

Phylogenetics, Taxonomy and Evolution of
Camellia (Theaceae) in the Indochinese
Peninsula

A thesis submitted for the degree of Doctor of Philosophy

by

Zhao Dongwei

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Supervisors: Professors John A.N. Parnell &

Trevor R. Hodkinson

Botany Department

School of Natural Sciences

Trinity College Dublin

The University of Dublin, Ireland

Declaration

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Summary

Tea, camellias and oil camellia have brought huge profits to people worldwide. These plants belong to the genus *Camellia*. The variable morphological characters of the group make the classification of *Camellia* very difficult and controversial. After the work of Sealy who laid the foundation of modern classification of *Camellia*, monographers, especially Zhang and Min, held very different opinions on the species boundaries and hotly debated the infrageneric classification. However, all three taxonomists shaped their views largely based on the collections from China. Similarly, using the samples mainly collected in China, subsequent researchers investigated the molecular phylogeny of *Camellia* with DNA markers but without yielding a formal classification. Here, species from Indochina, including Cambodia, Laos, Myanmar, Thailand and Vietnam, were added to fill the data gaps in previous studies, to yield a new taxonomic treatment of the group and to infer the origin, evolution and dispersal of *Camellia* in this area. The species were also reviewed, described and assessed to clarify their nomenclatural and conservation status, geographic distributions and diagnostic character states.

The single copy nuclear DNA *RPB2* 11–16 and 23 intron regions were found to be very informative for the phylogenetic reconstruction in *Camellia*, especially when used in combination. The phylogenetic accuracy and resolution of *RPB2* gene trees were effectively improved with the addition of Indochinese species of *Camellia* compared to previous studies lacking these taxa. A new classification of *Camellia* is proposed here based on the *RPB2* and other gene trees, and the morphological and other data to generally categorise Indochinese species into ten amended sections: *Archecamellia*, *Camelliopsis*, *Corallina*, *Cylindriea*, *Furfuracea*, *Heterogenea*, *Paracamellia*, *Piquetia*, *Stereocarpus* and *Thea*. Among them, sect. *Thea* is enlarged to include *C. longissima*, which has been barely investigated and may supply new genetic characters for tea breeding. Gene trees reconstructed using chloroplast DNA markers in *Camellia* are usually incongruent with those of nuclear DNA and analyses using morphological, chemical, cross tests and other data. These incongruences may weaken its value in the phylogenetic analyses. Multicopy nuclear DNA markers, such as the *LEAFY* region and ITS, are affected by gene duplications in *Camellia* and need to be carefully interpreted in phylogenetic investigations.

Not only the topologies of gene trees but also the fossil calibration points selected can influence the results of molecular dating. To minimize the potential problems of calibration, six different combinations of calibration points using between one and four fossils were analysed with the concatenated *RPB2* (intron 11–16 and intron 23) data. The results suggested that the crown age of *Camellia* was 48.5 Ma with a 95% highest posterior density interval of 39.25–58.92 Ma. This places the evolution of *Camellia* earlier than that estimated previously by the *LEAFY* region analysis in which the fossil *C. japonoxyla* was applied to constrain the stem age of *Camellia*. However, the ancestral areas of *Camellia* cannot be simply inferred by the molecular dating

analyses using the present distribution data because of a lack of fossil records and a changeable climatic and geographic history. Most of the recognised sections diversified in the Early and Middle Miocene probably due to the rapid uplift of Qinghai-Tibetan Plateau and a series of mountain building events introduced by the India-Eurasia collision which created great ecological opportunities to drive speciation in Indochina. The varying types of seed dispersal mechanisms of *Camellia* would allow long-distance terrestrial dispersal over millions of years. It is proposed that when there was a land bridge between Indochina and Indonesian Archipelago at 20–30 Ma, some species of *Camellia* colonized the islands of the latter and subsequently became isolated by the South China Sea, leading to the allopatric speciation of *C. lanceolata*.

Species of *Camellia* in Indochina were examined, described and discussed with illustrations, distribution maps, conservation assessments, nomenclatural notes and a key to them. In total, 11 sections, including the new sect. *Gilbertia*, 43 species and four varieties of *Camellia* are recognised in Indochina. Two new combinations, *C. drupifera* var. *kissi* and *C. drupifera* var. *stenophylla* are proposed here. Among them, 27 species are endemic to Indochina. There are 17 synonyms of *Camellia* identified, including one new synonym, *Bembiciopsis*, and three of them are lectotypified here. In terms of sections, 25 synonyms are recognised, including ten new ones, and two of them are lectotypified. Under the 47 accepted specific and infraspecific taxa, 112 synonyms are recognised, including 30 names that are lectotypified or neotypified here and 42 new synonyms.

Many species of *Camellia* in Indochina, such as yellow camellias, have been exposed to critical over-exploitation for medicinal or ornamental purposes in their natural habitats. The natural resources of *Camellia* are of fundamental importance for the breeding of tea, oil camellia and horticultural species and thus require a strict protection for their sustainable development. This thesis provides the taxonomic framework in the region for such conservation.

Keywords: Assam tea; biogeography; *Camellia*; conservation; evolution; Indochina; molecular dating; nomenclature; phylogenetics; *RPB2*; taxonomy; Theaceae; typification.

Abbreviations

The abbreviations used in this thesis are listed here except herbarium acronyms and units listed in the *International System of Units* (Bureau International des Poids et Mesures 2006). Latin abbreviations are in accordance with McNeill et al. (2012) and Stearn (2013).

A: number of alleles per locus

AFLP: amplified fragment length polymorphism

Art./Arts.: Article or Articles of *International Code of Nomenclature for Algae, Fungi, and Plants* (Melbourne Code)

BI: Bayesian inferences

BIC: Bayesian information criterion

bp: base pairs

BS: bootstrap

ca.: *circa*, about

comb. nov.: *combinatio nova*, new combination

CMS: *The Chicago Manual of Style*: <http://www.chicagomanualofstyle.org/home.html>

cpDNA: chloroplast deoxyribonucleic acid

CTAB: hexadecyl-trimethyl-ammonium bromide

diam.: diameter

DNA: deoxyribonucleic acid

dNTPs: deoxynucleotide triphosphates

Dr.: Doctor

ed.: *editio*, edition

EDTA-Na₂: Ethylene-diamine-tetra-acetate acid disodium salt dihydrate

e.g.: *exempli gratia*, for example

et al.: *et alii*, and others

excl.: *exclusus*, excluded

fig.: *figura*, figure

FOC: *Flora of China*

FRPS: *Flora Reipublicae Popularis Sinicae*

GBSSI/waxy: granule-bound starch synthase

GTR: general time reversible (nucleotide-substitution model)

h: haplotype diversity

H_E: expected heterozygosity

HPD: highest posterior density (interval)

ICN: *International Code of Nomenclature for Algae, Fungi, and Plants* (Melbourne Code)

IPNI: The International Plant Names Index: <http://ipni.org/index.html>

ISSR: inter-simple sequence repeat (deoxyribonucleic acid)

ITS: internal transcribed spacer region of 18S–26S nuclear ribosomal deoxyribonucleic acid

JK: Jackknife

Ma: megaaunus (ago)

