cm long, racemose, flowers few, 3 to 7; axes 1.5 – 3.5 cm, terete to subangular; bract and bracteoles caducous. **Flower** big, pedicellate, pedicel 0.4 – 0.7 cm, hypanthium reddish-green (in vivo), not glaucous, not fibrous, 10 – 15 × 8 – 10 mm, pyriform, pseudostalk distinct, 5 – 7 mm; sepals reddish-green (in vivo), 4, free, unequal, semiorbicular, outer lobes 3.5 – 4 × 7 mm, inner lobes 5 – 7 × 10 mm, semiorbicular; petals whitish, 4, coherent, orbicular, 2 × 2 mm; outer stamens, 2.5 – 3 mm, yellowish, anthers, c. 1 mm, sacs parallel, connective gland conspicuous; style c. 30 – 40 mm, ovules 9 – 12 per locule, irregularly radiating. **Fruit** globose to ovoid, c. 5 × 5 cm, surface smooth, calyx ring with persistent sepal lobes; seed 1 to 2, ovoid, c. 3 × 2 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Myanmar, Thailand, Cambodia, Laos, Vietnam and Peninsular Malaysia.

ECOLOGY OR HABITAT. Primary forest, sometimes along river on sandstone.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering and fruiting all year round.

VERNACULAR NAME(S). Cambodia: Kanlung rung (Koh Kong), Phlang phnom (Koh Kong). Laos: Va yong (Viangchan). Vietnam: Cay roi (Hanoi City), Gioi (Phu Tho), Tram do.

USES. Fruit edible.

NOTES.

1. *Syzygium siamense* is morphologically close to *S. jambos* but differs in its reddish-green receptacle and rounded to cordate leaf base (versus receptacle greenish and leaf base attenuate in *S. jambos*). Gagnepain (1920) regarded the current species as a variety of *S. jambos* under var. *sylvatica*. In the *Flore générale de l'Indochine*, Gagnepain did not include *S. siamense* in the species key because at that time only the type specimen was available and little was known about this species. Gagnepain (1920) and Merrill & Perry (1938) reported var. *sylvatica* in Hongkong and Guangdong respectively. Merrill & Perry (1938) concurred with Gagnepain (1920) in differentiating var. *sylvatica* from var.

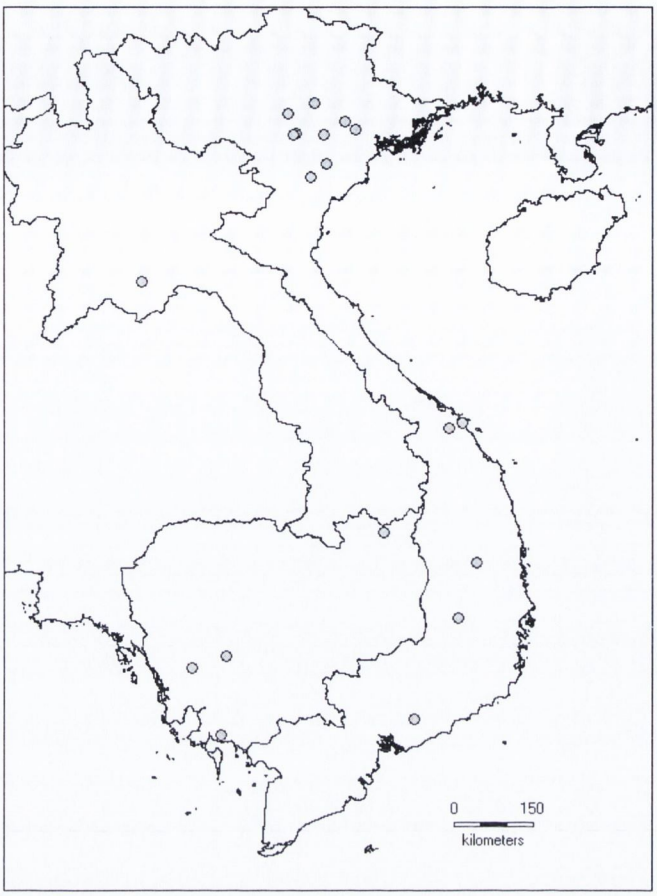
jambos by its slightly cordate or rounded leaf base: I was not able to verify this because I have not examined the original material from Hongkong and Guangdong.

SPECIMENS EXAMINED.

CAMBODIA. Kampong Speu: Samroang Tong, Phnum Chreav [Mt. Chereev], April 1870, *Pierre 994* (**BM**, **K**, **P**) – Kampong Spoe: Phnum Aural, 16 February 2001, *P.Boyce K.Enghourt, M.Sophal & S.Kosal MoE Herb. Cat. 507* (**K**); Phnum Aural, 3 March 2001, *K.Enghourt, M.Sophal & S.Kosal MoE Herb. Cat. 595* (**K**) – Kampot: Mt. Bokor, Popok Vil waterfall, 7 December 1968, *M.A.Martin 1212* (**P**) – Koh Kong: , Mt. Trok, 4 March 1966, *M.A.Martin 293* (**P**); Phn Rodam?, 23 February 1966, *M.A.Martin 350* (**P**) – Ratanikiri: , Virachey National Park, Ho Chi Minh trail, 17 December 2005, *P.Thomas, K.Teah, K., K.Sokhon, S.Teng, S.Sokhon & Y.Bounsoeung 91* (**E**).

LAOS. Mekong river, September 1878, *Pierre Harmand 1923* (**P**) – Viangchan: Nam Ngum reservoir, 23 October 1974, *Vidal 6022* (**P**).

VIETNAM. Bac Giang: March 1925, *Petelot 1832* (**P**) – Cochinchina: July 1870, *Pierre s.n.* (**P**) – Da Nang: Ba Na National Park, 5 July 2002, *Phuong 11916* (**HN**); Tourane and vicinity, 13 June 1927, *J. & M.S. Clemens 3509* (**P**) – Dac Lac: Chu Bloe, *Schmid 996* (**P**) – Dac Lak: Buon Ko Tam, 12 March 1956, *Schmid s.n.* (**P**) – Dong Nai: Bien Hoa, Mt. Chua Chan, 10 January 1914, *Chevalier 29923* (**P**) – Ha Nam: Lat Son, August 1887, *Bon 3489* (**P**) – Ha Tay: , Mt. Ba Vi, 11 September 1886, *Balansa 2863* (**P**); Mt. Ba Vi, October 1886, *Balansa 2864* (**P**) – Hai Duong: Chi Linh, Hoang Hoa Tham, 6 November 1996, *T.N.Ninh & Bastien, D. VN 189* (**HN**) – Hanoi City: , Ninh Thai?, 15 May 1889, *Bon 4191* (**P**); Ninh Thai?, 14 December 1886, *Bon 3312* (**P**); Khanh Thuong, 26 March 1881, *Bon 359* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 8 January 2000, *P.K.Loc PKL 10369* (**CPNP**) – Phu Tho: Trung Giap forest reserve, 4 June 1918, *Chevalier Fleury, F. 37551* (**P**) – Thai Nguyen: Luk Xa, March 1933, *Petelot s.n.* (**P**).



Map 43. Distribution of *Syzygium siamense* (Craib) Chantaranothai & J.Parn. in Cambodia, Laos and Vietnam.

48. *Syzygium sterrophyllum* Merr. & L.M.Perry, J. Arnold Arbor. 19: 103, 232 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 57, fig. 3758 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 908 (2003); J. Chen & Craven, Fl. China 13: 343 (2007). **Type**: China, Kwangtung, Shi-wan-da-shan, July 1933, *Tso 23377* (holotype **A** n.v. [barcode 71321]). Paratypes: *Balansa 1159* (**P**!) and *Simond s.n.* (**P**!).

– [*Eugenia fluviatilis* auct. non Hemsl.: Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 810 (1920).]

Shrub to 3 m tall, to 4 cm diameter. Glabrous on all parts. **Twig** angular (4-angled) and slightly winged, older twig terete, 1.5 – 2 mm diameter, stout, smooth on young twig, older cracked and flaky on old twig, brownish, not contrasting to leaf colour. **Leaves** opposite, 5.5 – 8 × 0.8 – 1.6 cm, 5 to 8 times as long as wide,

lanceolate, base attenuate, margin, entire, recurved below, apex acute and blunt or rounded with no distinct acumen, blade coriaceous, dark greenish; midrib sunken above, raised below; secondary veins (Type A.I) 20 – 25 per side per blade, 1 – 2 mm apart, 30 – 35 degrees ascending from midrib, slender, faint and raised to flattish above, faint below; tertiaries faint, reticulate; inner intramarginal veins c. 0.5 mm from leaf margin, straight, outer intramarginal veins faint; petiole 0.2 – 0.7 cm long, 1/10 – 1/16 of blade length, to 1 mm diameter, slender, not contrasting to blade colour. **Inflorescence** terminal and axillary on leafy twig, 1 – 3 cm long, paniculate, first order branching, flowers few, 7 – 17; axes 0.5 – 2.5 cm, angular; bract and bracteoles persistent, triangular, bract 1 × 0.5 mm, bracteoles 0.5 × 0.2 mm. **Flower** whitish, small, sessile or pedicellate, pedicel 1 – 3 mm, hypanthium not glaucous, not fibrous, 3.0 – 4.5 × 2.0 mm, obconic, pseudostalk indistinct, subsessile, to c. 1 mm; sepals 4, free, 0.2 – 0.5 × 2.0 mm, triangular, undulate on rim; petals coherent, 2.0 – 2.5 × 2.0 – 2.5 mm, orbicular; outer stamens 4.5 – 5.0 mm, anthers 0.4 mm, sacs parallel, connective gland conspicuous; style 5.0 – 8.0 mm, ovules 7 – 10 per locule, irregularly arranged, radiating. **Fruit** obloid, 0.4 – 0.5 × 0.35 – 0.4 cm, surface smooth, blackish, calyx ring with smooth rim; seed 1, obloid, 0.35 – 0.45 × 0.25 – 0.3 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: China (Guangxi, Hainan and Yunnan), Laos, Vietnam and Cambodia.

ECOLOGY OR HABITAT. A rheophytic shrub growing in streambeds on rocky terrain.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: May, June, July, September. Fruiting: October.

VERNACULAR NAME(S). Tram la cung (Vietnam).

NOTES.

1. Initially Gagnepain (1920) had referred the Indochinese species to *E. fluviatilis* but later Merrill (1938), in addition to Chinese specimens, identified them as a new species, *Syzygium sterrophyllum*. Merrill (1938) differentiated *S. sterrophyllum* from *S. fluviatile* by its tetragonous twig, obtusely acuminate and

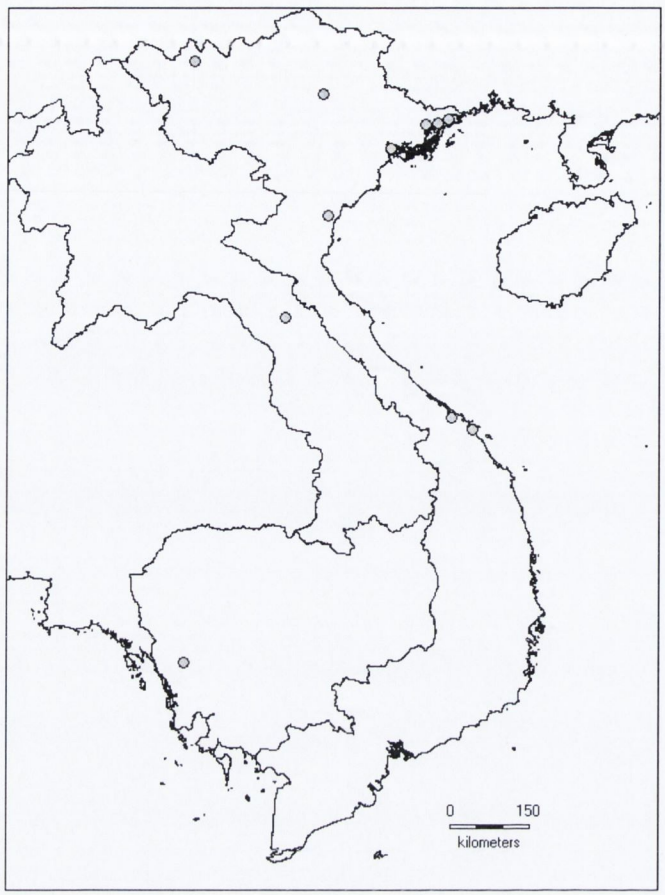
dark greenish leaf and sessile or subsessile flowers. *S. fluviatile* is confine to Hainan and it is characterized in having terete twigs, leaves yellowish brown and linear-oblong with a rounded tip and pedicellate flower. Both of these species are rheophytic shrubs. In their recent treatment of Myrtaceae in the *Flora of China*, Chen & Craven (2007) found that the distribution of *S. fluviatile* and *S. sterrophyllum* overlap in Guangxi and Hainan.

SPECIMENS EXAMINED:

CAMBODIA. Pursat: Veal Veng, 20 May 1999, *Bansok 92* (**BKF**, K)

LAOS. Khammouan: Nakai plateau, Nam Theun river, 8 January 1998, *T.C.Whitmore 3717* (**E**).

VIETNAM. 7 March 1980, *Thai & Thuan 488* (**HN**) – Da Nang: Tourane and vicinity, May 1927, *J. & M.S. Clemens 3254* (**K**); Tourane and vicinity, May-July 1927, *J. & M.S. Clemens 3254* (**K**) – Quang Ninh: Dam Ha, Sai Vong Mo Leng, 18 May 1940, *W.T.Tsang 30139* (**A**, **E**, **K**, **P**); Dam Ha, Sai Vong Mo Leng, 18 September 1940, *W.T.Tsang 30189* (**E**, **K**, **P**); Ha Coi, Tsai Wong Mo Shan and vicinity, October 1936, *W.T.Tsang 27099* (**E**, **K**, **P**); Quang Yen, 12 September 1885, *Balansa 1149* (**K**, **P**); Tien Yen, Ho Yung Shan and vicinity, October 1940, *W.T.Tsang 29930* (**P**); Van Yen, 19 October 1891, *Balansa 4488* (**K**) – Thanh Hoa: Mieu Thon, 15 December 1977, *Pham Van Dung 19 A* (**VFU**) – Thua Thien-Hue: Phu Loc, 1 September 1980, *Nhan N.T. 868* (**HN**); Phu Loc, 17 August 1979, *Tran Loi Sanh 89* (**HN**) – Tonkin: Long Tcheou, *Simond s.n.* (**P**).



Map 44. Distribution of *Syzygium sterrophyllum* Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

49. *Syzygium syzygioides* (Miq.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 109 (1938), in Mem. Amer. Acad. Arts 18: 171 (1939); Backer & Bakh.f., Fl. Java 1: 341 (1963); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 58, fig. 3760 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 111 (1994); I.M.Turner, Gard. Bull. Singapore 47: 383 (1995); P.Chantaranothai & J.Parn., Fl. Thailand 7: 901 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 908 (2003); Newman; et al., Checkl. Vas. Pl. Lao PDR: 245 (2007) – *Calyptranthus caryophyllifolia* sensu Blume, Bijdr. 1089 (1826), non Willd. (1796: 976) – *Jambosa syzygioides* Miq. Fl. Ind. Bat. 1(1): 431 (1855), nom. nov.; N.P. Balakr., Fl. Jowai 1: 200 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 402 (1985) – *Eugenia syzygioides* (Miq.) M.R.Henderson, Gard. Bull. Sing. 12: 154, figs. 30b &c (1949); Kochummen in Ng, Tree Fl. Mal. 3: 219 (1978). **Type**:

Java, *Anon. s.n.*, (lectotype **L**! [HLB 908.151-622, annotated by Blume as '*Syzygium caryopyillifolium*' and by Miquel as *Jambosa syzygioides*'] here designated; isolectotype **L**! [HLB898.203 – 378, annotated by Blume *as* '*Calyptranthes caryophyllifolia*']). (see note 1)

– *Syzygium nelitricarpium* Teijsm. & Binnend. Nat. Tijdscr. Ned. Ind. 27: 53 (1863). **Type**: n.v. (fide Koord. & Valeton, Med. 40: 126 (1900))

– *Eugenia pseudosyzygioides* M.R.Henderson, Gard. Bull. Singapore 11: 315, fig. 9 (1947), in Gard. Bull. Sing. 12: 260 (1949). **Type**: Malaysia, Trengganu, Bukit Kajang, *SFN 30451 (Corner)* (holotype **SING** n.v.; isotype **K**!, **L**!)

– [*Syzygium caudatum* Wallich, *Wallich Numer. List 3591* (1831) (**K-W**!, **L**!, **P**!), nom. nud.]

– [*Syzygium vimineum* Wall ex P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 61, fig. 3768 (1992) – *Eugenia viminea* Wallich, *Wallich Numer. List 3593B* (1831) (**K-W**!, **L**!), nom. nud.]

– [*Eugenia cymosa* auct non Lam (1789): Wight, Ill. 2: 17 (1841), Ic. 2: t. 555 (1843), Kurz, J. Asiat. Soc. Bengal 46: 67 (1877); Kurz, Forest Fl. Burma 1: 486 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 482 (1879); Koord. & Valeton, Med. 40: 126 (1900); King, J. Asiat. Soc. Bengal 70: 100 (1901); King, in Mater. Fl. Malay Penins. 12:: 530 (1901); Brandis, Ind. Trees: 321 (1906); Merr., J . Straits Branch Roy. Asiat. Soc. 77: 225 (1917); Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 823 (1920); Merr., En. Born.: 427 (1921); Ridl., Fl. Malay. Penins. 1: 737 (1922); Craib, Fl. Siam. Enum. 1: 637 (1931); Corner, Wayside Trees Mal. 1: 496, plate 147, fig. (1940). (fide type of *Eugenia cymosa* Lam: *Commerson s.n.* in *Herb. Lamarck*, **P-LA**! [barcode P00412456]).]

Tree to 20 m tall. Glabrous on all parts. **Twig** terete, 1.5 – 2 mm diameter, slender, surface smooth, whitish to brownish, contrasting or not to leaf colour. **Leaves** opposite, 5 – 7 × 2 – 3.5 cm, 2 to 3 times as long as wide, elliptic to ovate, base cuneate, c. 45 degrees ascending from midrib, margin flat, apex acuminate, with distinct acumen, 0.5 – 1 cm, 1/6 – 1/14 of blade length, blade subcoriaceous to chartaceous, greenish brown; midrib sunken above, raised below; secondary veins (Type A.I) fine and slender, 25 – 45 per side per blade, narrowly spaced, 1 – 2 mm apart, c. 60 degrees from midrib, faint above, prominent below; tertiaries faint, reticulate; inner intramarginal 0.5 – 1 mm from leaf margin, straight, outer

intramarginal veins absent or faint; petiole 0.3 – 0.5 cm, 1/10 – 1/14 of blade length, 1.5 – 2 mm diameter, stout, brownish. **Inflorescence** terminal or axillary near apex of leafy twig, to 4 cm long, paniculate, to second degrees branching, spreading, flowers many, to 32; axes slender, to c. 4 cm long, angular; bract and bracteoles persistent and triangular, bract 0.5 × 0.5 mm, bracteoles 0.5 ×0.3 mm. **Flower** sessile, hypanthium not glaucous, not fibrous, 3 × 2 mm, obconic, pseudostalk distinct, c. 1 mm; sepals 4, free, triangular, 0.8 – 1 × 1 – 1.5 mm; petals 4, free, orbicular, 2 – 3 × 2 – 3 mm; outer stamens 3.5 – 4 mm, anthers, c. 0.5 mm, sacs parallel, connective gland conspicuous; style c. 5 mm, ovules 10 – 14 per locule, irregularly radiating. **Fruit** globose to depressed globose, 7 × 7 – 8 cm, surface smooth, calyx ring with smooth to undulating rim; seed 1, depressed globose, c. 0.4 × 0.6 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Widespread from India to Java. In Indochina the species occurs in Cambodia and Vietnam.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: April, May, June. Fruiting: February.

VERNACULAR NAME(S). Pring Khmum (Cambodia: Kandal), Tram kien kien (Vietnam: Ken Giang).

USES. Wood is used for house building (Lemmens et al., 1995).

NOTES.

1. Blume (1826) misidentified specimens from Java (see types of *Syzygium syzygioides*) as *Calyptranthes caryophyllifolia* Willd. These specimens were later renamed as a new species by Miquel as *Jambosa syzygioides* Miq.

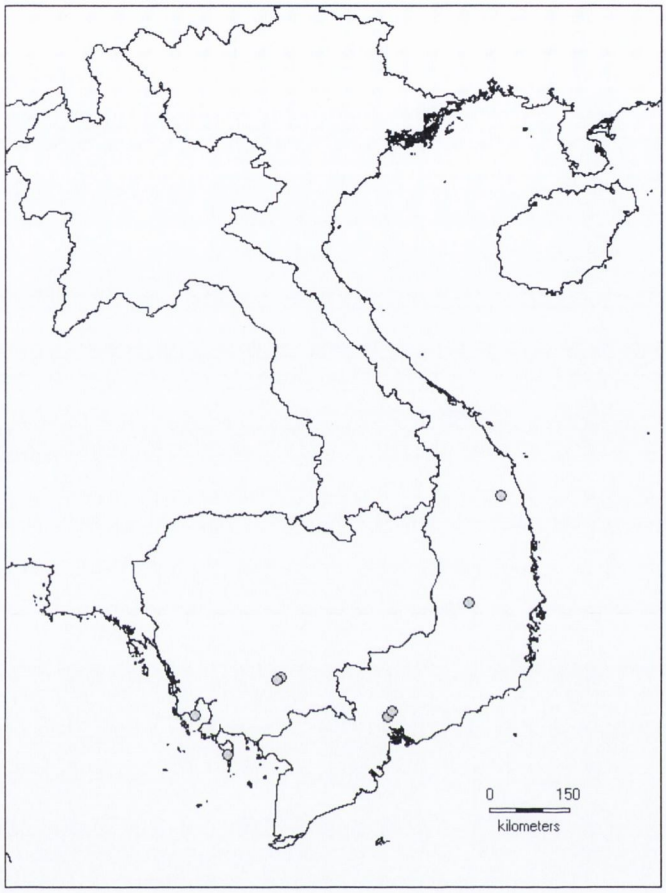
SPECIMENS EXAMINED.

CAMBODIA. Kandal: Phnom Penh, *Pierre s.n.* (**BM**, **K**); Phnom Penh, 5 April 1933, *Bejaud 561* (**P**) – Koh Kong: Che Ko, 15 February 1965, *T.Kira, K.Hozumi, K.Yoda & S.Kokawa 874* (**BKF**).

LAOS. Louang Phabang, *de Rouw 316* (CMU n.v.) (fide Newman et al, 2007b)

VIETNAM. Ba Ria-Vung Tau: Ba Ria, April 1866, *Pierre s.n.* (**P**) – Cochinchina: *Pierre s.n.* (**BM**, **K**) – Dac Lak: *Schmid VN 998* (**P**) – Dong Nai:

Bien Hoa, May 1866, *Pierre s.n.* (**P**); Bien Hoa, June 1909, *d'Alleizette s.n.* (**L**) – Ho Chi Minh City: Thu Duc, April 1867, *Pierre s.n.* (**P**) – Ken Giang: Phu Quoc Is., 15 January 1874, , *Pierre s.n.* (**P**).



Map 45. Distribution of *Syzygium syzygioides* (Miq.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

50. *Syzygium tetragonum* (Wight) Wall. ex Walp., Repert. Bot. Syst. 2: 179 (1843); D.G. Long & Rae in Grierson & D.G. Long, Fl. Bhutan 2: 285 (1911); A.M.Cowan & Cowan, Tree N. Bengal: 67 (1929); Merr. & L.M.Perry, J. Arnold Arbor. 19: 229 (1938); N.P. Balakr., Fl. Jowai 1: 199 (1981); Harid. & R.R.Rao, Forest Fl. Meghalaya: 402 (1985); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 112 (1994); P.Chantaranothai & J.Parn., Fl. Thailand 7: 903, fig. 28 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); D.D.Soejarto et. al. Seed Pl. Cuc Phuong NP Checkl.: 429 (2004) [as *S. cinereum*]; J. Chen & Craven, Fl. China 13: 349 (2007)

– *Eugenia tetragona* Wight, Ill. Ind. Bot. 2: 16 (1841); Kurz, J. Asiat. Soc. Bengal 46: 66 (1877); Kurz, Forest Fl. Burma 1: 484 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 497 (1879). **Type**: Bangladesh, Silhet, F. de Silva *s.n.* in *Wallich Numer. List 3550* (1831) (holotype **K-W**!; isotypes **E**!, **BM**!, **P**!). (Fide Noltie (2005: 362))

– *Eugenia subviridis* Craib, Bull. Misc. Inform. Kew 1929: 117 (1929). **Type**: Thailand, Chiengmai, Doi Sutep, *Kerr 3503* (lectotype **ABD** n.v., designated by P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 113 (1994); isolectotypes **BM**!, **K**!).

– *Syzygium nienkui* Merr. & L.M.Perry, J. Arnold Arbor. 19: 228 (1938). **Type**: China, Dai Land, Dung Ka, 23 Sept 1932, *Chun & Tso 43905* (holotype **A** n.v. [barcode 71314]; isotype **NY**! [barcode 405592]).

– [*Syzygium ficifolium* Wallich, Wallich Numer. List 3558 (1831) (**K-W**!), nom. nud.]

– [*Syzygium rameum* Wallich, Wallich Numer. List 3595 (1831) (**K-W**!), nom. nud.]

Tree 6 – 8 m tall. Glabrous on all parts. **Twig** angular (4-angled) and winged, older twig terete, 2.5 – 3 mm diameter, stout, surface smooth, brownish, not contrasting to leaf colour. **Leaves** opposite, 11.5 – 16.5(– 2.7) × 4.5 – 7 cm, 2.5 to 3 times as long as wide, obovate to elliptic, base strongly attenuate, 30 – 35 degrees ascending from midrib, margin flat, apex usually acuminate, sometimes mucronate, obtuse or rounded, acumen if present, 0.5 – 1 cm, 1/23 – 1/30 of blade length, blade chartaceous to subcoriaceous, greenish; midrib sunken above, raised below; secondary veins (A.II or A.III), stout, 10 – 15 per side per blade, 5 – 15 mm apart, 45 – 60 degrees ascending from midrib, prominent to faint, sunken above, prominent below; tertiaries prominent to faint, reticulate; inner intramarginal 1 – 2 mm from leaf margin, straight to slightly looped, outer intramarginal veins prominent; petiole 1.5 – 2 cm, 1/12 – 1/16 of blade length, 1.5 – 2 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** lateral-axillary on leafy twig or axil of fallen leaves, rarely terminal or axillary on leafy twig, 3.5 – 4.5 cm long, paniculate, first to second degrees branching, flowers many, to 37; axes stout, 3 – 4 cm long, angular; bract and bracteoles caducous, triangular, bract 1.5 × 1.5 mm, bracteoles 1 × 0.5 mm.

Flower sessile, hypanthium not glaucous, not fibrous, 2.5 – 4 × 2 – 3 mm, pyriform to obconic, pseudostalk distinct, c. 1 mm; sepals 4, free, triangular, c. 05 × 1.5 mm; petals 4, coherent, orbicular, 1.5 × 1.5 mm; outer stamens 3.5 – 4 mm, anthers, c. 0.4 mm, sacs parallel, connective gland inconspicuous; style c. 1.5 mm, ovules c. 10 per locule, irregularly radiating. **Fruit** (immature) globose, 0.1 – 1 × 0.5 – 1 cm, surface smooth, calyx ring with smooth to undulating rim; seed 1, globose, c. 0.3 × 0.5 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Bhutan, Nepal, India, Bangladesh, Myanmar, Thailand, Vietnam and South China. In Indochina, documented in Vietnam only but may be present in Cambodia and Laos.

ECOLOGY OR HABITAT. In primary or secondary forest, along river to 1450 m.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: January, March, May, November. Fruiting: February.

VERNACULAR NAME(S). Not documented.

USES. Not documented.

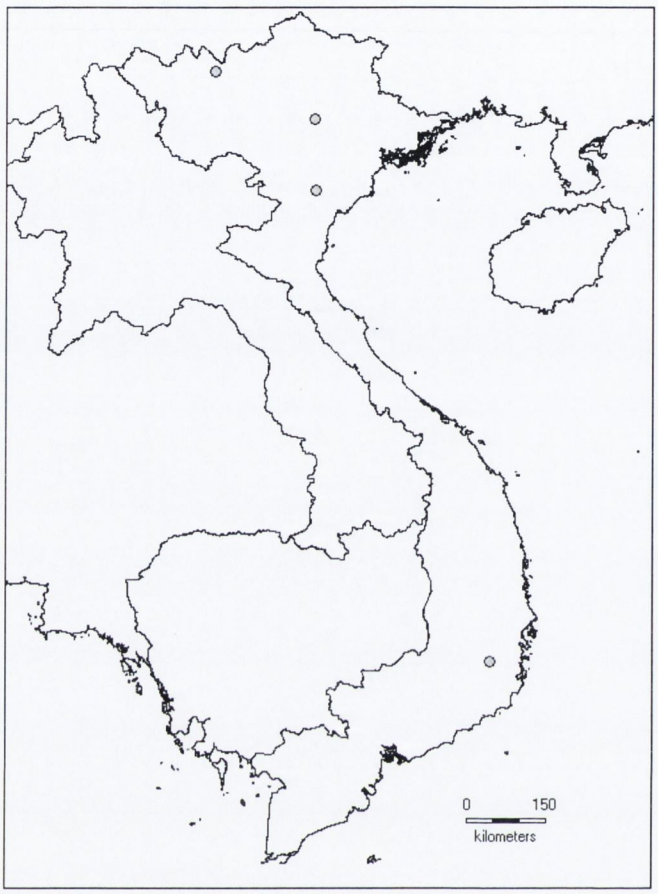
NOTES.

1. Although this is a widespread species, it was not collected in Indochina until 1938 and based on its distribution may be present in Cambodia and Laos. This species is distinctive in having winged and quandrangular twigs, attenuate leaf bases and inflorescences which are often axillary on the axils of fallen leaves.

SPECIMENS EXAMINED.

VIETNAM. Lam Dong: Da Chay, 19 March 1997, *Averyanov; N.Q.Binh; P.K.Loc VH 2934* (**P**); Lao Cai: Chapa, 23 January 1964, *Schmid 4* (**P**) – Ninh Binh: Nho Quan, Cuc Phuong National Park, 1 September 2003, *N.M.Cuong M.V.Xinh & N.H.Quang MC 78* (**CPNP**); 22 May 2000, *D.D.Soejarto N.M.Cuong 11589* (**CPNP**); 18 November 1999, *D.D.Soejarto, N.M.Cuong, N.Q.Binh, N.T.Hiep & M.V.Xinh 11035* (**CPNP**); 22 May 2000, *D.D.Soejarto & N.M.Cuong 11579* (**CPNP**); 22 May 2000, *D.D.Soejarto & N.M.Cuong 11541* (**CPNP**); 23 October 2000, *N.M.Cuong, M.V.Xinh & D.T.Kien NMC 1121*

(**CPNP**) – Vinh Phuc: Mt. Tam Dao, 3 March 1938, *Petelot 6303* (A); Mt. Tam Dao, 20 February 1940, *Petelot 5303* (**P**).



Map 46. Distribution of *Syzygium tetragonum* (Wight) Wall. ex Walp. in Cambodia, Laos and Vietnam.

51. *Syzygium thorelii* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 107 (1938); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 114 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 905 (2002) – *Eugenia thorelii* Gagnep., Notul. Syst. 3: 333 (1917); Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 816, (1920); Craib, Fl. Siam. Enum. 1: 664 (1931). **Type**: Laos [Thailand], Kemmarat, fl., *Thorel 3010* (lectotype **P**! barcode P00589178] here designated; isolectotype **P**!, *Thorel s.n.* [3010] [barcode P00589178], **K**! [barcode K000276196]). Remaining former syntypes: Laos, between Xieng-Kuong and Pak-lay, fl., *Thorel s.n.* (cited as *Thorel 3010* in protologue) (**P**! [barcode P00589265]); Laos, Vien-Chang, fl., *Thorel 3010* (**P**! [barcode P00589264]).