MCMC: Metropolis-coupled Markov chain

MCMCMC: Metropolis-coupled Markov chain Monte Carlo

ML: maximum likelihood

MP: maximum parsimony

N.A.: not available

No.: numero, number

nom. illegit.: *nomen illegitimum*, illegitimate name

nom. nud.: *nomen nudum*, name unaccompanied by a description or diagnosis or reference to a published description or diagnosis

nuDNA: nuclear deoxyribonucleic acid

PAL: phenylalanine ammonialyase

PCR: polymerase chain reaction

PDF: portable document format

pH: potential of hydrogen

Ph.D.: Doctor of Philosophy

PP: Bayesian posterior probability

Prof.: Professor

RAPD: random amplified polymorphic nuclear deoxyribonucleic acid

RNA: ribonucleic acid

RPB2: the second largest subunit of ribonucleic acid polymerase II

sect.: sectio, section

s.l.: *sensu lato*, in a broad sense

s.n.: *sine numero*, without a number

syn. nov.: *synonymon novus*, new synonym

SSR: simple sequence repeat (deoxyribonucleic acid), or microsatellite

subg.: subgenus

t.: *tabula*, plate, a full-page illustration

TBR: tree-bisection-reconnection

var.: *varietas*, variety

viz.: *videlicet*, namely; as follows

vol.: *volumen*, volume

v/v: volume/volume

w/v: weight/volume

Styles

The general style of this thesis follows the requirements of *Thesis Submission Guidelines* on the website of Academic Registry, Trinity College Dublin, The University of Dublin (<http://www.tcd.ie/academicregistry/downloads/assets/world/Thesis%20Submission%20Guidelines.pdf>). Other specific styles are explained below.

In this thesis, the words Indochinese Peninsular or Indochina indicate the geographic area including Cambodia, Laos, Myanmar, Thailand and Vietnam.

Following *The Chicago Manual of Style* (CMS, Online 16th edition:

<http://www.chicagomanualofstyle.org/home.html>), Chinese names are written using Hanyu Pinyin (or Pinyin) for Romanising Chinese (Chapter 11.102 of CMS) in the order that family name comes before the given name based on Chinese practice when the full name is given (Chapter 8.15 of CMS). Vietnamese names are written in the same order as Chinese (Chapter 16.86 of CMS). The standard form of author names in Latin follows the International Plant Names Index (IPNI: <http://www.ipni.org/ipni/authorsearchpage.do>) but the person's family name is cited in full at the first place of citation of the taxon (with exceptions of taxa presented in the acknowledgements, figures, key, maps, summary or tables where author's names are not cited) and in the taxonomic literature cited in Chapter 4 (the author's family name is underlined when information is unavailable to allow verification of the correct author). Nevertheless, each name in the References is cited as the family name followed by the capitalized initial letter(s) of given name(s) regardless of nationality. For example, the Vietnamese botanist Tran Ninh's (1943–, Tran is the family name; Vietnamese: Trần Ninh) standard abbreviation is Ninh. His name is listed in the References as Tran N.

All herbaria mentioned are represented by their acronyms in Index Herbariorum (<http://sweetgum.nybg.org/science/ih/>) and printed in bold with one exception: 'NUOL' indicates the Herbarium of Department of Biology, National University of Laos which does not appear in Index Herbariorum.

Some journals do not have the information of volume, which is here indicated by the year of publication in the References accordingly. All websites cited in this thesis had been accessed before 13 April 2018. Unless otherwise stated, all figures, maps, photos and tables are taken, produced or revised by the author.

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Chapter 1 Introduction

Plants of *Camellia* Linnaeus (Theaceae, Ericales, Asterids, according to APG IV 2016) are evergreen shrubs or trees that grow in a range of forests, occurring from temperate, subtropical to tropical areas (Min 2000). They are distributed in East, South and Southeast Asia, including Bhutan, Cambodia, China, India, Indonesia, Japan, Korea, Laos, Malaysia, Myanmar, Nepal, Philippines, Thailand and Vietnam (Merrill 1923, Banerji 1965, Keng 1972, Grierson 1984, Hô 1991, Min 2000, Kress et al. 2003, Newman et al. 2007), from roughly 85°E (Banerji 1965) to 141°E (Kirino 1998) in longitude, 41°N (Kirino 1998) to 7°S (Min 2000) in latitude and up to 3200 m (Min 2000) in elevation. Most known species of *Camellia* occur in South and Southwest China and Vietnam (Min 2000).

1.1 Economic and horticultural uses

Camellia is an economically important genus including tea, oil camellia and several horticultural species (Min 2000). Tea, *C. sinensis* (Linnaeus) Kuntze, was firstly recorded and used by the Chinese more than two millennia ago (Fang 1998, Lu et al. 2016). The first monograph on tea, *Cha Jing* (the classic of tea), was written by Lu Yu in ca. 780 AD during the Tang dynasty (Ukers 1935). Oil camellia, *C. drupifera* Loureiro, and a horticultural species, *C. japonica* Linnaeus, have been planted for centuries in Asia for their high-quality oil and the adorable flowers, respectively (Sealy 1958, Min 2000). Golden/yellow camellias, such as *C. petelotii* (Merrill) Sealy, are valued for its yellow flowers in South China and North Vietnam (Min 2000). Those plants generate huge economic and cultural benefits today, e.g., the global export value of black tea was \$ 5.7 billion in 2013 (Chang 2015).

1.2 Species of *Camellia*

1.2.1 Number of species

Linnaeus (1753) named *C. japonica* and *Thea sinensis* Linnaeus in his *Species Plantarum*. The former is a common ornamental plant and the latter is tea. Loureiro (1790) described *C. drupifera* and three species of *Thea* Linnaeus from Cochinchina and China. Kochs (1900) recorded 25 species under *Thea*. Later, 37 species of *Camellia* were recognised by Cohen Stuart (1916). In China, Hu (1937, 1938) and his collaborators (Hu et al. 1938) described eight new species of *Camellia* and added another 14 new names in 1965 (Hu 1965b). Meanwhile, Gagnepain (1942) recorded 12 new species of *Thea* in Indochina and Sealy (1949, 1951) described 11 new species and varieties that were mainly found in China. In his monograph of *Camellia*, Sealy (1958) counted 82 species and listed another 24 names that represented ‘doubtful, imperfectly known and excluded species’.

About 200 new species of *Camellia*, mainly found in China, were described between 1979 and 1997 (Zhang 1979, 1980, 1981a, 1984, 1989, 1990, Zhang & Li 1981, Mo & Zhong 1985, Zhang &

Ren 1991, Min 1994, 1997, Ye 1996a). Then, Zhang (Zhang Hongda or Hung Ta Chang; abbreviation: Hung T. Chang; Chinese: 张宏达) counted about 280 species of *Camellia* in the world (Zhang 1998). However, Min (Min Tianlu or Tien Lu Ming; abbreviation: T.L. Ming; Chinese: 闵天禄) thought that Zhang's species concept was too narrow to be correct. He revised this genus to include 119 species (Min 2000) and generally insisted on his taxonomy in *Flora of China* (Min & Bartholomew 2007). However, more than 30 new species of *Camellia* have been described since 2007 (Liu et al. 2007, Orel & Wilson 2010b, 2010d, 2012a, 2012b, Orel et al. 2012, 2013, 2014a, 2014b, Tran & Luong 2013, Orel & Curry 2014, 2015, Luu et al. 2015, 2016, Luong et al. 2016b) and they are mainly distributed in the Indochinese Peninsula, especially in southern Vietnam. Historical variation in the number of recognised *Camellia* species is shown in Figure 1.1.