– *Eugenia cambodiana* Gagnep. Not. Syst. 3: 319. 1917, in Lecomte, Gén. Indo-Chine 2: 810 (1920) – *Syzygium cambodianum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 105 (1938). **Type**: Cambodia, s. loc., fl., 1874, *Jullien s.n.* (lectotype **P**! [barcode P00589294] here designated; isolectotype **P**! [2 sheets, barcodes P00589295 & P00589296], **K**! [barcode K000276185]), **syn. nov.** (see note 1)

Shrub 1 – 2 m tall. Glabrous on all parts. **Twig** terete, 1 – 2 mm diameter, slender, surface smooth, brownish, not contrasting toleaf colour. **Leaves** opposite, subopposite or alternate, (3.5 –)5 – 6(– 9) × (1 –)1.5 – 2.5 cm, 2 to 5 times as long as wide, mostly obovate to oblong – obovate, sometimes lanceolate, base attenuate with unequal base, 20 – 30 degrees from midrib, margin flat, apex rounded, acute or obtuse, acumen absent, blade chartaceous, dark brownish; midrib sunken above, raised below; secondary veins (Type A.I) slender, 7 – 12 per side per blade, narrowly spaced, 2 – 3 mm apart, 20 to 30 degrees ascending from midrib, inconspicuous and raised above, prominent below; tertiaries slender, prominent, reticulate; inner intramarginal veins prominent, distance from margin c. 1 mm, straight, outer intramarginal veins faint; petiole 0.5 – 0.8 cm, 1/7 – 1/10 of blade length, c. 1 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary on apex of leafy twig, 3 – 6 cm long, paniculate, second order branching, flowers many, 39 – 90, the first order branches branched out from the main stalk at almost the same point, umbel-like, the second order branch is relatively short (c. 1 mm) and flowers are clumped closely together at the branch-end forming head, flowers in triplets are arranged very closely, usually there are 7 – 13 flowers at branch-end; axes slender, 2.5 – 5.5 cm long, angular; bract and bracteoles persistent, triangular, bract 1 × 1 mm, bracteoles 0.5 × 0.5 mm. **Flower** sessile, hypanthium not glaucous, not fibrous, 4 – 4.5 × 2.5 – 3 mm, obconic, pseudostalk distinct, 1 – 1.5 mm; sepals 4, free, triangular, c. 0.5 × 1 mm, undulating on hypanthium rim; petals 4, coherent, orbicular, 3 × 3 mm, c. 4 glands per petal; outer stamens 5 mm, anthers c. 0.4 mm, sacs parallel, connective gland conspicuous, large; style c. 4 mm, ovules c. 10 per locule, irregularly radiating. **Fruit** subglobose, 0.6 × 0.5 cm, surface smooth, clayx ring with smooth to undulating rim; seed 1, subglobose, c. 5.6 × 4.6 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: Endemic to Continental Southeast Asia, found in Cambodia, Laos, Thailand and Vietnam.

ECOLOGY OR HABITAT. In forest along rivers on boulders.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Vulnerable (VU B1ab(i, iii).

PHENOLOGY. Flowering: March, Jun, December. Fruiting: April.

VERNACULAR NAME(S). Laos: Kam (Louang Phabang), , Kok kam (Viangchan), Va nam (Louang Phabang).

USES. Fruit edible (Thailand) and used as medicine.

NOTES.

1. Gagnepain (1920) noted that *Syzygium cambodianum* is almost similar to *S. thorelii*, but considered both as different species in that the leaves of *S. cambodianum* are opposite as opposed to alternate, with more pustulations below the leaf surface and the inflorescence head is two times bigger. I consider *S. cambodianum* conspecific with *S. thorelii* in having the same leaf venation type, leaf shape (apex without distinct acumen and base unequal-attenuate) and inflorescence type (glomerulate). The leaf arrangement is variable as alternate and opposite leaves can occur in the same specimens (for example *Vidal 2520* & *Vidal 2786*).

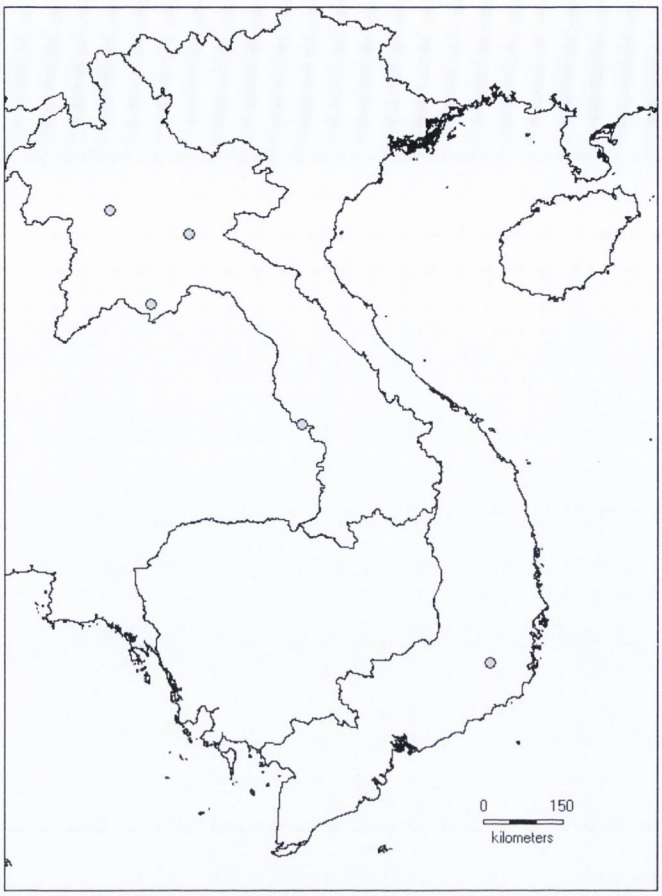
SPECIMENS EXAMINED.

CAMBODIA. s. loc. June 1874, , *Jullien s.n.* (**K**).

LAOS. Louang Phabang: April 1954, *Vidal 2786* (**P**); Ban Song, 29 December 1953, *Vidal 2520* (**P**) – Viangchan: *Thorel 3010* (**P**); 26 December 1952, *Vidal 2101* (**P**) – between Xieng Khouang and Pak Lay: *Thorel s.n.* (**P**).

THAILAND. Kemmarat (Laos): *Thorel 3010* (**K**, **P**).

VIETNAM. Lam Dong: Col de Prenn, 22 March 1957,*Tixier 08* (**P**).



Map 47. Distribution of *Syzygium thorelii* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.



Plate 5.30. Lectotype of *Eugenia cambodiana* Gagnep.

52. *Syzygium thumra* (Roxb.) Merr. & L.M.Perry, J. Arnold Arbor. 20: 103 (1939); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 114 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 905 (2002); W.J.Kress & L.H.Lace, A

Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 242 (2007); J.Chen & Craven, Fl. China 13: 358 (2007) – *Eugenia thumra* Roxb. [Hort. Bengal.: 92 (1814), nom. nud.] Fl. Ind. ed. 1832, 2: 495 (1832); Wight, Icon. Pl. Ind. Orient. 2: t.: 617 (1843); Kurz, J. Asiat. Soc. Bengal 46: 67 (1877); Kurz, Forest Fl. Burma 1: 488 (1877); Duthie in Hook.f., Fl. Brit. Ind. 2: 481 (1878); Brandis, Ind. Trees: 321 (1906); Craib, Fl. Siam. Enum. 1: 664 (1931). **Type**: Ic. Roxb. No. 2507, ined. (lectotype **K**! [downloaded from Royal Botanic Gardens, Kew (2006)] here designated, **C** n.v.)).

– *Eugenia ferruginea* Wight, Icon. Pl. Ind. Orient. 2: t. 554 (1842) non Poir. (1813), nom. illeg. – *Microjambosa ferruginea* Blume, Mus. Bot. 1: 118 (1850). **Type**: Wight, Icon. Pl. Ind. Orient. 2: t. 554 (1842).

– *Eugenia punctifolia* Ridl., J. Fed. Malay States Mus. 10: 91 (1920) – *Eugenia thumra* subsp. *punctifolium* (Ridl.) Chantaranothai & J.Parn., Kew Bull. 48: 610 (1993). **Type**: Thailand, Mamu, *Kloss 6704* (holotype **K**!).

– *Syzygium sphaeranthum* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 113 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 57, fig. 3756 (1992). *Eugenia sphaeranthum* Gagnep. Not. Syst. 3: 333 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 830 (1920). **Type**: Laos, plateau of Attopeu, fl., *Harmand in Herb. Pierre 3192* (lectotype **P**! [barcode P00589180] with Delpy drawing dated Dec. 1899 attached, here designated; isolectotypes **P**! [3 sheets, barcodes P00589181, P00589182 & P00589183], **K**! [barcode K000276191]), **syn. nov.** (see note 1)

– *Eugenia thumra* Roxb. var. *penangiana* King, J. Asiat. Soc. Bengal 70: 92 (1901); M.R.Henderson, Gard. Bull. Sing. 12: 260 (1949) – *Syzygium* thumra (Roxb.) Merr. & L.M.Perry var. *penangianum* (King) I.M. Turner, J. Singapore Natl. Acad. Sci. 22-24: 25 (1996). **Type**: Malaysia, Penang, Waterfall, May 1890, *Curtis 2410* (holotype **K**!; isotype **SING**!). (see note 2)

– [*Syzygium speciosum* Wallich, *Wallich Numer. List 3568* (1831) (**K-W**!), nom. nud.]

– [*Eugenia laosensis* auct. non Gagnep.: Gagnep., Notul. Syst. (Paris) 3: 326 (1918), quoad spec. *Thorel s.n.* (Nong Kay).]

Tree to 20 m tall. Glabrous on all parts. **Twig** terete, c. 3 mm diameter, stout, surface smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 10 – 13.5 ×

3.5 – 4.5 cm, 3 times as long as wide, elliptic to oblong, base strongly attenuate, 30 – 35 degrees from midrib, margin flat, apex acute, with no distinct acumen, blade subcoriaceous, blade dark brownish to blackish; midrib sunken above, raised below; secondary veins (Type A.II) 10 – 15 per side per blade, broadly spaced, 5 – 10 mm apart, 60 – 70 degrees from midrib, prominent and raised on both surfaces; tertiaries faint, reticulate; inner intramarginal veins c. 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole 1 – 1.5 cm, 1/7 – 1/11 of blade length, c. 1.5 mm diameter, slender, dark brownish, not contrasting blade colour. **Inflorescence** terminal or axillary at apex of leafy twig, 5 – 7 cm long, paniculate, third to fourth order branching, spreading, flowers many, c. 300; axes 5 – 7 cm, angular; bract and bracteoles caducous. **Flower** sessile, bud globose, hypanthium not glaucous, not fibrous, 4.5 × 3.5 mm, obconic, pseudostalk distinct, 2.5 – 3 mm; sepals 4, free, unequal, semiorbicular, outer lobes c. 2 × 2.5 mm, inner lobes c. 2 × 3 mm, semiorbicular; petals 4, free, orbicular, c. 2.5 × 3 mm; outer stamens c. 5 mm, anthers c. 0.6 mm, sacs parallel, connective gland conspicuous; style c. 5 mm, ovules 20 – 25 per locule, irregularly radiating. **Fruit** not seen.

DISTRIBUTION: India (Bengalia), Myanmar, Cambodia, Laos, Thailand, Peninsular Malaysia and South China (Hong Kong and Guangdong).

ECOLOGY OR HABITAT. Primary or secondary forest.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Not documented.

VERNACULAR NAME(S). Prin Mret (Cambodia: Ratanakiri).

USES. Timber used for building.

NOTES.

1. Gagnepain (1920) differentiated *Syzygium sphaeranthum* from *S. thumra* by its leaves (without any elaboration in the protologue), the terete twig and the triplet flower arrangement in the inflorescence. In comparison with *Syzygium thumra* from other regions (India, Myanmar, Peninsular Malaysia and Thailand), I do not see any differences between these two species in their leaf venation and inflorescence. *Syzygium thumra* when dried is distinctive in having dark brownish

and shiny leaves that are contrasting in colour to the whitish twig, and has a highly branched panicle (third to fourth order).

2. Two infraspecific groups are formally recognised, var. *penangianum* (King) I.M. Turner in Peninsular Malaysia and subsp. *punctifolium* (Ridl.) Chantaranothai & J.Parn. in Thailand. According to King, in comparison with var. *thumra*, the leaves of var. *penangianum* are narrower with a lower number of secondary veins and the inflorescence is shorter with acutely angular branches. In subsp. *punctifolium*, the upper leaf surface is raised postulate at the apex as opposed to depressed pustulate. I am hesitant to attribute the characters mentioned above as an infraspecific variation because firstly these are rather plastic characters in *Syzygium* and secondly the differences in comparison with *S. thumra* from other localities are minute.

SPECIMENS EXAMINED.

CAMBODIA. Ratanakiri: Ban Long, 11 January 1969, *M.A.Martin 1452* (**P**).

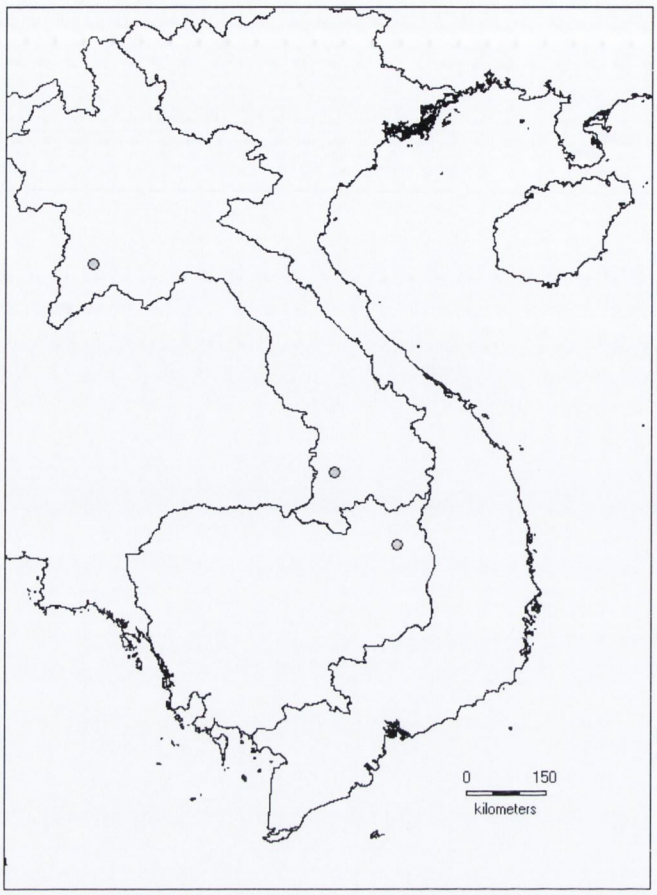
LAOS. Attapeu: Bolaven plateau [Attopeu plateau], *Pierre (Harmand) 3192* (**P**) – Xaignabouli: Nong Kai, 1866-1868, *Thorel s.n.* (**P**).

ADDITIONAL SPECIMENS EXAMINED (not included types).

MYANMAR. Megui, 13 April 1909, *J.H.Lace 4793* (**E**); Moulmien, *H.Falconer 939* (**E**).

INDIA. Bengalia, Calcuttam, 1836-1838, *J.W.Helfer 60* (**E**, L).

THAILAND. Chiang Mai, 20 Aprilf 1989, *J.F.Maxwell 89-475* (**BKF**, **L**); Muang Loi, March 1924, *Kerr 8784* (**BKF**).



Map 48. Distribution of *Syzygium thumra* (Roxb.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

53. *Syzygium tonkinense* (Gagnep.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 105 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 59, fig. 3764 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 909 (2003) – *Eugenia tonkinense* Gagnep. Not. Syst. 3: 334 (1918), in Lecomte, Gén. Indo-Chine 2: 811 (1920). **Type**: Vietnam, Hanoi, Vo-xa, fl., 1 July 1885, *Bon 2968* (cited as *Bon 298* in the protologue) (lectotype **P**! [barcode P00589175] here designated; isolectotypes **P**! [barcode P00589176]).

– *Syzygium touranense* Merr. & L.M.Perry, J. Arnold Arbor. 19: 111. 1938. **Type**: Vietnam, Annam, Tourane, *J. & M.S. Clemens 4300* (holotype **A** n.v. [barcode 71339]; isotype **K**!, **NY**! [barcode 405598]), **syn. nov.**

Tree to 25 m tall. Glabrous on all parts. **Twig** terete, c. 2 mm diameter, slender, surface smooth to slighly flaky, pale brownish, not contrasting to leaf colour.

Leaves opposite, 5.5 – 11 × 2.5 – 6 cm, 2 to 2.5 times as long as wide, elliptic, slightly obovate, base cuneate, slightly attenuate, margin flat, apex acuminate, with distinct acumen, 0.5 – 1 cm, acumen 1/14 – 1/15 of blade length, blade chartaceous, shiny, dark brownish; midrib sunken above, raised below; secondary veins (Type A.II) slender, 8 – 9 per side per blade, broadly spaced, 5 – 8 mm apart, to 70 degrees ascending from midrib, faint and raised upper surface, faint on lower surface; tertiaries faint, reticulate; inner intramarginal veins 1 – 2 mm from leaf margin, looped, outer intramarginal veins prominent; petiole c. 0.5 cm, 1/11 – 1/15 of blade length, c. 1 mm diameter, slender, dark brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, 3 – 5 cm long, paniculate, second to third order branching, flowers many, to 63 flowers, the last branch order is short, c. 1 mm or less, flowers compacted in heads at branch-ends; axes c. 3 cm, terete and compressed; bract and bracteoles caducous. Flower whitish, globular, sessile, hypanthium not glaucous, not fibrous, c. 3 × 2.5 mm, obconic, pseudostalk distinct, c. 1.5 mm; sepals 4, free, 0.3 – 0.5 × 0.8 mm, triangular , undulate on rim; petal 4, coherent, 1.8 – 2 × 2 mm, orbicular; outer stamens to 5 mm, anthers c. 0.5 mm, connective gland, conspicuous; style c. 3 mm, ovules c. 10 per locule, irregularly radiating. Fruit not seen.

DISTRIBUTION: Endemic to Vietnam.

ECOLOGY OR HABITAT. Primary forest.

CONSERVATION STATUS. IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: May-July. Fruiting: not documented.

VERNACULAR NAME(S). Vietnam: Tram bac, Tram bacbo.

USES. Not documented

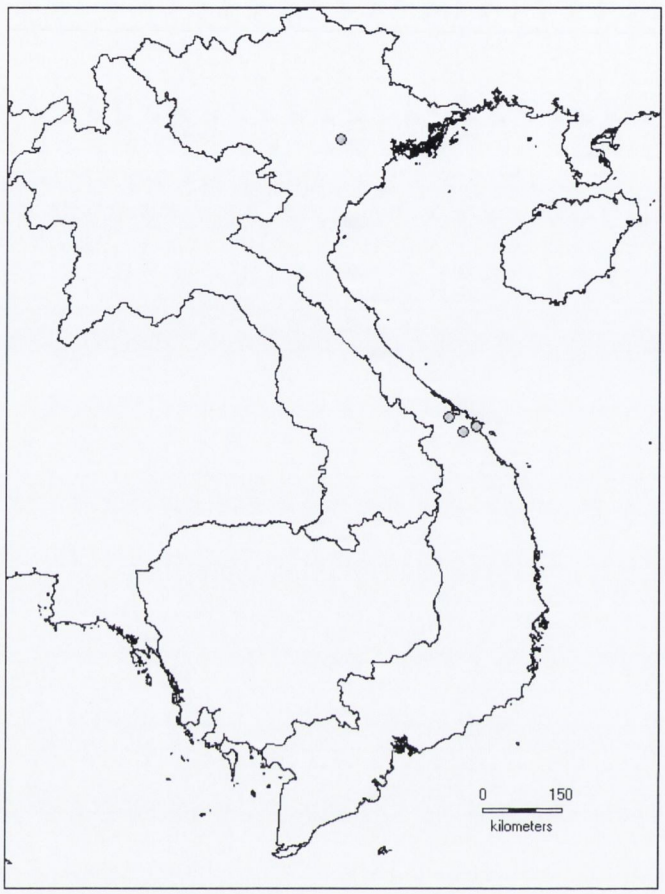
NOTES.

1. *Syzygium tonkinense* is distinctive by its shiny and dark brownish leaves, globular flowers and glomerulate inflorescence.

SPECIMENS EXAMINED.

VIETNAM. Da Nang: Ba Na National Park, 4 July 2002, *Phuong 4844* (**HN**); Tourane and vicinity, May-July 1927, *J. & M.S. Clemens 4300* (**K**) – Hanoi City:

Vo Xa?, 1 July 1885, *Bon 2968* (**P**) – Thua Thien-Hue: Bach Ma National Park, 8 May 2003, *N.T.Hiep, L.Averyanov & N.T.Vinh HLF 1691* (**HN**).



Map 49. Distribution of *Syzygium tonkinense* (Gagnep.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

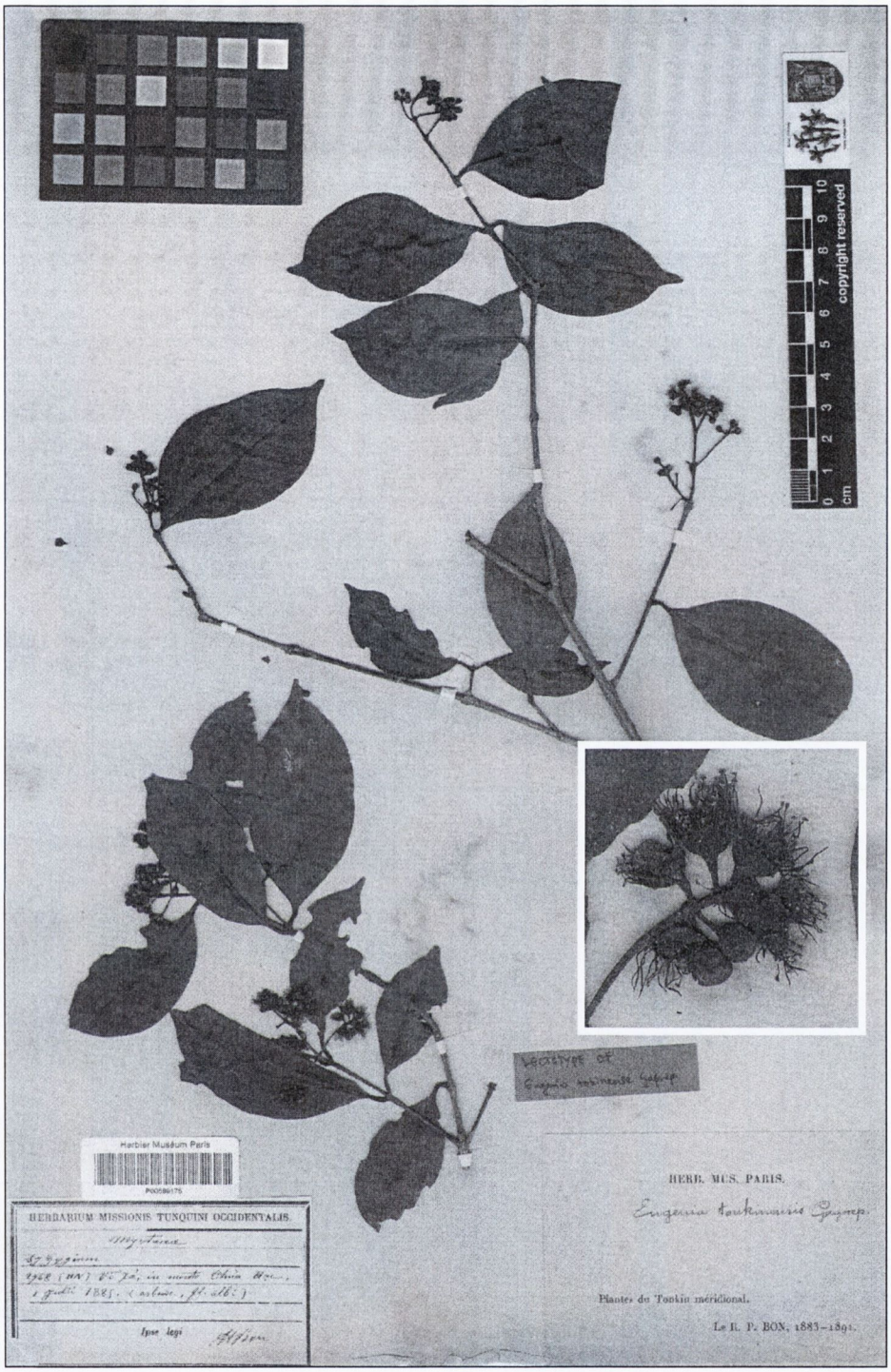


Plate 5.31. Lectotype of *Syzygium tonkinense* (Gagnep.) Merr. & L.M.Perry.

54. *Syzygium tsoongii* (Merr.) Merr. & L.M.Perry, J. Arnold Arbor. 19: 112 (1938); Merr. & L.M.Perry, J. Arnold Arbor. 19: 224 (1938); P.H.Hô, Fl. Ill. Viêtnam (Cây co Viêtnam) 2: 60, fig. 3766 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 909 (2003); J.Chen & Craven, Fl. China 13: 351

(2007) – *Eugenia tsoongii* Merr. Philip. Jour. Sci. 21: 504 (1922). **Type**: China, Kwangtung, Tung Sing, 22nd June 1918, *Tsoong 1867 (C.C.C. 3748)*, (holotype **PNH**†; **A** n.v. [barcode 69413]).

– *Eugenia leucocarpa* Gagnep. Not. Syst. 3: 327 (1918), in Lecomte, Fl. Gén. Indo-Chine 2: 828. 1921, non Merr. (1916). **Type**: Annam [Vietnam], province of Than-hoa, near Cua-bang, *Bon 5578* (lectotype **P**! [barcode P00589197], here designated; isolectotypes **P**! [2 sheets, barcodes P00589198, P00589199]).

Shrub to 1.5 m tall. Glabrous on all parts. **Twig** angular (4-angled) and winged when young, terete when old, 1 – 1.5 mm diameter, slender, surface smooth, whitish to pale brownish, contrasting or not to leaf colour. **Leaves** opposite, 3.5 – 6 × 0.5 – 1 cm, 3.5 to 5 times as long as wide, lanceolate, base acute, c. 45 degrees from midrib, margin flat, apex rounded, obtuse or acute, coriaceous, pale greenish to yellowish brown; midrib sunken above, raised below; secondary veins (Type A.II) slender, 10 – 15 per side per blade, narrowly spaced, 2 – 3 mm apart, 20 to 30 degrees ascending from midrib, faint on both surfaces; tertiaries faint, reticulate; inner intramarginal veins 0.5 – 1 mm from leaf margin, straight, outer intramarginal veins faint; petiole c. 0.2 cm, 1/15 – 1/30 of blade length, c. 1 mm diameter, stout, dark brownish to blackish, contrasting blade colour. **Inflorescence** terminal and axillary near leafy twig apex, 3.5 – 4 cm long, paniculate, first order branching, flowers many, to 33; axes 3 – 3.5 cm, angular, slender; bract and bracteoles caducous. **Flower** whitish (in vivo), sessile, hypanthium c. 7 × 2 mm, corrugated, glaucous, not fibrous, clavate, pseudostalk distinct, c. 2 mm; sepals 4 – 5, free, c. 0.5 × 1 mm, triangular; petals 4 – 5, coherent, 2 × 2 mm, orbicular; outer stamens c. 0.6 cm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style c. 6 mm, ovules c. 10 per locule, in 2 longitudinal rows. **Fruit** (immature) whitish, globose, 0.5 × 0.5 cm, surface smooth, calyx ring with persistent sepal lobes; seed subglobose, 0.4 × 0.4 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: China (Guangxi, Hainan and Hunan) and Vietnam.

ECOLOGY OR HABITAT. Rheophytic shrubs growing on streambeds on boulders and gravels, growing in swift-running water.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: Jun, July, August, November. Fruiting: May, August, October, Novermber, December.

VERNACULAR NAME(S). Vietnam: Tram choi (Quang Binh), Tram qua trang, Tram trait trang.

USES. Not documented.

NOTES.

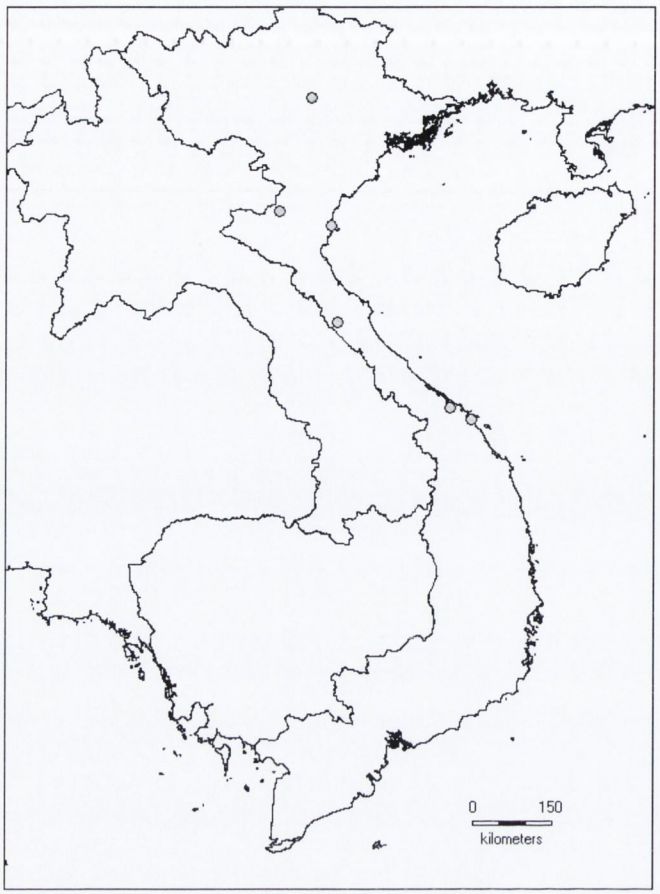
1. This obligate rheophytic species is allied to *S. antisepticum* in the subg. *Sequestratum.*

SPECIMENS EXAMINED.

VIETNAM. Da Nang: Tourane and vicinity, June 1927, *J. & M.S. Clemens 3380* (**BM**, **K**) – Ha Tinh: Huong Son, 8 October 1998, *M.Frank & N.T.Hiep 445* (**HN**) – Nghe An: Que Phong, 21 December 2002, *N.Q.Binh & D.D.Cuong VN 1045* (**HN**) – Quang Binh: Bien Trien village, July 1930, *Petelot 4676* (**P**); 12 May 1964, *L.N.Hiep 5915* (**HN**) – Than-hoa: Cua Bang, 14 August 1892, *Bon 5578* (**P**) – Thua Thien-Hue: Phu Loc, 3 August 1979, *Thai & Thuan 04* (**HN**) – Tonkin: Ouonbi, 2 November 1885, *Balansa 1148* (**P**); Along bay, Biches island, August 1911, *Lecomte & Finet 798* (**P**).

ADDITIONAL SPECIMENS EXAMINED

CHINA: Guangdong: 2 Sept 1981, *G.H.Yip 467* (**BM**) – Hainan: 26 July 1933, *C.Wang 33342* (**P**); Chung Kon, June-July 1935, *J.L.Gressitt 1034* (**E**); Dung Ka to Wen Fa Shi, 1932-1933, *C.L.Tso & N.K.Chun 43688* (**P**); Xian, 5 December 2000, *MO-IBSC 396 & 395* (**BM**).



Map 50. Distribution of *Syzygium tsoongii* (Merr.) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

55. *Syzygium vestitum* Merr. & L.M.Perry, J. Arnold Arbor. 19: 110 (1938); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 60, fig. 3767 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 909 (2003); J.Chen & Craven, Fl. China 13: 343 (2007). **Type**: Annam [Vietnam], Mt. Bana, May-July 1927, *J & M.S. Clemens 3296* (holotype **A** n.v. [barcode 71340]; isotypes **K**!, **NY**! [barcode 405599], **BM**!).

Tree to 10 m tall. Hairy on twigs, leaves, inflorescences and flowers. **Twig** terete, 2 – 3 mm diameter, stout, brownish, not contrasting to leaf colour. **Leaves** opposite, 11 – 20 × 4 – 7 cm, 2.5 to 3 times as long as wide, elliptic, oblong or obovate, base cuneate to slightly rounded, 40 – 50 degrees from midrib, margin flat, apex cuspidate or shortly and abruptly acuminate, acumen 0.5 – 1.5 cm, 1/11 – 1/25 of blade length, blade chartaceous to subcoriaceous, dark brownish; midrib

sunken above, raised below; secondary veins (Type II or III) stout, 10 – 25 per side per blade, broadly spaced, 5 – 15 mm apart, 50 – 60 degrees ascending from midrib, prominent and sunken above, prominent below; tertiaries prominent, subscalariform; outer intramarginal veins 2 – 3 mm from leaf margin, straight, prominent; petiole 0.5 – 1 cm, 1/20 – 1/30 of blade length, c. 2 mm diameter, stout, brownish, not contrasting to blade colour. **Inflorescence** terminal or axillary near apex of leafy twig, to 14 cm long, paniculate, first order branching, flowers many, to 63; axes stout, c. 13 cm long, terete to subangular, surface hairy; bract and bracteoles caducous, ,lanceolate, bract 1 × 0.3 mm, bracteoles 0.5 ×0.2 mm. **Flower** whitish, sessile, hypanthium 4 – 6 × 2 – 4 mm, obconic, hairy, pseudostalk distinct, 2 – 3 mm; sepals 4, free, semiorbicular, 1 × 2.5 mm; petals 4, coherent, orbicular, c. 2.5 × 2.5 mm; outer stamens c. 1.5 mm, anthers c. 0.5 mm, sacs parallel, connective gland conspicuous; style 4 – 5 mm, ovules c. 7 per locule, irregularly radiating. **Fruit** globose to depressed globose, 2 × 1.5 – 2 cm, surface rugose to smooth, calyx ring with smooth rim; seed 1, globose to depressed globose, 1.7 × 1.2 – 1.7 cm, cotyledons free, intercotyledonary intrusion absent.

DISTRIBUTION: South China (Yunnan) and Vietnam.

ECOLOGY OR HABITAT. Primary forest to 1500 m.

CONSERVATION STATUS. IUCN Global Status: Data Deficient (DD); IUCN Regional (Indochina) Status: Data Deficient (DD).

PHENOLOGY. Flowering: July, August. Fruiting: Not documented.

VERNACULAR NAME(S). Tram phu (Vietnam).

USES. Not documented.

NOTES.