This thesis focuses on the natural species of *Camellia*. The numerous cultivars of *Camellia* are not considered. However, many natural species were described from specimens which were collected from planted materials, some plausible 'wild' species have not been found in the wild and even recently, some cultivars of *Camellia* were deliberately described using Latin binomials: these names which related to natural Indochinese species of *Camellia* will be discussed case by case.

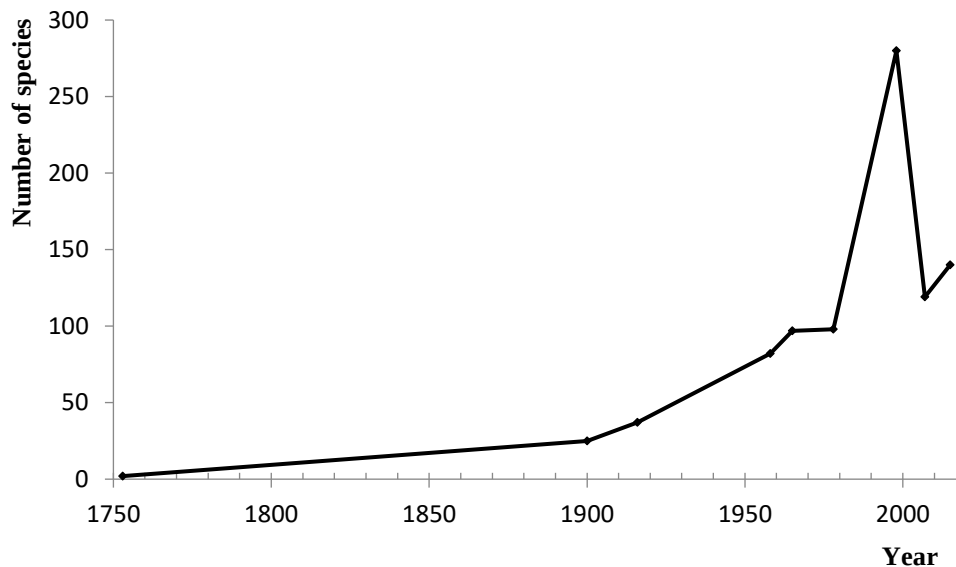


Figure 1.1. The number of *Camellia* species recognised over time.

1.2.2 Controversy of species boundaries

The species boundaries of *Camellia* have been hotly debated as far back as Linnaeus' time. One example comes from the species of sect. *Thea* Griffith of *Camellia*. This section contains tea and its phylogenetically closely-related species whose leaves can be used as beverage. After his description of *T. sinensis* in 1753, Linnaeus (1762) replaced this name with *T. bohea* Linnaeus, an illegitimate replacement name for *T. sinensis* (because Linnaeus [1762: 734 & 735] cited all the referenced illustrations of *T. sinensis* under *T. bohea*, making the latter nomenclaturally superfluous, Articles [Arts]. 6.11, 52.1 & 52.2[d] of the *International Code of Nomenclature for*

Algae, Fungi, and Plants [ICN], McNeill et al. 2012), and added a new species, *T. viridis* Linnaeus. These two names represented ‘black tea plant’ and ‘green tea plant’, respectively, but both are usually treated as the same species, *C. sinensis* (Sims 1807, Seemann 1859, Sealy 1958, Zhang 1981a, 1998, Zhang & Bartholomew 1984, Min 2000, Min & Bartholomew 2007, Zhao et al. 2017b). Since then, many other names for tea have been published. In 1958, Sealy recognised 54 synonyms of *C. sinensis* while Min merged 61 in 2000.

Moreover, different taxonomists’ treatments of the collections of tea plants from China led to a great expansion in sect. *Thea*, accompanied by huge controversies. Min (1992) merged Zhang’s (1981a, 1981b, 1984) sections *Thea* and *Glaberrima* Hung T. Chang, including 47 species in total, into a broader sect. *Thea* and only recognised 12 species. Then, Zhang et al. (1996) selected 18 disputed species from Zhang’s sect. *Thea*, which represented seven species according to Min’s (1992) taxonomy, and insisted that 16 of them were real. Moreover, Zhang (1996b) emphasized that his sect. *Glaberrima* (three species) was valid and that Min’s (1992) argument was groundless. Nevertheless, Min insisted that his taxonomy was correct (Min 2000, Min & Bartholomew 2007). However, Chen et al. (2000) considered that Zhang’s (1998) taxonomy of sect. *Thea* was detailed but excessively subjective whereas Min’s (1992) species boundaries were clearer, but that there were still too many species in Min’s sect. *Thea*. Therefore, they (Chen et al. 2000) only recognised five species in this section. Similar intense debates happened about sections *Archeamellia* Sealy, *Chrysantha* Hung T. Chang (Zhang 1979, 1991, 1996a, Min & Zhang 1993, Zhang & Ye 1993), *Camellia* (Zhang 1989, Liu et al. 1991, Min 1998), *Camelliopsis* Pierre (Sealy) and *Theopsis* Cohen-Stuart (Zhang 1981a, 1998, Zhang & Bartholomew 1984, Min 2000, Min & Bartholomew 2007).

In the preface of Min’s (2000) monograph of *Camellia*, Wu (Wu Zhengyi or Cheng Yih Wu; abbreviation: C.Y. Wu; Chinese: 吴征镒), the last Editor-in-Chief of *Flora Reipublicae Popularis Sinicae* (FRPS), stated that Min (2000) ‘clarified the severe chaos and mistakes of many species’ (original in Chinese: 澄清了不少种类的严重混乱和错误). As the author of the account of *Camellia* in FRPS, Zhang acknowledged that his former works (Zhang 1981a, Zhang & Bartholomew 1984) contained ‘too many’ species (Tremblay 2007: 11), but he still recognised 280 species of *Camellia* when he was 84 years old (Zhang 1998). However, where do these ‘chaos and mistakes’ come from and, why?

Objectively, natural variation in *Camellia* is widespread. Not only do a series of morphological characters vary considerably within species (Kondo et al. 1989, Zhao & Yang 2012), but many genes (Xiao 2001, Vijayan et al. 2009) and even whole genomes also change frequently (Xia et al. 1994, Gu 1997).

Morphological variation has been understood and treated in different ways. For instance, the number of locules in the ovary, was usually employed to distinguish different species (Min 2000),

and sometimes different sections and subgenera (Zhang & Bartholomew 1984); however, locule number can be variable within a monospecific population or even in a single individual (Zhao & Yang 2012).