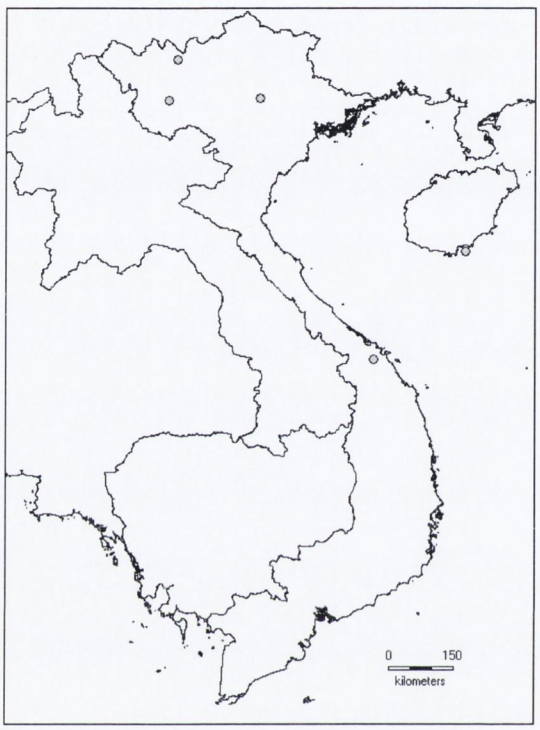
1. In Indochina, *Syzygium vestitum* is the only species with pubescent leaves. The other hairy species is *S. levinei* but its indumentum is confined to the inflorescence.

SPECIMENS EXAMINED.

LAOS. Viangchan: Phou Khaokhoay, 29 October 1971, *Vidal 5696* (**P**).

VIETNAM. s. loc. 25 July 1976 , *Tam* et al. *LX-VN 181* (**HN**) – Lao Cai: Chapa, July 1930, *Petelot 6145* (**A, SING**); Sa Pa, 11 December 1964, *Doan Khao &*

Truong Quoc VN 2870 (**HN**) − Quang Nam-Da Nang: Mt. Ba Na, May 1927, *J. & M.S. Clemens 4453* (**K**); Mt. Ba Na, May-July 1927, *J. & M.S. Clemens 3296* (**A**, **BM**, K, NY) − Son La: Thuan Chau, 16 October 2005, *N.Q.Binh & D.D.Cuong VN 1587* (**HN**) − Vinh Phuc: Mt. Tam Dao, 15 August 1997, *Phengkhlai 10604* (**BKF**); Mt. Tam Dao, 1965, *Doan Diew & Viet Trung VN 4513* (**HN**).



Map 51. Distribution of *Syzygium vestitum* Merr. & L.M.Perry in Cambodia, Laos and Vietnam.



Plate 5.32. Inflorescence of *Syzygium vestitum* Merr. & L.M.Perry. Photo courtesy of Pranom Chantaranothai.

56. *Syzygium zimmermannii* (Warb. ex Craib) Merr. & L.M.Perry, J. Arnold Arbor. 19: 114 (1938); P.H.Hô, Fl. Ill. Viêtnam (Cây co Viêtnam) 2: 62, fig. 3772 (1992); P.Chantaranothai & J.Parn., Thai Forest Bull. (Bot.) 21: 120 (1994), in P.Chantaranothai & J.Parn., Fl. Thailand 7: 909 (2002); W.J.Kress & L.H.Lace, A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar: 315 (2003); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 910 (2003); M.F.Newman et al., Checkl. Vas. Pl. Lao PDR: 246 (2007) – *Eugenia zimmermannii* Warb. ex Craib, Bull. Misc. Inform. Kew 1914: 124 (1914); Gagnep. Not. Syst. 3: 335. 1918, et in Lecomte, Fl. Gén. Indo-Chine 2: 835 (1921). **Type**: Thailand, Bangkok, 1899, *Zimmermann 160* (holotype **K**!; isotypes **L**!, **P**!).

Tree to 20 m. Glabrous on all parts. **Twig** terete, subangular, 2 – 3 mm diameter, stout, smooth, whitish, contrasting to leaf colour. **Leaves** opposite, 8.5 – 12.5 × 2.2 – 3.2 cm, 3 to 4 times as long as wide, elliptic, oblong – elliptic or oblong – obovate, base slightly unequal, attenuate, 20 – 30 degrees from midrib, margin flat, apex mostly acute and obtuse, sometimes rounded, acumen absent, blade

chartaceous, dark greenish; midrib flat above, raised below; secondary viens (B), 6 – 10 per side per blade, broadly spaced, 7 – 10 mm apart, c. 50 degrees from midrib, prominent to inconspicuous and flattish above, prominent below, 1 – 3 pairs of basal secondary veins (acrodromous veins) arcuate, extend from base to half way or near leaf apex (forming outer intramarginal veins); tertiaries prominent, reticulate; inner intramarginal veins extend from well above the leaf base (after basal secondary veins) to leaf apex, looped, c. 2 mm from leaf margin; petiole 0.5 – 1 cm, 1/25 – 1/50 of blade length, 1 – 2 mm diameter, slender, brownish, not contrasting to blade colour. **Inflorescence** terminal and axillary near the apex of leafy twig, to 10 cm long, paniculate, first order branching, flowers 9 to 15; axes stout, to 8 cm long, angular; bract and bracteoles caducous, ovate, bract 1.7 × 1 mm, bracteoles 1.5 × 1 mm. **Flower** pedicellate, pedicel 0.3 – 0.5 cm, hypanthium not glaucous, not fibrous, 6 – 6.5 × 5 – 5.5 mm, pyriform, pseudostalk distinct, 2.5 – 3 mm; sepals 4, free, suborbicular, c. 3.5 × 4 mm; petals 4, free, suborbicular, 5 – 6.5 × 5.5 – 7 mm; outer stamens 10 – 11 mm, anthers c. 0.7 mm, sacs parallel, connective gland conspicuous; style 7 – 8 mm, ovules 16 – 18 per locule, irregularly radiating. **Fruit** not seen.

DISTRIBUTION: Laos, Thailand and Vietnam.

ECOLOGY OR HABITAT. In primary forest along river.

CONSERVATION STATUS. IUCN Global Status: Least Concern (LC); IUCN Regional (Indochina) Status: Least Concern (LC).

PHENOLOGY. Flowering: May-July. Fruiting: not documented.

VERNACULAR NAME(S). Laos: Kai va (Luoang Phabang), Va poum pa (Luoang Phabang).

USES. Flowers are used to treat fever.

NOTES.

1. *Syzygium zimmermannii* is almost similar to *S. pierrei* but differs by its terminal or near terminal inflorescence, shorter pedicel and longer petiole.

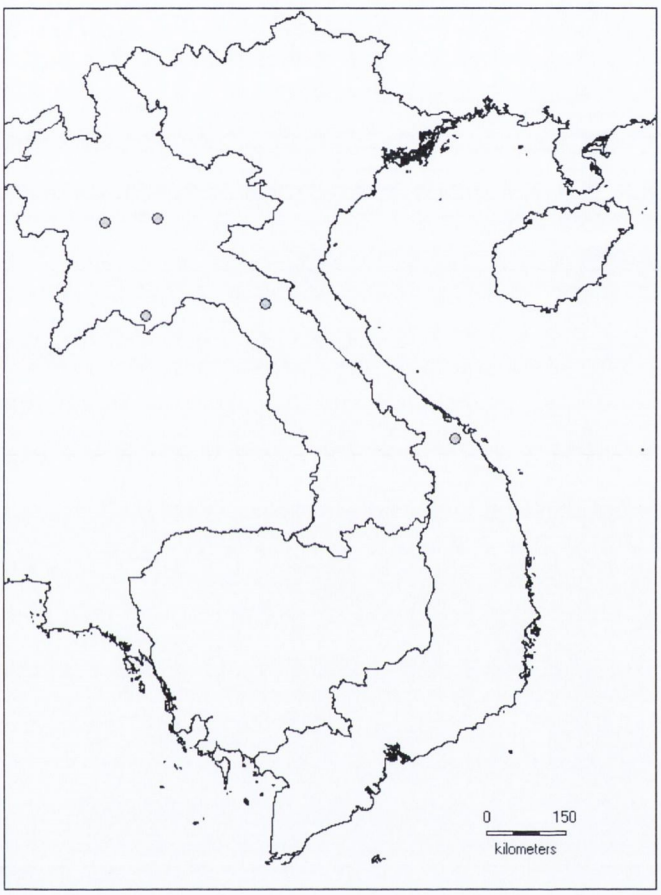
SPECIMENS EXAMINED.

LAOS. Louang Phabang: Ban Song, 29 December 1953, *Vidal 2521* (**P**); Muong You, December 1903, *Spire 419* (**P**); Muong You, *Spire 1519* (**P**) – Viangchan: 1866-1868, *Thorel s.n.* (**P**).

VIETNAM. -Quang Nam - Da Nang: Mt. Bana, , May 1927, , *J. & M.S. Clemens 3110* (**A**, **K**); -Son La: between Van Yen and Van Bu, Black River, March 1927, *Petelot 4037* (**P**).

ADDITIONAL SPECIMENS EXAMINED.

THAILAND. Bangkok, 1899, *Zimmermann 160* (**K**, **L**, **P**) – Chiang Mai, 15 June 1911, *Kerr 1855* (K, **TCD**); Chiang Mai, *Kerr 20018* (K, **TCD**).



Map 52. Distribution of *Syzygium zimmermannii* (Warb. ex Craib) Merr. & L.M.Perry in Cambodia, Laos and Vietnam.

Incompletely known species

Syzygium sp. aff. Syzygium tripinnatum (Blanco) Merr., Philipp. J. Sci. 79: 419 (1951) – *Eugenia javanica var. balansae* Gagnep., in Lecomte, Fl. Gén. Indo-Chine 2: 838 (1920). **Types**: Tonkin [Vietnam], Mt. Bavi, 11 September 1886,

Balansa 2863; Tonkin [Vietnam] (**P**!), forest at the base of Mt. Bavi, October 1886, *Balansa 2864* (**P**!, **K**!).

NOTES. Gagnepain (1920) considered this taxon as a variety of *S. samarangense* (= *E. javanica*). The leaf is different from the typical *S. samarangense* in having a cuneate base, prominent acumen, longer petiole and without arcuating basal secondary veins. The inflorescence is lax and the flowers have a long pedicel. The closest species that I can morphologically associate this taxon with is *S. tripinnatum* (representative specimen: *Merrill Sp. Blanco. 889,* **US**! [viewed image]). This species is found in the Philippines and Taiwan. I have not examined any herbarium specimens of *S. tripinnatum*, therefore I cannot decide the status of this taxon.

Syzygium sp. aff. Syzygium rubicundum Prodr. Fl. Ind. Orient.: 330 (1834); P.H.Hô, Fl. Ill. Viêtnam (Câyco Viêtnam) 2: 57, fig. 3756 (1992); K.D.Nguyen, (Myrtaceae) Checkl. Pl. Spp. Vietnam 2: 908 (2003). **Voucher**: Vietnam, sin. loc., 28 August 1986, *Anon. LX-VN 3467* (**HN**).

NOTES. This taxon is represented by one specimen in a premature flowering state. It is similar to *S. rubicundum* but differs from the *S. rubicundum* type (*Herb. Wight Prop. No. 1072* (**E**!)) in having broader leaves. More specimens are needed to confirm the status of this taxon.

5.7 Overall findings and discussion

This study recognised a total of 56 *Syzygium* species in Indochina, including four commercial species (*S. aqueum*, *S. aromaticum*, *S. malaccense* and *S. samarangense*), within the four subgenera: *Acmena*, *Perikion*, *Sequestratum* and *Syzygium*. Eight species, including *S. crassiflorum*, *S. bokorense*, *S. chantaranothaianum*, *S. cucphuongense*, *S. glomerulatum*, *S. harmandii*, *S. pierrei* and *S. tonkinense*, are confined to Indochina. *Syzygium bokorense*. *S. chantaranothaianum* and S. *cucphuongense* are new to science. Vietnam harbours the most species, 49 in total, followed by 29 species in Laos and 27 species in Cambodia (see table 5.2). Several species that were previously described by Gagnepain (1917) and Merrill & Perry (1939) are no longer recognised here in this revision. Among the 28 species described by Gagnepain (1917), only ten species names are accepted while only four of the eight species described by Merrill & Perry (1939) are accepted. Sixty two lectotypes have been designated in this study. Twenty three species names that were previously accepted were put into synonymy. In relation to Thailand and China, 35 Indochinese species are shared with Thailand and 28 species with China. Of these, 19 species are found in all the three regions. *Syzygium attopeuense* and *S. corticosum* are new records for Thailand.

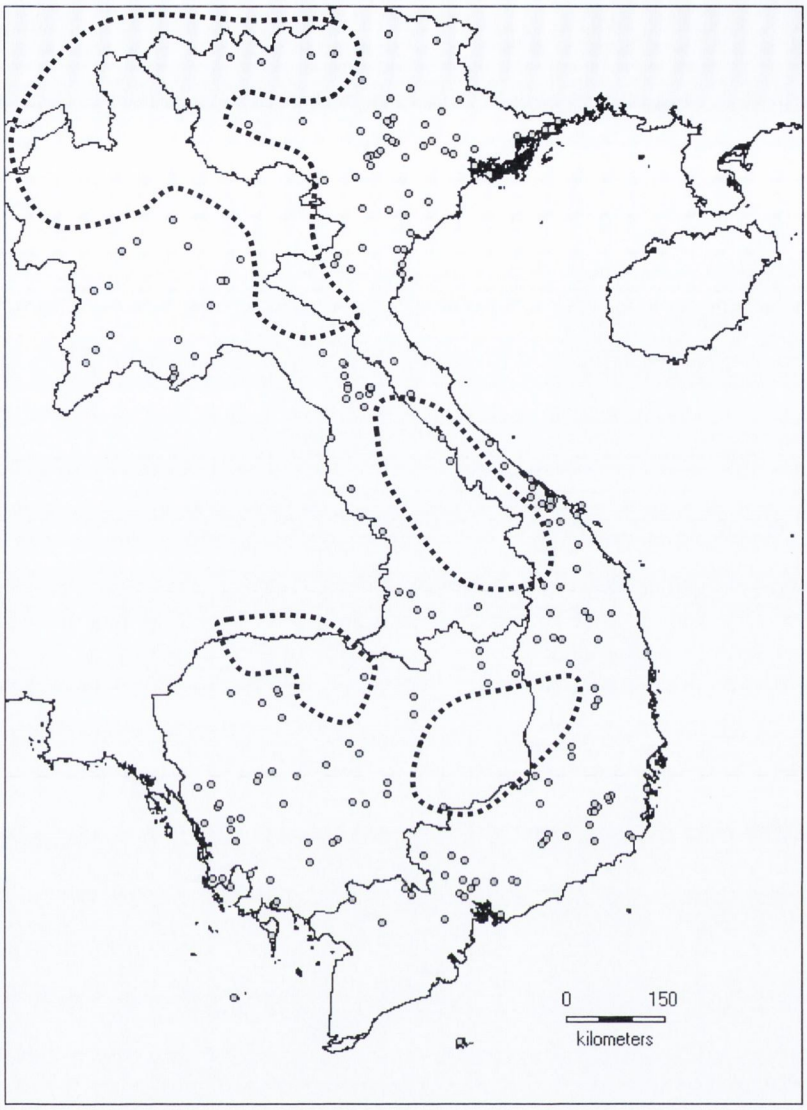
Table 5.2: *Syzygium* species in Cambodia, Laos and Vietnam, excluding commercial species (*S. aqueum*, *S. aromaticum*, *S. malaccense* and *S. samarangense*).

Cambodia	Laos	Vietnam	
S. antisepticum	*S. abortivum*	*S. abortivum*	*S. megacarpum*
S. bokorense	*S. acuminatissimum*	*S. acuminatissimum*	*S. melanophilum*
S. borneense	*S. angkae*	*S. angkae*	*S. nervosum*
S. claviflorum	*S. antisepticum*	*S. antisepticum*	*S. nigrans*
S. cumini	*S. attopeuense*	*S. araiocladum*	*S. oblatum*
S. diospyrifolium	*S. borneense*	*S. attenuatum*	*S. odoratum*
S. formosum	*S. bullockii*	*S. attopeuense*	*S. pachysarcum*
S. glomerulatum	*S. championii*	*S. balsameum*	*S. pierrei*
S. grande	*S. crassiflorum*	*S. boisianum*	*S. polyanthum*
S. hancei	*S. cumini*	*S. borneense*	*S. praecox*
S. harmandii	*S. grande*	*S. bullockii*	*S. ripicola*
S. hemisphericum	*S. hancei*	*S. buxifolium*	*S. siamense*
S. jambos	*S. harmandii*	*S. chantaranothaianum*	*S. sterrophyllum*
S. levinei	*S. hemisphericum*	*S. cucphuongense*	*S. syzygioides*
S. lineatum	*S. jambos*	*S. championii*	*S. tetragonum*
S. megacarpum	*S. lineatum*	*S. claviflorum*	*S. thorelii*
S. nigrans	*S. megacarpum*	*S. corticosum*	*S. tonkinense*
S. oblatum	*S. nigrans*	*S. crassiflorum*	*S. tsoongii*
S. pachysarcum	*S. oblatum*	*S. cumini*	*S. vestitum*
S. polyanthum	*S. pachysarcum*	*S. diospyrifolium*	*S. zimmermannii*

S. ripicola *S. samarangense* *S. siamense* *S. sterrophyllum* *S. syzygioides* *S. thorelii* *S. thumra*	*S. pierrei* *S. ripicola* *S. siamense* *S. syzygioides* *S. sterrophyllum* *S. thorelii* *S. thumra* *S. vestitum* *S. zimmermannii*	*S. fastigiatum* *S. formosum* *S. glomerulatum* *S. grande* *S. hancei* *S. hemisphericum* *S. imitans* *S. jambos* *S. levinei* *S. lineatum*

The conservation status following *IUCN Red List Categories and Criteria* ver. 3.1 (IUCN, 2001) was applied to each species. 23 species were Data Deficient (DD), 28 were Least Concern (LC), three species were Near Threatened (NT), two species were Vulnerable (VU). Although many species are categorised as DD because of insufficient data to assess their status, in my opinion, the majority of them are likely to fall into the threathened categories, either in Critically Endangered, Endangered or Vulnerable. About 60% of herbarium specimens used in this study are more than 50 yrs old (1861-1959) and since then, the land-use, demography and forest cover in Indochina has drastically changed. Therefore the conservation status given is possibly an underestimation.

The Indochinese *Syzygium* are undercollected, this is highlighted by some of the widely distributed species for example *S. balsameum*, *S. nervosum* and *S. tetragonum*, which are found in China, Thailand and Vietnam but have not been collected in Cambodia and Laos. This is not surprising since the number of botanical collections for Indochina in general is very low and it is estimated that there are roughly three collections per $100km^2$ for Laos, four collections per $100km^2$ for Cambodia and 14 collections per $100km^2$ for Vietnam respectively (M.F.Newman et al., 2007). Based on the collection localities of *Syzygium* in Indochina, the botanically poorly collected areas are usually in the highlands along the Annamite range and in the vicinity of the political borders between Cambodia, China, Laos, Thailand and Vietnam (Map 53): in Cambodia, bordering Vietnam (Mondulkiri and Kratie) and Thailand (Oddor Meanchey and Preah Vihear); in Laos, bordering China (Phong Sali, Louang Namtha, Bokeo and Oudomsai) and Vietnam (Louang Prabang, Houa Phan and Xieng Khouang and Bolikhamsai); in Vietnam, bordering China (Lai Chau, Lao Cai, Ha Giang and Cao Bang).



Map 53. Collection localities for all *Syzygium* in Indochina. Grey dots are localities where *Syzygium* had been collected; dotted line demarcate areas with natural vegetation where there are no or very few collections made (the vegetation cover was inferred from *Google Maps*, retrieved on July 2010).

General summary and future work

The history and progress to date of systematic research of Myrtaceae in general and specifically *Syzygium* have been reviewed in Chapter 1. The long standing problems of differentiating *Eugenia* s.s.-*Syzygium* s.l. had affected approaches to floristic treatment of *Syzygium* and have been extensively debated in the past. At present, *Eugenia* has been widely accepted as distinct from *Syzygium*. The current research focus has shifted to the systematics within *Syzygium* and its segregate genera.

A taxonomic treatment of *Syzygium* for Indochina has been presented in Chapter 5. Species descriptions accompanied with typifications, synonyms, ecology, usages, vernacular names, lists of specimens examined, distribution maps, comments and herbarium images have been provided. In total, 56 *Syzygium* species in Indochina were recognised within the subgenus *Acmena*, *Perikion*, *Sequestratum* and *Syzygium*. Seven species (*S. crassiflorum*, *S. bokorense*, *S. chantaranothaianum*, *S. glomerulatum*, *S. harmandii*, *S. pierrei* and *S. tonkinense*) are endemic to Indochina. Three species are new to science (*S. bokorense*, *S. chantaranothaianum* and *S. cucphuongense*). Sixty two lectotypes have been designated here in this study. Twenty three species names that were previously accepted were put into synonymy. Vietnam harbours the largest number of species (49), followed by Laos (30) and Cambodia (27). Thirty-five Indochinese species are shared with Thailand while 28 with China. Of these, 19 species are found in all the three regions. Two species (*S. attopeuense* and *S. corticosum*), formerly described from Indochina, are new records for Thailand.

Following the *IUCN Red List Categories and Criteria* ver. 3.1 (IUCN, 2001), 23 species were Data Deficient (DD), 28 were Least Concern (LC), three species were Near Threatened (NT) and two species were Vulnerable (VU). The assessments given were probably an underestimation because 60% of the herbarium specimens used in this study are more than 50 years old (1861-1959)

and since then the situation in Indochina has changed in term of the land-use, demography and forest cover.

Syzygium in Indochina is undercollected. Based on the collection localities of *Syzygium* in Indochina, the botanically poorly collected areas are usually in the highlands along Annamite chain and forested areas close to the political borders of Cambodia, China, Laos, Thailand and Vietnam.

A comparative study of leaf anatomy in *Syzygium* was carried out to assess its taxonomic value. General generic and subgeneric descriptions of leaf anatomy were elaborated. The differences among the subgeneric groups proposed by Craven and Biffin (2010) were critically assessed. Stomatal types and midrib vascular system were reinterpreted in reference to previous studies. The results showed that the stomatal types, crystal frequency and midrib vascular types were correlated to the subg. *Acmena*, *Perikion*, *Sequestratum* and *Syzygium* (see Table 3.2). However, the leaf anatomical characters of subg. *Perikion* are diverse and overlapped with subg. *Acmena* and *Sequestratum*.

The significance of morphological characters relative to the classification of infrageneric groups based on nucleotide sequence phylogenies was investigated. Leaf anatomical and macromorphological data were used to contruct the phylogeny of *Syzygium*. ETS and ITS sequences of twelve *Syzygium* species from Southeast Asia were generated here for the first time and were incorporated into the established ETS-ITS phylogeny. Later, morphological characters were optimised onto the ETS-ITS cladogram. The results showed some degrees of congruence in the morphological and molecular estimates of the relationship. In the morphological majority-consensus tree, there was agreement on the monophyly of the subg. *Sequestratum* and *Syzygium* whereas subg. *Acmena* and *Perikion* are sisters forming a clade. In the strict consensus tree of the morphological estimates, only subg. *Sequestratum* was supported with DI 2–3. The topologies within the clade of subg. *Syzygium* derived from morphological and molecular estimates are different. Within this clade, characters reflecting size are phylogenetically uninformative whereas possible predictors for subclades may be geography and midrib vascular system. The result of the NMDS ordination is

in accordance with the phylogeny in delimitating three groups: subg. *Syzygium*, subg. *Sequestratrum* and subg. *Perikion-Acmena*. In all analyses, morphological characters that support the subgeneric clades are: stomata, crystals, midrib vascular system, inflorescence type, hypanthium shape, anther locules, placentation and seed intercotyledonary intrusion. Hypotheses of characters polarity in *Syzygium* were made based on parsimony analysis. The species placement in the subgeneric categories were determined from the cladograms and ordination diagram.

Future work

There are three aspects concerning approaches to future research, all of which complement one another: (1) research utilising nucleotide data; (2) research in taxonomic revisions; and (3) comparative study and survey in specific areas in micro- or macromorphology, ontogeny, pollination and breeding. In all future studies, a sufficient and representative sampling size is essential considering the diversity and size of the genus. This is particularly important for subg. *Syzygium* which is estimated to include c. 1,000 species.

To date, studies by Harrington and Gadek (2004) and Biffin et al. (2007) utilizing nuclear DNA (ETS and ITS) and chloroplast DNA (*mat*K, *ndh*F and *rpl*16) respectively, have been the basis for the recently proposed infrageneric classification of *Syzygium* (Craven and Biffin, 2010). In their phylogenies, within the clades of subgenera *Syzygium*, *Sequestratum* and *Perikion*, there was no strong resolution for finer clades. Future research in identifying suitable DNA sequence regions for analysis will be profitable for discovering clades below subgeneric rank. In addition to this, other unplaced taxa including *PseudoEugenia* Scort., *Aphanomyrtus* Miq., *Eugenia* sect. *Fissicalyx* M.R.Hend. and *Strongycalyx* Blume, should be incorporated in future undertakings. This study and the study by Biffin et al. (2006) suggested that in subg. *Syzygium*, geography may be an important predictor for species relatedness. Therefore, a historical biogeographic study may be useful to give better insight in the evolution of *Syzygium*.

Because of the large species number in *Syzygium*, the scope of taxonomic revisions has been confined to narrow geographical boundaries such as countries

or region. This can be problematic, as was shown in the past, when different workers adopted different classification schemes. Merrill and Perry (1937, 1938a) were the first to provide revisions at a monographic scale on what was then accepted as the genera *Acmena* and *Cleistocalyx*. *Acmena* is monophyletic and is now placed under *Syzygium* subg. *Acmena* while *Cleistocalyx* is paraphyletic. Recent studies, included here, showed that the clade of subg. *Sequestratum* is strongly supported by molecular and morphological data and in my opinion is suitable for monographical revision. Taxonomic revisionary work provides the fundamental knowledge on the taxon nomenclature, distribution, morphology, ecology etc., which is needed in other research areas. Therefore, future research should focus on completing the taxonomic revision in regions that so far have not been investigated like Myanmar, Kalimantan, Sulawesi and the Philippines.

In addition to the foregoing suggestions, other specific areas that are worth investigating include:

- Examining potentially promising morphological characters including hypanthium fibre bundles, the position of placenta, the orientation and arrangement of ovules, the development of the testa and intrusive tissues in the seed, midrib vascular type and stomatal type.
- Investigating the implication of breeding systems for taxonomy in term of apomixis, hybridisation and introgression.
- Studying the ecology to determine how it affects the taxonomy in terms of phenotypic variation and speciation.

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Appendices

Appendix 3.1. Samples used in anatomy study in Chapter 3. The format follows species, distribution, collector's name and number and herbarium duplicate. Abbreviation for geographical distribution follows: AUS = Australia; BOR = Borneo; CBD = Cambodia; CHH = Hainan; CHS = China South East; IND = India; JAW = Jawa; LAO = Lao PDR; MAL = Peninsular Malaysia; NWC = New Caledonia; NWG = Papua New Guinea; PHI = Philippines; SUM = Sumatra; THA = Thailand; VIE = Vietnam.

Piliocalyx francisii Guillaumi: NWC – *H.S. McKee 8185* (L). ***Syzygium abortivum*** (Gagnep.) Merr. & L.M.Perry: LAO - *Thorel* s.n. (**P**); THA - *Thorel* s.n. (**P**); VIE - *Squire 106* (**P**), *Vidal 795A* (**P**). ***S. acuminatissimum*** DC.: CHS - Tsang 2714 (**P**); THA - *Beusekom & Phengklai 842* (**BKF**), *Kerr 8749* (**TCD**). ***S. aksornae*** P.Chantaranothai & J.Parn.: MLY - *King 5780* (**TCD**) ;THA - *Kerr 12238* (**TCD**). ***S. angkae*** (Craib) P.Chantaranothai & J.Parn.: THA - *Fenelly 7* (**TCD**), *H.B.G. Garrett 1120* (**TCD**); VIE - *Martin M.A. 936* (**P**), *Vidal 794A* (**P**). ***S. antisepticum*** (Wight) S.N. Mitra: CBD - *Martin 164* (**P**), *Smitinand & Abbe 6489* (**BKF**); MLY - *King 5433* (**TCD**); PHI - *Hutchinson 7548* (**L**); THA - *Fenelly 16 (TCD)*, *Kerr 9799* (**TCD**), *Kerr 9799* (**TCD**). ***S. apodophyllum*** (F.Muell.) B.Hyland: AUS - *Hyland 9176* (**L**), *Irvine 821* (**L**). ***S. araiocladum*** Merr. & L.M.Perry: VIE - *Tsang 29081*, *Tsang 30349* (**P**). ***S. attenuatum*** (Miq.) Merr. & L.M.Perry: THA - *Kerr 11785* (**TCD**), *Phusomsaeng 245* (**BKF**), *Ploenchit 291* (**BKF**). ***S. attopeuense*** (Gagnep.) Merr. & L.M.Perry: LAO - *Tixier 2235708* (**P**); THA - *Phengnaren* et al. *95* (**BKF**); VIE - *Rejamanek* s.n. (**P**); *Schmid* s.n. (**P**). ***S. balsameum*** Wall. ex A.M. & J.M.Cowan: THA - *Beusekom & Phengklai 2580* (**BKF**), *Kerr 920* (**TCD**); VIE - *Balansa 2878* (**P**). ***S. bankense*** (Hassk.) Merr. & L.M.Perry: BOR - *Endert 1584* (**L**), *S 41554* (**L**), *SAN 86080* (**L**); JAW - *Ploem* s.n. (**L**); SUM - *bb. 14399* (**L**); *Kostermans 760* (**L**); *Bogor cult. V.B116* (**L**). ***S. bicolor*** Merr. & Perry: NWG - *Hartley 1200* (**L**), *NGF 41971*(**L**). ***S. boisianum*** (Gagnep.) Merr. & L.M.Perry: VIE - *Petelot 6202* (**P**), *Petelot 6274* (**P**), *Tsang 27341* (**P**), *Tsang 30728* (**P**). ***S. borneense*** (Miq.) Miq.: CBD - *Martin 182* (**P**); LAO - *Vidal 2223* (**P**) ;THA - *Kerr 17298* (**BKF**); VIE - *Tsang 29839* (**L**). ***S. bullockii*** (Hance) Merr. & L.M.Perry: CHH - *Lei 1022* (**P**); VIE - *J. & M.S. Clemens 3716* (**P**), *Lecomte & Finet 883* (**P**), *Pierre 1870* (**P**). ***S. canicortex*** B.Hyland: AUS - *Hyland 10155* (**L**), *Irvine 1694* (**L**). ***S. championii*** (Benth.) Merr. & L.M.Perry: VIE - *Tsang 26910* (**P**), *Tsang 27174* (**P**), *Tsang 27222* (**P**). ***S. claviflorum*** Wall.: CBD - *Chevalier 31723* (**P**); THA - *Parnell, Chayamarit, Pooma, Simpson, Suddee & B. de Wilde 1851* (**TCD**); VIE - *Balansa 2880* (**L**), *Pierre* s.n. (**P**), *VN 1368* (*Schmid*) (**P**). ***S. corynanthum*** (F.Muell.) L.A.S.Johnson: AUS - *Hyland 4121 R.F.K.* (**L**), *Hyland 9795* (**L**). ***S. cryptophlebium*** (F.Muell.) Craven & Biffin: AUS - *Balgooy 1505* (**L**), *Gray 678* (**L**), *Hyland 8320* (**L**), *Irvine 1284* (**L**), *Smith & Pedley 11042* (**L**). ***S. cuminii*** (L.) Skeels: CBD - *Petelot 3190* (**P**), *Pierre 3190* (**P**); LAO - *Tixier 1735609* (**P**), *Vidal*