The species of *Camellia* possess relatively high levels of genetic diversity. Allozymic investigation using 17 polymorphic loci and 60 populations of *C. japonica* by Wendel & Parks (1985) suggested that the genetic diversity was ‘very high’ (mean number of alleles per locus, $A = 2.16$; expected heterozygosity, $H_E = 0.27$). This conclusion was supported by another analysis using four microsatellite (or simple sequence repeat, SSR) loci and 518 samples of *C. japonica* ($A = 16.5$, $H_E = 0.84$, Ueno et al. 2000). Using 20 primers of RAPD (random amplified polymorphic DNA), eight primer combinations of AFLP (amplified fragment length polymorphism) and 120 individuals, Tang et al. (2006) analysed the genetic diversity of *C. nitidissima* C.W. Chi, a synonym of *C. petelotii* (Min & Zhang 1993), and indicated that the intraspecific genetic diversity was ‘relatively high’ based on the percentage of polymorphic loci (78.1% for RAPD and 72.5% for AFLP), H_E (0.27 for RAPD and 0.24 for AFLP) and Shannon’s index (0.40 for RAPD and 0.37 for AFLP). The ‘abundant variation’ was also detected in *C. taliensis* (W.W. Smith) Melchior by chloroplast *rpl32-trnL* (haplotype diversity, $h = 0.84$) and nuclear *PAL* (phenylalanine ammonia-lyase) ($h = 0.84$) markers (Liu et al. 2012), as well as in our former work using 14 microsatellite loci and 587 samples ($A = 6.78$, $H_E = 0.60$, Zhao et al. 2014). A widely used nuclear DNA (nuDNA) marker, ITS (internal transcribed spacer region of 18S–26S nuclear ribosomal DNA, Baldwin et al. 1995, China Plant BOL Group et al. 2011), was reported to have variable multiple copies in the genome of *Camellia* species, which makes phylogenetic analyses of *Camellia* expansive and labour-consuming (Vijayan & Tsou 2008, Vijayan et al. 2009) because of the inability to directly sequence from PCR products using Sanger sequencing (Sanger & Coulson 1975, Sanger et al. 1977a, 1977b). Moreover, more than 15 species of *Camellia* have lost or added whole genomes, yielding variable ploidies (Min 2000). For instance, *C. reticulata* Lindley, an ornamental and oil source species (Min 2000), is usually hexaploid but tetraploids and diploids have also been reported (Xia et al. 1994, Gu 1997).

Genetic and environmental reasons may account for the highly variable morphological characters of *Camellia*. On the one hand, many species have been readily hybridized with each other in species compatibility experiments (Hilsman 1961, Ackerman 1973, Takeda 1990, Charvet 2008), and some of them were found living in the same habitat together and flowering at the same time in natural forest, this may allow gene flow through pollen transfer by non-specialist pollinators (Lea 1996). Hybrids may have variable forms compared with their parents (Bezbaruah & Gogoi 1972, Cheng et al. 1994). On the other hand, morphological and chemical characters changed in cultivation based on nutrient and temporal variation (Wang et al. 1993, Yao et al. 2005). Specimens of the same species collected from several natural habitats that had different light, soil and moisture conditions varied in morphology, such as the shape and size of leaves and the colour of flowers (Lea 1996).

Subjectively, different taxonomists may have various opinions on the boundaries of species. The monographers of *Camellia* did not discuss the species concepts they used (Sealy 1958, Zhang 1981a, Min 2000), not unlike most of their counterparts (McDade 1995). In practice, taxonomists, like Zhang (1981a) and Min (2000), might try to use the evolutionary species concept but probably employed a phenetic species concept (De Queiroz 2007), as shown in their different views of the phylogeny of this genus. However, the issue where they disagreed with each other was generally on the delimitation of species: how broad or narrow a species should be (Min 2000: 48). Species delimitation was heavily dependent on their individual knowledge and judgement.

Table 1.1. Different treatments on 21 species of camellias from Jingshaji Valley of China.

	Original names	Zhang 1998	Min 1998	Min 2000	Min & Bartholomew 2007
Zhang 1989	<i>C. albo-sericea</i> ¹	<i>C. albo-sericea</i> ¹	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. brevigyna</i>	‘ <i>C. brachygyna</i> ’ ²	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. brevipetiolata</i>	<i>C. brevipetiolata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. chunii</i>	<i>C. chunii</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. huiliensis</i>	<i>C. pitardii</i>	<i>C. reticulata</i>	<i>C. pitardii</i>	<i>C. pitardii</i>
	<i>C. jinshajiangica</i>	<i>C. jinshajiangica</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. lanosituba</i>	<i>C. lanosituba</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. mairei</i> var. <i>lapidea</i>
	<i>C. minor</i>	<i>C. saluenensis</i>	<i>C. saluenensis</i>	<i>C. saluenensis</i>	<i>C. saluenensis</i>
	<i>C. oligophlebia</i>	<i>C. oligophlebia</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. pentapetala</i>	<i>C. pentapetala</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. pentaphylacoides</i>	<i>C. oligophlebia</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. pentaphylax</i>	<i>C. chunii</i> var. <i>pentaphylax</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	‘ <i>C. stichoclada</i> ’ ³	<i>C. stictoclada</i>	<i>C. reticulata</i> f. <i>albescens</i>	<i>C. reticulata</i> f. <i>albescens</i>	<i>C. reticulata</i>
	<i>C. subliberpetala</i>	<i>C. pitardii</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. tenuivalvis</i>	<i>C. tenuivalvis</i>	<i>C. saluenensis</i>	<i>C. saluenensis</i>	<i>C. saluenensis</i>
	<i>C. xichangensis</i>	<i>C. albo-sericea</i> ¹	<i>C. reticulata</i> f. <i>albescens</i>	<i>C. reticulata</i> f. <i>albescens</i>	<i>C. reticulata</i>
Liu et al. 1991	<i>C. bailinshanica</i>	<i>C. bailinshanica</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. bambusifolia</i>	<i>C. bambusifolia</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. brevicolumna</i>	<i>C. brevicolumna</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. kangdianica</i>	<i>C. bailinshanica</i>	<i>C. reticulata</i>	<i>C. reticulata</i>	<i>C. reticulata</i>
	<i>C. phelloderma</i>	<i>C. phelloderma</i>	<i>C. reticulata</i>	<i>C. mairei</i> var. <i>lapidea</i>	<i>C. mairei</i> var. <i>lapidea</i>

Note: ¹The correct spelling is *C. albo-sericea* (Min 1998, Art. 60.9). ²Typographical error for *C. brevigyna* (Min & Bartholomew 2007). ³Typographical error for *C. stictoclada*. The latter was shown in the Keywords of the protologue (Art. 60.1).