2202 (**P**); VIE - *Petelot 4679* (**P**), *Petelot 6394* (**P**), *Thorel* s.n. (**P**). ***S. diospyrifolium*** (Wall. ex Duthie) S.N.Mitra: THA - *Santisuk* s.n. (*BKF 100184*) (**BKF**); VIE - *Balansa 2865* (**P**), *Chevalier 30093* (**P**). ***S. divaricatum*** (Merr. & L.M.Perry) Craven & Biffin: AUS - *Hyland 3165 R.F.K.* (**L**), *Hyland 8800* (**L**). ***S. fastigiatum*** (Blume) Merr. & L.M.Perry: THA – *K. & S. Larsen 32708* (**TCD**), *Kerr 16843* (**TCD**), *Kerr 18155* (**TCD**); VIE - *Pierre* s.n. (**P**). ***S. formosum*** (Wall.) Masam.: THA - *Chantaranothai, Parnell, Simpson & Pooma 90/590* (**TCD**), *Fennelly 13* (**TCD**); VIE - *Vu Van Cuong 434* (**P**). ***S. francisii*** (Bailey) L.A.S.Johnson: AUS - *Hyland 6677* (**L**), *Smith 05150* (**L**). ***S. grande*** *(Wight) Walp.*: THA - *Chataranothai, Parnell & Simpson 90/548* (**TCD**), *Kerr 14000* (**TCD**), *Parnell, Chayamarit, Pooma, Simpson, Suddee & B. de Wilde 1869* (**TCD**); VIE - *Pierre* s.n. (**P**). ***S. graveolens*** (F.M.Bailey) Craven & Biffin: AUS - *Gray 2048* (**L**), *Irvine 1447* (**L**). ***S. gustavioides*** (F.M.Bail.) B.Hyland: AUS - *Hyland 3220 R.F.K.* (**L**), *Hyland 8777* (**L**). ***S. hancei*** *Merr. & L.M.Perry*: CBD - *Middleton & Monyrak 623* (**TCD**); CHS - *Tsang 26695* (**P**); THA - *Chantaranothai, Parnell, Simpson & Sridit 90/225* (**TCD**); VIE - *Petelot 2596* (A), *Pierre* s.n. (**P**), *Tsang 27389* (**P**). ***S. harmandii*** (Gagnep.) Merr. & L.M.Perry: CBD - *Hahn* s.n. (**P**). ***S. hedraiophyllum*** (F.Muell.) Craven & Biffin: AUS - *Hyland 9290* (**L**), *Irvine 1681* (**L**). ***S. hemisphericum*** (Walp.) Alston: CBD - *Diffon 509* (**P**), *Magnen, Gourgand & Châtillon 7* (**P**); THA - *Smitinand 10351* (**BKF**); VIE - *Pierre* s.n. (**P**). ***S. imitans*** Merr. & L.M.Perry: VIE - *Tsang 26890* (**P**), *Tsang 27232* (**P**), *Tsang 30415* (**P**). ***S. jambos*** (L.) Alston: LAO - *Spire 1025* (**P**); VIE - *Balansa 2862* (**P**), *Chevalier 30092* (**P**). ***S. jasminifolium*** (Ridl.) P.Chantaranothai & J.Parn.: MLY - *FRI 17545* (**L**); THA - *Sangkhachand, Phusomsaeng & Nimanong 1073* (**BKF**). ***S. khaoyaiense*** (P.Chantaranothai & J.Parn.) Craven & Biffin: THA – K. Larsen 10316 (**BKF**). ***S. kinabaluense*** (Stapf) Merr. & L.M.Perry: BOR - RSNB 194 (**L**), RSNB 4743 (**L**), RSNB 5884 (**L**), S 35823 (**L**), S 44469 (**L**), Smith 508 (**L**). ***S. levinei*** (Merr.) Merr.: VIE - *Balansa 2887* (**P**), *Balansa 2891* (**P**), *D'Alleizette* s.n. (**L**). ***S. lineatum*** (DC.) Merr. & L.M.Perry: CBD - Martin 1085 IREFC M37 (**P**), Martin 1676 (**P**); LAO - Harmand 252 (**P**); THA - Kerr 9283 (**TCD**). ***S. luehmannii*** (F.Muell.) L.A.S.Johnson: AUS - *Hyland 9207* (**L**), *Irvine 1639* (**L**); NWG - *Brass 24853* (**L**). ***S. mackinnonianum*** (B.Hyland) Craven & Biffin: AUS - *Hyland 11162* (**L**), *Hyland 3310 R.F.K.* (**L**). ***S. malaccense*** (L.) Merr. & L.M.Perry: LAO - Harmand 48 (**P**); VIE - Petelot 3387 (**P**), ,Thorel 311 (**P**). ***S. megacarpum*** (Craib) N.C.Rathakrishnan & N.C.Nair: LAO - *Vidal 2577* (**P**); THA - *Chantaranothai, Parnell & Simpson 90/432* (**TCD**), *Fenelly 12* (**TCD**), *Parnell, Chayamarit, Pooma, Simpson, Suddee & B. de Wilde 2032* (**TCD**). ***S. mulgraveanum*** (B.Hyland) Craven & Biffin: AUS - *Hyland 8900* (**L**), Hyland 9248 (**L**). ***S. multibracteolatum*** (Merr.) Merr. & L.M.Perry: BOR - *S 124475* (**L**), *S 35667* (**L**), *S 36624* (**L**), *S 44292* (**L**). ***S. multipetalum*** Pancher ex Brongn. & Gris: AUS - *Ingle I.71* (**L**). ***S. nervosum*** DC.: CHS - Tsang 26778 (**P**); THA - *Maxwell* s.n. (*BKF 090782*) (**BKF**); VIE - *Balansa 2871* (**P**). ***S. nigrans*** (Gagnep.) Craven & Biffin: THA - *Murataet, Phengklai, Mitsuta, Nagamasu & Nantasan 37145* (**BKF**); VIE - *D'Alleizette* s.n. (**L**), *Pierre* s.n. (**P**), *Thorel* s.n. (**P**). ***S. nummularium*** Airy Shaw: BOR - *Richard 1981* (**L**), *Richard 2417* (**L**), *S 40942* (**L**). ***S. oblatum*** (Roxb.) Wall. Ex A.M. Cowan & Cowan: CBD - *Magnen, Gourgand & Chatillon* s.n. (**P**), *Martin 1567* (**P**); THA - *Collin 1368* (**TCD**), *Geesink et al* (**L**), *Parnell et al 2044* (**TCD**); VIE - *D'Alleizette* s.n. (**L**), *Martin 943* (**P**). ***S.***

odoratum DC.: VIE - *J. & M.S. Clemens 3778* (**P**), *J. & M.S. Clemens 4215* (**P**). ***S. pachysarcum*** (Gagnep.) Merr. & L.M.Perry: CBD - *Bejaud 569* (**P**), *Herbier Forestier du Cambodge 505* (**P**), *Magnen, Gourgand & Châtillon 2* (**P**); VIE - *Pierre* s.n. (**P**). ***S. phengklaii*** (P.Chantaranothai & J.Parn.) Craven & Biffin: THA - *Phengklai 4020* (**BKF**). ***S. polyanthum*** (Wight) Walp.: CBD - *Vidal 5010* (**P**); VIE - *Tsang 30136* (**L**), *Vu Van Cuong* 1586. ***S. polycladum*** Merr. & L.M.Perry: BOR - *Clemens 34208* (**L**), *Clemens 40690A* (**L**), *Clemens 40692A* (**L**), *S 29020* (**L**). ***S. praecox*** (Roxb.) N.C.Rathakrishnan & N.C.Nair: THA - *Kerr 17007* (**TCD**), *Phusomaeng & Pinnin 318* (**BKF**); VIE - *Schmid* s.n. (**P**), *Tsang* 30757 (**L**). ***S. pterophorum*** Merr. & L.M.Perry: BOR - *Clemens 29470* (**L**), *Clemens 32012* (**L**), *Clemens 33047* (**L**), *Clemens 33047* (**L**). ***S. ripicola*** (Craib) Merr. & L.M.Perry: CBD - *Bejaud 562* (**P**): VIE - *Beusokom & Phengklai* 106 (**P**), *d'Alleizette* s.n. (**L**), *Schmid* s.n. (**P**), *Vu Van Cuong* 278. ***S. sclerophyllum*** Thwaites: CBD - *Dy Phon 1141* (**P**), *Martin 806* (**P**), *Stone B.C. 9264* (**L**), *Vidal 4798* (**P**). ***S. siamense*** (Craib) P.Chantaranothai & J.Parn.: THA - *Kerr 12565A* (**TCD**), Kerr 598 (**TCD**); VIE - *Bon 4191* (**P**), *Chevalier 29923* (**P**). ***S. smithii*** Nied.: AUS - *Hyland 11365* (**L**), *Hyland 3134 R.F.K.* (**L**). ***S. stapfianum*** (King) I.M.Turner: MLY - *Wray-Smith KEP 79154* (**L**). ***S. sterrophyllum*** Merr. & L.M.Perry: CBD - *Bansok 92* (**BKF**); CHS - *Tsang 26735* (**P**); VIE - *Balansa 1149* (**P**), *Tsang 30189* (**P**). ***S. syzygioides*** (Miq.) Merr. & L.M.Perry: THA - Maxwell 85-123 (**BKF**); VIE - *d' Alleizette* s.n. (**L**), *Pierre* s.n. (barcode P00589397) (**P**), *Pierre* s.n. (**P**). ***S. tenuirame*** (Miq.) Merr.: JAW - *HB 834 & 843* (**L**); PHI - *Bureau Science 34495* (*Ramos & Pascasio*) (**L**), *Bureau Science 34709* (*Ramos & Pascasio*) (**L**); SUM - *Teysman* s.n. (**L**), *Unknown* s.n. (**L**). ***S. tephrodes*** (Hance) Merr. & L.M.Perry: CHH - *Hendry 8086* (**P**), *Lei 10* (**P**), *Wang 33411* (**P**). ***S. tetragonum*** (Wight) Walp.: IN - *J.D. Hooker* s.n. (**P**); THA - *Fenelly 5* (**TCD**); VIE - *Petelot 6303* (**P**); *VH 2934* (**P**). ***S. tetrapterum*** (Miq.) P.Chantaranothai & J.Parn.: JAW - *Cultivated Bogor V B.70* (**L**), ; MLY – *Mohd. Shah 2283* (**L**), *SFN 38935* (**L**). ***S. thorelii*** (Gagnep.) Merr. & L.M.Perry: LAO - *Thorel 3010* (**P**), *Vidal 2786* (**P**), *Vidal 2520* (**P**); THA - *Kerr 20698* (**TCD**). ***S. tonkinense*** (Gagnep.) Merr. & L.M.Perry: VIE - *Bon 2969* (**P**). ***S. tsoongii*** (Merr.) Merr. & L.M.Perry: CHH - *How, F.C. 70528* (**P**); VIE - *Balansa 1148* (**P**), *Balansa 1148* (**P**), *Lecomte & finet* (**P**). ***S. unipunctatum*** (B.Hyland) Craven & Biffin: AUS - *Gray 667* (**L**), *Hyland 7357* (**L**). ***S. vestitum*** Merr. & L.M.Perry: LAO - *Vidal 5696* (**P**); VIE - *Petelot 6145* (**P**), *Phengklai 10604*. ***S. wilsonii*** (F.Muell.) B.Hyland: AUS - *Dockrill 889* (**L**), *Smith & Pedley 10193* (**L**). ***S. zeylanicum*** (L.) DC.: THA – *Kerr 7083A* (**TCD**), *Kerr 15684* (**TCD**). ***S. zimmermannii*** (Warb.) Merr. & L.M.Perry: LAO - *Spire 419* (**P**); THA - *Kerr 20018* (**BKF**), *Zimmermann 101* (**L**); VIE - *Vidal 2521* (**P**).

Appendix 4.1. Species amplified and sequenced for ITS and ETS nuclear DNA. All specimens are collected from Thailand and vouchers were lodged in the herbarium in Khon Kaen University, Thailand.

Species	Voucher number
Eugenia uniflora L.	Chantaranothai & Kantachot 459
Syzygium hemisphericum (Wight) Alston	Chantaranothai & Kantachot 460
Syzygium aqueum (Burn.f.)Alston	Chantaranothai & Kantachot 466
Syzygium aromaticum (L.) Merr. & L.M.Perry	Chantaranothai & Kantachot 469
Syzygium nigrans (Gagnep.) Craven & Biffin	Harwood 2
Syzygium campanulatum Korth.	Chantaranothai & Kantachot 463
Syzygium cumini (L.) Skeels	Chantaranothai & Kantachot 470
Syzygium diospyrifolium Wall. ex. Duthie	Chantaranothai & Kantachot 471
Syzygium grande Walp.	Chantaranothai & Kantachot 462
Syzygium antisepticum (Blume) Merr. & L.M.Perry	Chantaranothai & Kantachot 465
Syzygium jambos (L.) Alston	Chantaranothai & Kantachot 464
Syzygium malaccense (L.) Merr. & L.M.Perry	Chantaranothai & Kantachot 467
Syzygium hancei Merr. & L.M.Perry	ATB & BCM 2
Syzygium nervosum A.Cunn. ex DC.	Chanaranothai et al. s.n.
Syzygium ripicola (Craib) Merr. & L.M.Perry	Chantaranothai & Kantachot 468
Syzygium thorelii (Gagnep.) Merr. & L.M.Perry	Chantaranothai & Kantachot 461

Appendix 4.2. List of character coding used in phenetic analysis.

Stomata

1. Paracytic: 0 = absent; 1 = present
2. Anisocytic: 0 = absent; 1 = present
3. Anomocytic: 0 = absent; 1 = present
4. Cyclocytic: 0 = absent; 1 = present
5. Staurocytic: 0 = absent; 1 = present

Epidermis abaxial anticlinal cell wall

6. Straight: 0 = absent; 1 = present
7. Curved: 0 = absent; 1 = present
8. Undulate: 0 = absent; 1 = present

9. Lamina cuticle texture: 0 = smooth; 1 = ornamented

Crystals

10. Druses: 0 = absent; 1 = present
11. Prismatic crystal: 0 = absent; 1 = present

Midrib adaxial surface texture

12. Grooved or concave: 0 = absent; 1 = present
13. Flat: 0 = absent; 1 = present
14. Convex: 0 = absent; 1 = present

Midrib abaxial surface texture

15. Convex: 0 = absent; 1 = present
16. Angled: 0 = absent; 1 = present
17. Flat: 0 = absent; 1 = present

18. Midrib adaxial phloem partition: 0 = absent; 1 = present or poorly developed

Midrib vascular system

19. Arc: 0 = absent; 1 = present
20. Arc with incurved margins: 0 = absent; 1 = present
21. Arc with interrupted bundles: 0 = absent; 1 = present
22. Circular: 0 = absent; 1 = present
23. Complex open system: 0 = absent; 1 = present

Midrib sclerenchyma

24. Continuous: 0 = absent; 1 = present
25. Discontinuous: 0 = absent; 1 = present

Lamina adaxial cell shape

26. Equal width and height: 0 = absent; 1 = present
27. Wider than high: 0 = absent; 1 = present
28. Higher than wide: 0 = absent; 1 = present

Lamina abaxial cell shape

29. Equal width and height: 0 = absent; 1 = present
30. Wider than high: 0 = absent; 1 = present
31. Irregular: 0 = absent; 1 = present

Palisade layer on adaxial surface

32. 1-layered: 0 = absent; 1 = present
33. 2-layered: 0 = absent; 1 = present
34. 3-layered: 0 = absent; 1 = present

35. Palisade layer, abaxial layer: 0 = absent; 1 = present

36. Lateral vein bundle sheath extension: 0 = absent; 1 = present

37. Foliar sclereid: 0 = absent; 1 = present

Twig texture

38. Angular and/or winged: 0 = absent; 1 = present
39. Terete, compressed or subangular: 0 = absent; 1 = present

40. Leaf arrangement: 0 = opposite or subopposite; 1 = verticillate

Leaf base

41. Cordate or rounded: 0 = absent; 1 = present
42. Cuneate or slightly attenuating: 0 = absent; 1 = present
43. Strongly attenuating: 0 = absent; 1 = present

44. Leaf ratio (maximum dimension): 0 = 3 times longer than wide or less; 1 = more than 3 times longer than wide

45. Leaf texture: 0 = chartaceous or thinly coriaceous; 1 = thickly coriaceous

Leaf colour

46. Dark brownish: 0 = absent; 1 = present
47. Light brownish or yellowish: 0 = absent; 1 = present
48. Greenish: 0 = absent; 1 = present

Leaf venation type

49. Type I: 0 = absent; 1 = present
50. Type II: 0 = absent; 1 = present
51. Type III: 0 = absent; 1 = present
52. Type IV: 0 = absent; 1 = present
53. Type V or VI: 0 = absent; 1 = present

54. Inflorescence type: 0 = paniculate; 1 = racemose or solitary

55. Hypanthium shape: 0 = conical/turbinate; 1 = clavate/elongated

56. Calyx: 0 = free; 1 = calyptrate

57. Petals coherence: 0 = free; 1 = coherent

58. Stamen dehiscence: 0 = longitudinal slits; 1 = apical slits

59. Placentation and orientation: 0 = placentas upper-axile; 1 = placentas axile

60. Seed intercotyledonary intrusion: 0 = absent; 1 = present

61. Leaf length maximum: 0 = 0–20 cm; 1 = equal or more than 20 cm

62. Petiole ratio (petiole length/blade length): 0 = 0–0.15; 1 = equal or more than 0.19

63. Hypanthium diameter: 0=1–10 mm; 1 = equal or more than 15 mm

64. Outer stamen length maximum: 0 = 0–12 mm; 1 = equal or more than 15 mm

65. Style length maximum: 0 = 0-17 mm; 1 = equal or more than 20 mm

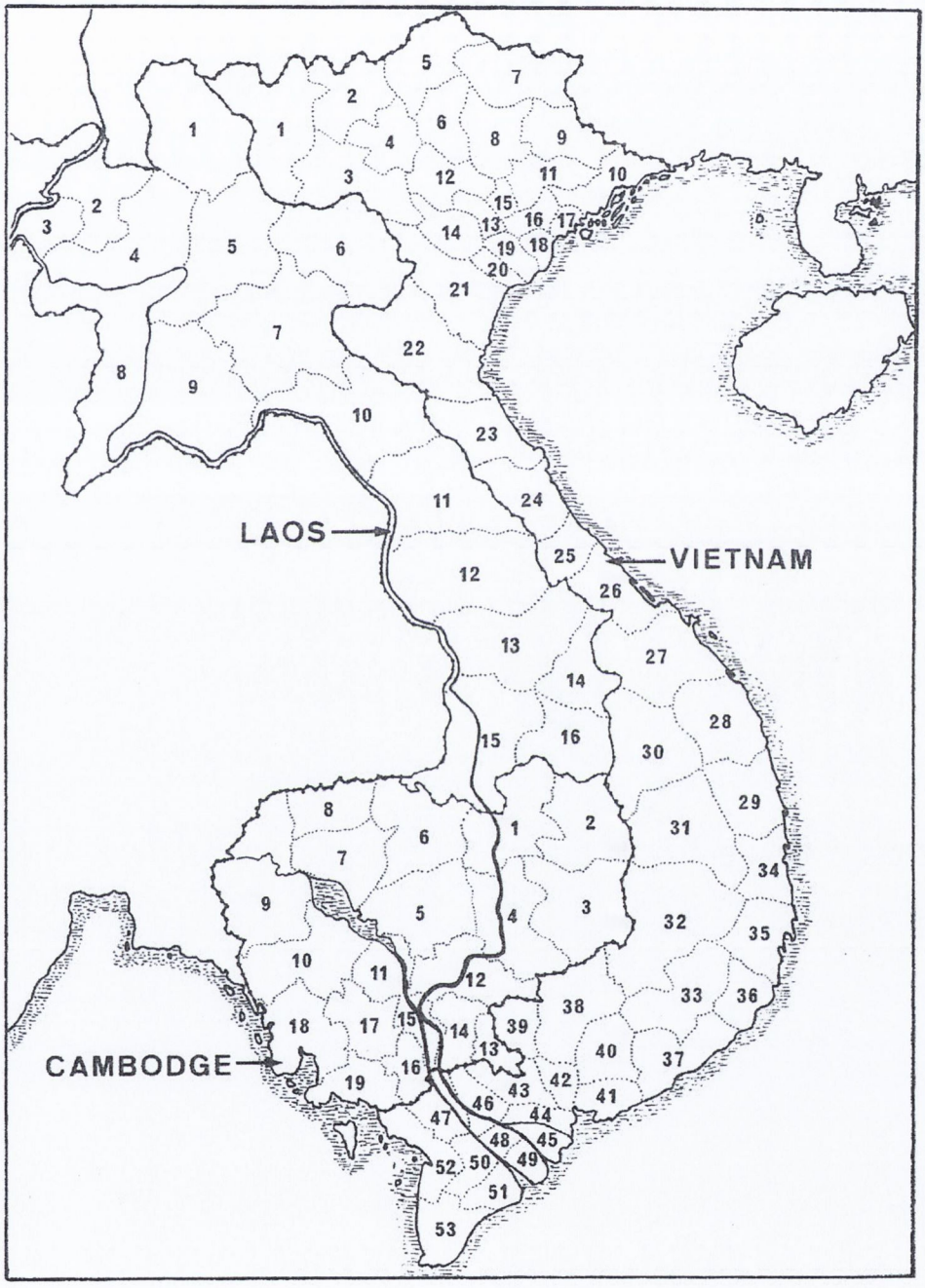
Appendix 4.3. Matrix of morphological character scored for phylogenetic analysis.

Species/ Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Eugenia uniflora	2	2	0	2	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0	0	1	0	0	0	0	0	0
E. bracteata	2	4	0	2	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0
Syzygium angkae	0	3	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	0
S. aqueum	(0,1)	4	1	0	0	0	0	0	1	(0,1)	1	0	0	0	0	0	0	2	0	0	1	2	1	0	0	0	0	1	0	0	0	0	1	0
S. aromaticum	(0,1)	4	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	1	0	0	1	0	0	0
S. attopeuensis	(0,1)	1	1	0	(0,1)	0	0	1	(0,1)	1	2	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0
S. balsameum	(0,1)	0	0	0	0	0	0	4	1	1	1	0	0	0	0	0	0	0	0	0	2	3	0	0	0	1	0	1	0	0	0	0	0	0
S. borneense	(0,1)	3	1	0	0	0	0	1	(0,1)	0	1	0	1	0	0	0	0	0	0	0	0	3	0	0	0	1	0	1	0	0	0	0	0	0
S. bullockii	(0,1)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
S. bokorense	(0,1)	1	0	0	0	0	0	0	1	(0,2)	1	2	0	0	0	0	0	2	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0
S. campanulatum	0	1	0	2	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
S. cumini	(0,1)	1	0	0	(0,1)	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0
S. diospyrifolium	0	4	0	0	0	0	0	3	1	0	1	2	0	0	0	1	1	2	1	0	(1,2)	2	1	0	0	0	0	1	0	1	0	1	1	1
S. fastigiatum	0	3	0	0	2	0	0	3	1	1	1	2	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0
S. formosum	0	4	1	0	(0,1)	0	0	3	1	0	1	0	0	0	0	1	1	2	1	0	(0,1)	2	1	0	0	0	0	1	0	1	0	1	1	1
S. grande	0	0	0	0	0	0	0	0	1	0	0	(1,2)	1	0	0	0	0	1	0	0	1	2	0	0	0	0	0	1	0	0	0	0	0	0
S. hancei	(0,1)	(1,3)	0	0	0	0	0	0	(0,1)	0	1	(1,2)	0	0	0	0	0	1	0	1	2	0	0	0	0	1	0	1	0	0	0	0	0	0
S. harmandii	0	1	1	0	1	0	0	3	1	0	0	0	0	0	0	1	1	2	0	1	2	1	1	0	0	0	0	1	0	0	0	1	1	0
S. hemisphericum	(0,1)	4	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	2	(1,3)	0	0	0	0	0	1	0	0	0	0	0	0
S. imitans	0	3	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	2	3	0	0	0	0	0	1	0	0	0	0	0	0
S. jambos	(0,1)	4	0	0	(0,1)	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	2	1	1	0	0	0	0	1	0	0	0	0	1	1
S. khaoyensis	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	2	4	0	0	1	1	0	1	0	1	0	0	0	0
S. levinei	(0,1)	3	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	(0,1)	(0,1)	0	0	0	1	0	1	0	0	0	0	0	0
S. lineatum	0	3	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	(1,2)	0	0	0	0	0	0	1	0	0	0	0	1	0
S. malaccense	(0,1)	0	0	0	0	0	0	0	1	1	1	1	0	0	1	(0,1)	0	0	0	0	1	3	(0,1)	0	0	0	0	1	0	1	0	0	1	1
S. megacarpum	0	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	1	1	2	2	1	0	0	0	0	1	0	1	0	1	1	1
S. nervosum	0	3	0	0	0	0	0	2	(0,1)	1	1	0	0	0	0	0	0	1	0	0	1	4	0	0	1	1	0	1	0	1	0	0	0	0
S. nigrans	0	1	0	0	0	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
S. oblatum	(0,1)	3	0	0	0	0	0	(0,1)	1	(0,1)	1	(0,1)	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0
S. pachysarcum	(0,1)	3	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	1	0	1	(0,1)	1	0	0	0	0	0	1	0	0	0	0	0	0

S. phengklaii	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0
S. pierrei	(0,1)	0	0	0	2	0	0	0	1	1	1	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
S. polyanthum	0	4	0	0	(0,1)	0	0	3	1	1	1	2	0	0	0	0	0	1	0	0	1	3	0	0	0	0	0	1	0	0	0	0	0	0
S. praecox	(0,1)	3	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0
S. ripicola	(0,1)	3	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	0	2	0	0	0	0	1	0	1	0	0	1	0	0	0
S. siamense	(0,1)	4	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	1	0	0	2	1	1	0	0	0	0	1	0	1	0	0	1	1
S. sterrophyllum	0	1	0	0	0	0	1	0	0	0	(0,1)	(0,1)	0	0	0	0	0	0	1	1	2	0	0	0	0	1	0	1	0	0	0	0	0	0
S. syzygioides	0	3	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	1	0	0	(1,2)	0	0	0	0	0	0	1	0	0	0	0	0	0
S. tetragonum	0	1	0	0	0	0	0	4	(0,1)	1	1	0	0	0	0	1	0	0	0	0	2	2	0	0	0	1	0	1	0	0	0	0	0	0
S. thorelii	(0,1)	4	0	0	(0,1)	0	0	0	(0,1)	1	1	1	0	0	0	0	0	1	1	0	2	1	0	0	0	1	0	1	0	0	0	0	0	0
S. tonkinense	0	4	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0
S. vestitum	0	3	0	0	0	0	0	0	(0,1)	1	1	1	0	0	0	0	0	1	0	0	0	2	0	0	0	1	0	1	0	0	0	0	1	0
S. zimmermanni	(0,1)	3	0	0	2	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	1	0	0	0	0	0	0
P. francii	3	1	0	1	(0,1)	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	2	(0,1)	0	0	0	1	0	0	1	0	0	0	0	0
S. acuminatissimum	3	4	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	(1,2,3)	0	0	0	1	1	0	1	0	0	0	0	0
S. divaricatum	3	4	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	1	0	1	0	0	0	0	0
S. graveolens	3	2	0	1	0	0	1	1	1	0	0	0	0	0	0	(0,1)	0	1	0	0	1	2	0	0	0	0	1	0	1	1	0	0	0	0
S. gustavioides	3	0	1	1	0	0	1	1	1	0	1	2	0	0	0	0	0	0	0	1	2	3	0	0	1	1	0	1	0	0	0	0	0	0
S. hedraiophyllum	3	1	0	1	0	0	1	1	0	0	1	0	1	0	0	1	0	2	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0
S. mackinnonianum	3	4	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	(0,1)	0	0	2	2	0	0	0	0	1	0	1	0	0	0	0	0
S. mulgraveanum	3	3	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	2	1	0	0	0	0	0	0	1	0	0	0	0	0
S. smithii	3	3	0	1	0	0	1	(0,1)	0	0	0	0	1	0	0	(0,1)	0	(0,1)	0	0	(1,2)	1	0	0	0	1	1	0	1	0	0	0	0	0
S. unipunctatum	j	2	0	1	0	0	1	(0,1)	1	0	1	0	0	1	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0
S. aksornae	(1,2)	4	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	2	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. antisepticum	(1,2)	4	0	1	0	0	1	0	1	1	1	(1,2)	0	0	0	(0,1)	0	1	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. araiocladum	(1,2)	4	0	1	0	0	1	0	1	1	1	1	0	0	0	0	0	1	0	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0
S. bankense	(1,2)	4	0	1	0	0	1	0	1	1	1	(1,2)	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. bicolor	(1,2)	4	0	1	0	0	1	0	1	2	1	1	1	0	0	0	0	0	0	1	1	(2,3)	0	1	0	1	0	1	0	0	0	0	0	0
S. cryptophlebium	(1,2)	4	0	1	2	0	1	0	1	1	1	1	0	0	0	0	0	(1,2)	1	1	(1,2)	1	0	1	0	0	0	1	0	0	0	0	1	0
S. francisii	(1,2)	4	0	2	(0,1)	0	1	0	1	1	1	1	0	0	0	0	0	1	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. jasminifolium	(1,2)	4	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	1	1	1	1	0	1	0	1	0	0	1	0	0	0
S. kinabaluense	(1,2)	4	0	1	0	0	1	0	1	(0,2)	1	(1,2)	1	0	0	1	0	1	0	1	1	2	0	1	0	1	0	1	0	0	0	0	0	0
S. luehmannii	(1,2)	4	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0
S. multibracteolatum	(1,2)	4	0	1	0	0	1	(0,1)	1	1	1	1	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. nummularium	(1,2)	4	0	1	0	1	1	0	1	1	1	1	0	0	0	1	0	(1,2)	0	1	1	2	1	1	0	1	0	1	0	0	0	0	0	0
S. odoratum	(1,2)	4	0	1	1	0	0	0	1	1	1	1	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0

S. polycladum	(1,2)	4	0	1	0	(0,1)	1	0	1	1	1	2	0	0	0	1	0	1	0	1	1	2	0	1	0	1	0	1	0	0	0	0	0	0
S. pterophorum	(1,2)	4	0	1	0	0	1	0	1	1	1	(1,2)	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. staphianum	(1,2)	4	0	1	0	0	0	0	1	1	1	2	0	0	0	1	0	1	0	1	1	2	0	1	0	1	0	1	0	0	0	0	0	0
S. tenuiramis	(1,2)	4	0	1	0	1	1	(0,1)	1	1	1	2	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. tephrodes	(1,2)	4	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. tetrapterum	(1,2)	4	0	1	0	0	1	0	1	1	1	(1,2)	0	0	0	1	0	1	0	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0
S. tsoongii	(1,2)	4	0	1	0	(0,1)	1	0	1	0	1	1	0	0	0	1	0	1	1	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0
S. wilsonii	(1,2)	4	0	1	2	(0,1)	1	(0,1)	1	1	1	1	0	0	0	(0,1)	0	2	1	1	1	1	0	0	0	0	0	1	0	0	0	0	1	1
S. abortivum	(1,4)	1	0	1	0	0	1	1	1	0	1	(1,2)	0	0	0	0	0	0	1	0	2	0	1	1	0	1	0	1	1	0	0	0	0	0
S. apodophyllum	(0,1)	4	0	1	0	0	1	0	1	1	1	0	0	0	0	1	0	2	0	0	2	1	1	1	1	0	0	1	0	0	0	0	0	0
S. attenuatum	(1,3)	0	0	1	1	(0,1)	0	1	1	1	1	(1,2)	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0
S. boisianum	(1,4)	1	0	1	0	0	1	0	1	1	1	0	0	0	0	0	0	2	0	0	1	1	1	1	0	1	0	1	1	0	0	0	0	0
S. canicortex	3	4	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	2	1	1	1	1	0	0	1	0	0	0	0	0	0
S. championii	(1,4)	1	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	1	0	0	(1,2)	0	1	1	0	1	0	1	1	0	0	0	0	0
S. claviflorum	(1,4)	1	0	1	0	0	1	1	1	1	1	2	0	0	0	0	0	1	0	0	(1,2)	(0,1)	1	1	0	1	0	1	1	0	0	0	0	0
S. coryanthum	(0,1)	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	2	1	1	1	0	0	0	1	0	0	0	0	1	1
S. multipetalum	3	0	0	1	2	0	1	1	1	2	1	2	0	0	0	(0,1)	0	1	0	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0

Appendix 5.1: Map of Indochina (Cambodia, Laos and Vietnam) showing provinces and list of provinces in alphabetical order. (from *Flore du Cambodge du Laos et du Viêtnam*)



LISTE ALPHABÉTIQUE DES PROVINCES

Les nombres indiquent la situation sur la carte

CAMBODGE

Battambang, 9
Kampot, 19
Kandal, 15
Koh Kong, 18
Kompong Cham, 12
Kompong Chhnang, 11
Kompong Speu, 17
Kompong Thom, 5
Kratie, 4
Mondulkiri, 3
Oddor Meanchey
Preah Vihear, 6
Prey Veng, 14
Pursat, 10
Ratanakiri, 2
Siem Reap, 7
Stung Treng, 1
Svay Rieng, 13
Takeo, 16

LAOS

Attopeu, 16
Bokeo, 3
Bolikhamsai, 10
Champassak, 15
Houa Phan, 6
Khammouane, 11
Louang Namtha, 2
Louang Prabang, 5
Oudomsai, 4
Phong Sali, 1
Saravane, 13
Savannakhet, 12
Sayabouri, 8
Sekong, 14
Vientiane, 9
Xieng Khouang, 7

VIÊTNAM

An Giang, 47
Bac Thai, 8
Bària-Vung Tàu, 41
Bên Tre, 45
Binh Dinh, 29
Binh Thuân, 37
Cân Tho, 50
Cao Bang, 7
Dac Lac, 32
Dông Nai, 40
Dông Thap, 46
Gia Lai, 31
Hà Bac, 11
Hà Giang, 5
Hà Nôi, 15
Hà Tây, 13
Hà Tinh, 23
Hai Hung, 16
Hai Phong, 17
Hô Chi Minh Ville, 42
Hoa Binh, 14
Khanh Hoa, 35
Kiên Giang, 52
Kon Tum, 30
Lai Châu, 1
Lâm Dông, 33
Lang Son, 9
Lào Cai, 2
Long An, 43
Minh Hai, 53
Nam Hà, 19
Nghê An, 22
Ninh Binh, 20
Ninh Thuân, 36
Phu Yên, 34
Quang Binh, 24
Quang Nam-Dà Nang, 27
Quang Ngai, 28
Quang Ninh, 10
Quang Tri, 25
Soc Trang, 51
Son La, 3
Sông Bé, 38
Tây Ninh, 39
Thai Binh, 18
Thanh Hoa, 21
Thua Thiên-Huê, 26
Tiên Giang, 44
Trà Vinh, 49
Tuyên Quang, 6
Vinh Long, 48
Vinh Phu, 12
Yên Bai, 4