One notable example comes from the controversies around camellias in the Jinshajiang Valley of China. Zhang and his collaborators published 21 new species of camellias found in Jinshajiang Valley (Zhang 1989, Liu et al. 1991, Table 1.1). After seven years, six of these species were combined with other species, one was treated as a variety and 14 of them remained as accepted

species according to Zhang (1998) himself. By contrast, Min (1998) combined 17 of them with *C. reticulata*, merged two of them into *C. reticulata* f. *albescens* (Hung T. Chang) T.L. Ming and treated the other two species as synonyms of *C. saluenensis* Stapf ex Bean. Later, Min (2000) revised his treatments and finally recognised that these camellias represented only three species and one variety (Min & Bartholomew 2007, Table 1.1). Min (1998) reported that wide morphological variation occurred in *C. reticulata*, including the shape and size of leaf, the colour and size of flower, the proportion of the length of the outer filaments that is tubular and the number of locules per ovary, as well as varying in ploidy. Xiao (2001: 96) investigated the morphological variation of these camellias and considered that Zhang had a very narrow concept of species whereas Min's broad circumscription of species resulted in the 'wrong species combinations'. His (Xiao 2001) morphological and molecular analyses suggested that there were at least three distinct groups, named the *C. xichangensis* Hung T. Chang group, the *C. minor* Hung T. Chang group and the *C. chunii* Hung T. Chang group, and that Min's broader *C. reticulata* was not supported.

1.2.3 Species delimitation: how to be more 'objective'?

A hot debate on different species concepts, including biological, ecological, evolutionary, phylogenetic and phenetic species concepts (De Queiroz 2007), and their applications (Luckow 1995), are prevalent in systematics for decades (Mayr 1942, Simpson 1951, Hey 2006). As suggested by De Queiroz (2007), the various species concepts may represent a 'different property' from a unified species concept. However, a species concept does not equal species delimitation. Most plant taxonomists may not care about the former (McDade 1995), but they do debate with each other on the latter (Wiens & Servedio 2000, Lim et al. 2012). Though there were many controversies on the boundaries of *Camellia* species as introduced above, some consensus is likely to be adopted by qualified taxonomists who generally for *Camellia*:

- (a) Avoid describing cultivated plants with the ICN (McNeill et al. 2012) and name them instead using the *International Code of Nomenclature for Cultivated Plants* (Brickell et al. 2009). Unfortunately, many authors seemed to neglect this option (Zhang 1961, 1984, Hu 1965b, Wang et al. 2011, Ma et al. 2012).
- (b) Recognise that the species of *Camellia* are highly variable. Thousands of cultivars of *C. japonica*, *C. reticulata*, *C. sasanqua* Thunberg, *C. oleifera* C. Abel and *C. sinensis* show the capacity for variation in *Camellia* (Web *Camellia* Register: <http://camellia.unipv.it/camelliadb2/>). By contrast, the natural variation of a single species has always remained obscure because of the poor accessibility of many specimens deposited in various herbaria worldwide, the time, labour and money consuming nature of taxonomic work indoors (Kemler 2015), the usually insufficient and high cost of field work in remote forests and the disproportionately poor reward to plant taxonomists (Krell 2000). These reasons might partly explain why some researchers value every natural mutation and are so eager to recognise it with a new name (Orel & Curry 2015). However, the wide range of variation in cultivars does remind us how broad a natural species of *Camellia* can

be (Wang et al. 1993, 1995). It is unreasonable to suppose that a species should vary narrowly in nature but broadly in cultivation.

(c) Recognise that not only morphology, but data from other sources, such as molecular markers, geographic distribution, pollination biology and chemistry, should all be used in taxonomy when they are available (Judd et al. 2008). The species boundary is a hypothesis which is open to repeated examinations by different taxonomists (Judd et al. 2008). It can be more ‘objective’ as long as more new data and approaches become available to test and revise it (Judd et al. 2008).

1.3 Classifications of *Camellia*

After the establishment of *Camellia* and *Thea* (Linnaeus 1753), Sweet (1818) firstly treated *Thea* as a synonym of *Camellia* (Art. 13 Ex. 3). Blume (1825) proposed *Calpandria* Blume which became a basionym of *Camellia* (Seemann 1859). In his posthumous papers, Griffith (1854) merged *Thea* into *Camellia* and firstly divided this genus into sections *Camellia* and *Thea*. The broad concept of the genus was accepted by Pierre (1887) but he applied *Thea* to it and divided this genus into six sections: *Calpandria* (Blume) Pierre, *Camellia*, *Camelliopsis* Pierre, *Euthea* Pierre, *Piquetia* Pierre and *Stereocarpus* Pierre. By contrast, Cohen Stuart (1916) adopted the name *Camellia* to represent this genus and divided it into five sections: *Calpandria*, *Eriandria* Cohen-Stuart, *Eucamellia* Cohen-Stuart, *Thea* and *Theopsis* Cohen-Stuart. Later, sections *Piquetia* and *Stereocarpus* were separated from *Camellia* and treated as new genera by Hallier (1921). Nakai (1940a, 1940b) supported Hallier’s (1921) treatment of adding two new genera and further divided the remain of *Camellia* into five genera: *Calpandria*, *Camellia*, *Camelliastrum* Nakai, *Thea* and *Theopsis* (Cohen-Stuart) Nakai. In 1958, Sealy merged these seven genera into *Camellia* and divided them into 12 sections. However, Sealy (1958) recognised *Yunnanea* Hu (1956) as an independent genus which was later synonymised with *Camellia* by Zhang (1981a). Though many collections from China were not available to Sealy, his work (Sealy 1958) contained the most species of *Camellia* at that time and laid the foundation of the modern classification of this genus.

Table 1.2. Classifications of *Camellia*.

Classifications	No. of subgenera	No. of sections	No. of species	Year of Publication
Sealy	0	12	82	1958
Zhang	4	22	280	1981, 1984, 1998
Min	2	14	119	2000, 2007

After Sealy’s (1958) work, there were two classifications of *Camellia* which included most known species (Table 1.2). They are presented below.

1.3.1 Zhang’s classification

After examining more collections from China, Zhang (1981a) treated *Yunnanea* and *Glyptocarpa*

(Hu 1965a) as synonyms of *Camellia* and proposed a new classification of this genus. He (Zhang 1981a) firstly divided *Camellia* into four subgenera (Figure 1.2, Table 1.2): *Camellia* (seven sections), *Metacamellia* Hung T. Chang (two sections), *Protacamellia* Hung T. Chang (three sections) and *Thea* Hung T. Chang (eight sections)—Zhang (1981a: 86) validly published subg. *Thea* as a new taxon, not a name at new rank because Linnaeus' *Thea* was neither directly referenced as required by Arts. 41.5 & 41.6 nor indirectly indicated (Art. 41.8). His work was firstly published in Chinese (Zhang 1981a) and then translated into English with corrections and updating in 1984, with the help of Bruce Bartholomew (Zhang & Bartholomew 1984). His final account of *Camellia* from China, written in Chinese, was a part of FRPS (Zhang 1998).

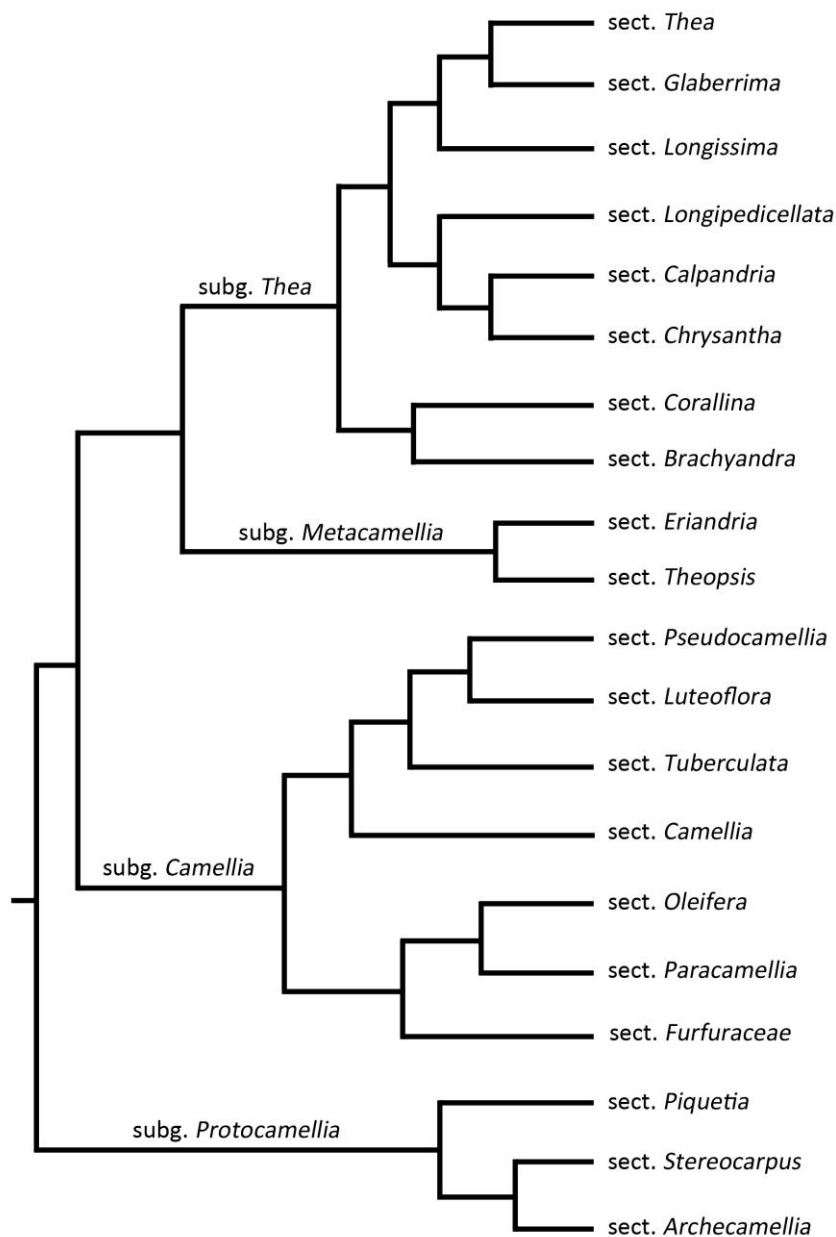


Figure 1.2. Zhang's opinion of the phylogeny of *Camellia*, generally based on his understanding of the morphological character evolution. Revised and redrawn from Zhang (1981a) and Zhang & Bartholomew (1984). The position of subg. *Protacamellia* is amended to represent a clade.

Zhang (1981a) emphasized a list of characters, such as whether the flower was subsessile or pedicellate, whether the bracteoles and sepals were differentiated, the number of bracteoles and sepals, the number of locules in the ovary, whether styles were free or connate and the size of flower and fruit, and employed them to distinguish different subgenera. Other characters, for instance, flower colour, whether the filament was free or connate, indumentum of ovary and the structure of the capsule surface, are mainly used to form different sections. The characters of the vegetative organs, including the indumenta of branchlet, leaf and sepal, and the shape of leaf and sepal, were often used to delimit species. Moreover, subsections and series were used by Zhang to categorise similar species in relatively large sections, like sect. *Camellia*.

Zhang's (1981a) treatment was the first relatively complete classification of *Camellia* (Figure 1.2). It was very different to that of Sealy (1958). Not only were many new materials added into this classification, but the circumscription of the sections was changed from Sealy's (1958) work, and frequently revised by Zhang himself. For instance, Zhang transferred the type of sect.

Archecamellia (Sealy 1958), *C. petelotii*, into his sect. *Longipedicellata* Hung T. Chang and selected *C. granthamiana* Sealy as the type of his amended sect. *Archecamellia* (Zhang 1981a, Zhang & Bartholomew 1984) and established another section named *Chrysantha* (type: *C. chrysantha* [Hu] Tuyama), to categorise the yellow camellias (Zhang 1979). Min and Zhang (1993) pointed out that Zhang's (1981a) treatment of sect. *Archecamellia* was illegitimate (Art. 53.1) and combined *C. chrysantha* with *C. petelotii*, and therefore treated sect. *Chrysantha* as a heterotypic synonym of sect. *Archecamellia*. Subsequently, Zhang (1996a) corrected his illegitimate treatment and put *C. petelotii* back into his sect. *Archecamellia* but emphasized that the flower colour of *C. petelotii* was white and different from that of *C. chrysantha*, so his sect. *Chrysantha* remained valid. Although the flower colour of *C. petelotii* was recorded neither on the type specimen (A. Petelot 848, Min & Zhang 1993) nor in the protologue (Merrill 1924), subsequent collections and investigations did verify that the flower colour of *C. petelotii* was yellow, not white (Rosmann 1997, Tran & Hakoda 1998a, Gao et al. 2005). A similar illegitimate treatment happened in sect. *Camellia* (Zhang 1981a, Min 1998) and was corrected later (Zhang & Bartholomew 1984).

Moreover, Zhang (1981a) clarified the circumscription of sect. *Theopsis* to include only the species with glabrous ovaries and transferred those species with pubescent ovaries of Sealy's sect. *Theopsis* into his sect. *Camelliopsis*. Later, Zhang and Bartholomew (Zhang & Bartholomew 1984: 199) incorrectly considered that sect. *Camelliopsis* proposed by Pierre (1887) under *Thea* and subsequently transferred into *Camellia* by Sealy (1958) was 'illegitimate' and adopted Cohen Stuart's (1916) sect. *Eriandria*. Furthermore, Zhang (1981a) abandoned Sealy's sect. *Heterogenea* Sealy, that Sealy (1958: 152) himself had called 'a collection of diverse species', and transferred those ten species into different sections (Zhang 1981a, Zhang & Bartholomew 1984).

1.3.2 Min's classification

Though there was a significant development from Sealy's (1958) taxonomy, Min (2000)

considered that the concepts and ranges of subgenera and sections in Zhang's (Zhang 1981a, 1998, Zhang & Bartholomew 1984) classification were not correct, nor was his very narrow circumscription of species. Therefore, Min (2000) revised and divided *Camellia* into two subgenera, *Thea* (eight sections) and *Camellia* (six sections), mainly based on whether the flowers were pedicellate or subsessile and the morphology of the bracteoles and sepals (Figure 1.3, Table 1.2, Min 2000, Min & Bartholomew 2007). However, Min's (2000) *Monograph of the Genus Camellia* was written in Chinese and did not attract attention internationally. In the FOC, Min & Bartholomew (2007) supplied an updated English edition of the classification of *Camellia* species in China. Unfortunately, the account of *Camellia* in FOC did not fully illuminate Min's (2000) classification.

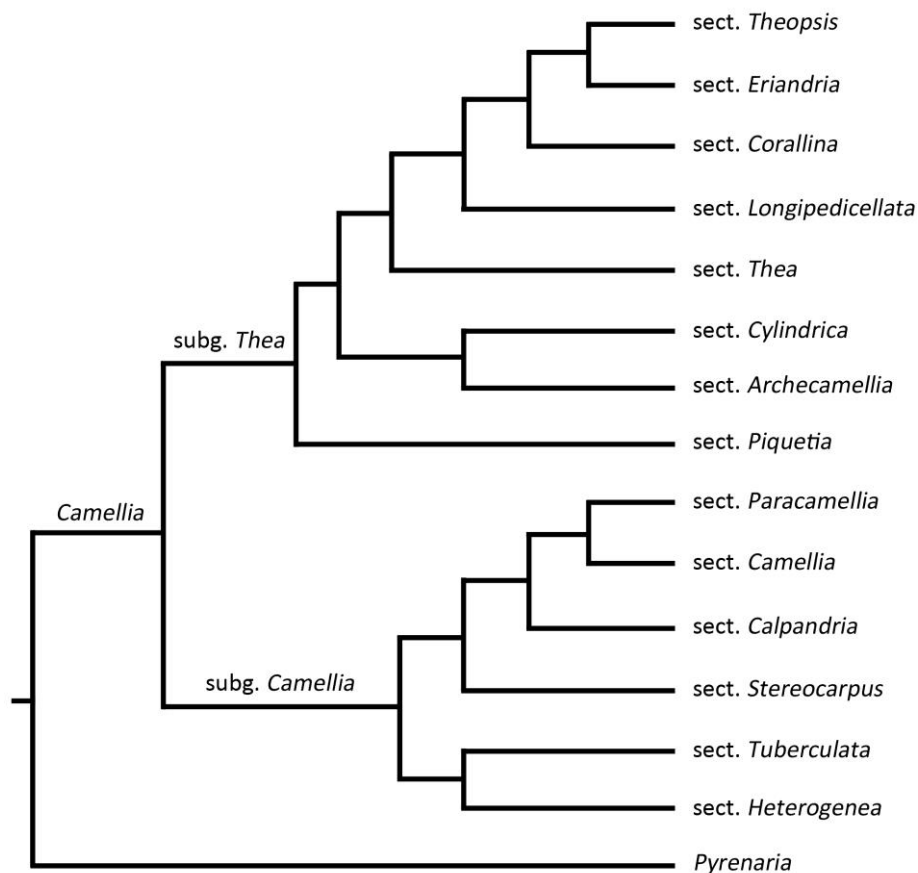


Figure 1.3. Min's (2000) phylogenetic tree of *Camellia*, based on morphological data. Redrawn from the original.

Min's (2000) classification was generally derived from that of Sealy (1958). He (Min 2000) retained Sealy's ten sections but agreed with the treatment of Zhang and Bartholomew (1984) of sections *Eriandra* (Min [2000: 192] incorrectly treated sect. *Camelliopsis* as a synonym of sect. *Eriandra*) and *Theopsis* but amended the circumscriptions of species. Remarkably, Min and Bartholomew (2007) adopted sect. *Eriandra* in the hardcopy and online PDF file of FOC but the online hypertext markup language file of FOC used sect. *Camelliopsis* (http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=317155). Min (2000: 210)

considered that sect. *Heterogenea* was a ‘natural group’ due to the white and sessile flowers and free styles. Compared with Zhang’s (1981a) classification, Min (2000) reduced the number of subgenera and sections and abandoned the ranks of subsection and series. For instance, he (Min 2000) merged Zhang’s sections *Chrysantha* and *Pleurocarpus* Hung T. Chang into sect. *Archecamellia*, treated sect. *Longissima* Hung T. Chang as a synonym of sect. *Longipedicellata* and transferred some species in sect. *Pseudocamellia* Sealy and all species in sections *Furfuracea* Hung T. Chang and *Protocamellia* Hung T. Chang into his sect. *Heterogenea*.

1.3.3 Other research

Hô (1991) counted 29 species of *Camellia* from Vietnam based on Zhang’s (1981a) classification. In his concise account, Hô (1991) firstly merged *Dankia* Gagnepain into *Camellia* without any comment. Unfortunately, Hô’s (1991) treatment had not been noticed by Min (Hô’s [1991] work was absent in Min’s [2000] references) nor by Zhang, probably because his *Cayco Vietnam* was written in Vietnamese and did not attract their attention.

Orel et al. (2013: 439) considered that though the arrangement of *Camellia* of Gao et al. (2005) generally following Zhang (1981a), the differences between Gao et al.’s (2005) arrangement and Zhang’s (1981a) classification were ‘sometimes rather substantial (e.g. in *Camellia* sect. *Archecamellia*)’—a typographical error of sect. *Archecamellia*—and that this arrangement ‘may be considered to be a fourth taxonomic treatment of the genus’. However, in their book, Gao et al. (2005: 22) introduced a single species, *C. amplexicaulis* (Pitard) Cohen-Stuart, of sect. *Archecamellia* following Zhang’s (1996a) treatment and further commented that ‘since *C. petelotii* is yellow-flowered, it has been moved to section *Chrysantha*.’—as elaborated in Section 1.3.1 above, *C. petelotii* was the type of sect. *Archecamellia* and this ‘substantial’ arrangement (Orel et al. 2013: 439) was merely a repeated mistake.

Recently, several new sections of *Camellia* represented by collections from southern Vietnam have been established. For example, Orel and Wilson (2010b) proposed sect. *Dalatia* Orel which nested in Zhang’s subg. *Protocamellia* Hung T. Chang (Zhang & Bartholomew 1984). Later, another new section, *Bidoupia* Orel, Curry & Luu was described (Orel et al. 2012). However, Orel et al. (2014a) began to favour Sealy’s (1958) taxonomy when they established the new sections *Capitatae* Orel and *Pierrea* Orel. All these new sections are discussed in Chapter 4.

1.4 Phylogeny of *Camellia*

Since several genera were excluded to form the Pentaphylacaceae Engler, the Theaceae Mirbel ex Ker Gawler (Ericales, Asterids, according to the APG IV 2016) has been narrowed to include about nine genera (Prince 2007). The Theaceae is nested in a different clade from the Pentaphylacaceae: both families are monophyletic (Schönenberger et al. 2005). Three tribes have been recognised in the Theaceae: Gordonieae (three genera), Stewartieae (one genus) and Theeae (five genera, Figure 1.4, Prince & Parks 2001, Li et al. 2013). *Camellia* nests in the Theeae and its phylogenetically

closest genus is *Pyrenaria* Blume, according to the analyses using plastid DNA markers (Prince & Parks 2001, Li et al. 2013), the second largest subunit of ribonucleic acid polymerase II (*RPB2*) regions (Xiao 2001) and morphological characters (Wang et al. 2006). However, an investigation using ITS suggested that *Polyspora* Sweet and *Camellia* were sister groups and that species of *Camellia* formed a monophyletic group (Li et al. 2011). The monophyly of *Camellia* was also supported by investigations using *RPB2* (Xiao 2001, Xiao & Parks 2003) and ITS (Vijayan et al. 2009). Another analysis using cpDNA markers (*atpI-H*, *matK*, *psbA5' R-ALS-11F*, *rbcL*) and the nuDNA *LEAFY* gene suggested that *Camellia* was not monophyletic but formed a clade with *Pyrenaria* s.l. (containing *Parapyrenaria* Hung T. Chang and *Tutcheria* Dunn, Zhang et al. 2014).

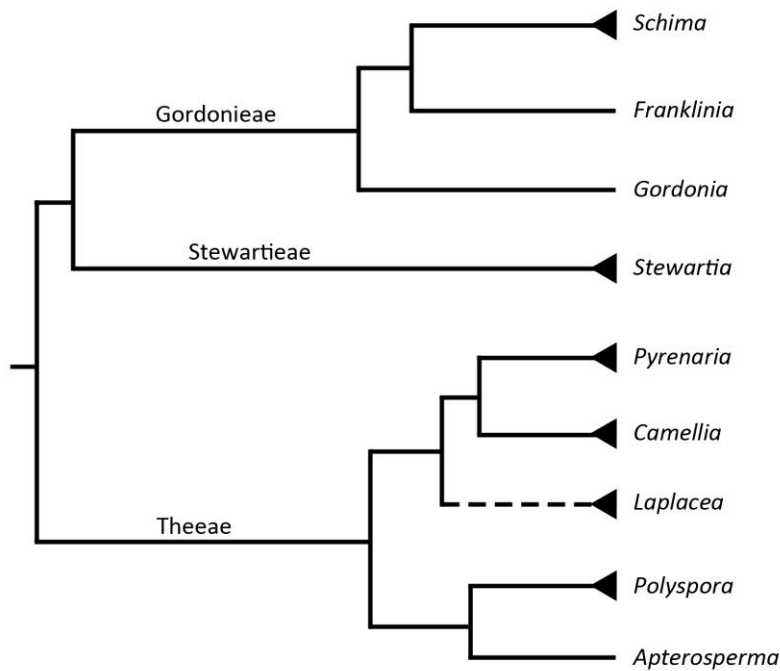


Figure 1.4. Summarized phylogenetic tree of the Theaceae using plastid DNA data (Li et al. 2013). Dashed line indicates an inferred position based on Prince & Parks (2001). Triangle at the tip of clade indicates the group has more than one species. Redrawn from the original.

1.4.1 Relationships proposed using the methods of evolutionary taxonomy

Evolutionary taxonomy has prevailed in plant systematics throughout the last century (Stevens 1986). Taxonomists tried to reconstruct an evolutionary route for the main groups of plant, such as different orders, through some guidelines that defined which character state was ‘primitive’ or ‘derived’, based on their understanding of paleobotanical, embryological, palynological, anatomical and other available data (Cronquist 1957, Thorne 1958, Stevens 1986). Three monographers of *Camellia*, Sealy, Zhang and Min, were all deeply influenced by this hypothesis.

In his monographs of *Camellia*, Zhang (Zhang 1981a: 1, Zhang & Bartholomew 1984: 13) discussed four deficiencies of Sealy’s (1958) work. One of them was that ‘he did not emphasize the taxonomic relationships’. But Sealy (1958) did state his view about the evolutionary history of

Camellia, only without a tree-like diagram to show the relationship. For example, Sealy (1958: 27) considered that sect. *Archecamellia* (type: *C. petelotii*) was the ‘base-group’ from which the other known species ‘could have been derived’. Sealy’s (1958: 27) view arose because he considered that the pedicellate flower and 11–16 ‘not clearly differentiated’ bracteoles and sepals were the ‘primitive’ character states in *Camellia*.

However, Zhang presented the first illustrated ‘phylogenetic tree’ of *Camellia* to explain his understanding on the evolution of different sections, accompanied by five ‘rules’ to explain ‘primitive’ and ‘derived’ character states by which he believed that the phylogeny could be ‘traced’ (Zhang 1981a, Zhang & Bartholomew 1984). His main points are shown in Figure 1.2 though in his original tree-like graph, the subg. *Protocamellia* was located at the root as the ‘common ancestor’ rather than as shown in Figure 1.2, and three main clades were simultaneously derived from this root (Zhang 1981a, Zhang & Bartholomew 1984). In his opinion (Zhang 1981: 4, Zhang & Bartholomew 1984: 16), the ‘primitive’ character states included numerous undifferentiated bracteoles and sepals, numerous free petals and stamens, five free styles and ‘a central columella’ in the ovary. The type of his subg. *Protocamellia* and sect. *Archecamellia* was *C. granthamiana* (Zhang 1981, see Section 1.3.1 above).

Sealy’s (1958) view had given Min (2000: 67) ‘profound inspiration’. Min and Zhang (1996) presented a tree-like diagram to explain the phylogenetic relationship of *Camellia*. Later, Min (2000) revised it in his monograph of *Camellia*, as shown in Figure 1.3. Min (2000: 72) considered that sect. *Piquetia* (type: *C. piquetiana*) was the most ‘primitive’ taxon because of its large leaf, short raceme, persistent bracteoles and sepals and five nearly distinct carpels (see Section 1.3.2 above).

However, as pointed out by Min (2000: 52) himself, the ‘phylogenetic relationship’ reconstructed using the method of evolutionary taxonomy often varied between different researchers. Some researchers even thought that such classification was ‘an art, rather than a science’ (Hull 1967), which may suggest how subjective this method is (Judd et al. 2008).

1.4.2 Phylogenetic method

After his first attempt of using the methods of evolutionary taxonomy to reconstruct the phylogeny of *Camellia*, Min (2000: 71) proposed another phylogenetic tree of this genus using the approach of Hennig’s (1965) phylogenetic systematics. Data of 27 morphological characters were collected from his 14 sections of *Camellia* and were analysed by section. Min (2000: 68) argued that there were too many species of *Camellia* to readily analyse by species and he believed that almost all taxa in his classification were ‘relatively natural’. His (Min 2000) investigation suggested that sect. *Piquetia* was sister to all other 13 sections and the latter was divided into two clades, coinciding with pedicellate and sessile flowers. Unfortunately, neither Zhang nor Min discussed the implication of molecular phylogenetic methods for reconstructing the phylogeny of *Camellia*,

though this new approach was so prevailing and critical in plant taxonomy at the end of 20th century (Chase et al. 1993, Chaw et al. 1997, Oxelman et al. 1997) and it had been used in research on the Theaceae (Morton et al. 1996) and even with *Camellia* (Prince & Parks 1997).

The first molecular phylogenetic analysis of *Camellia*, using a large-scale sampling of species, was undertaken by Xiao Tiaojang, which was presented in his Ph.D. thesis (Xiao 2001) and reported subsequently (Xiao & Parks 2001, 2002, 2003). The nuDNA marker *RPB2* was employed to reconstruct the phylogeny of *Camellia* using 149 species representing 14 sections based on Zhang's (1981a) classification. A summarized phylogenetic tree of this research is shown in Figure 1.5. Unfortunately, the molecular data of *RPB2* were not deposited in a public database, e.g., GenBank, nor were the results published in a peer-reviewed academic journal.

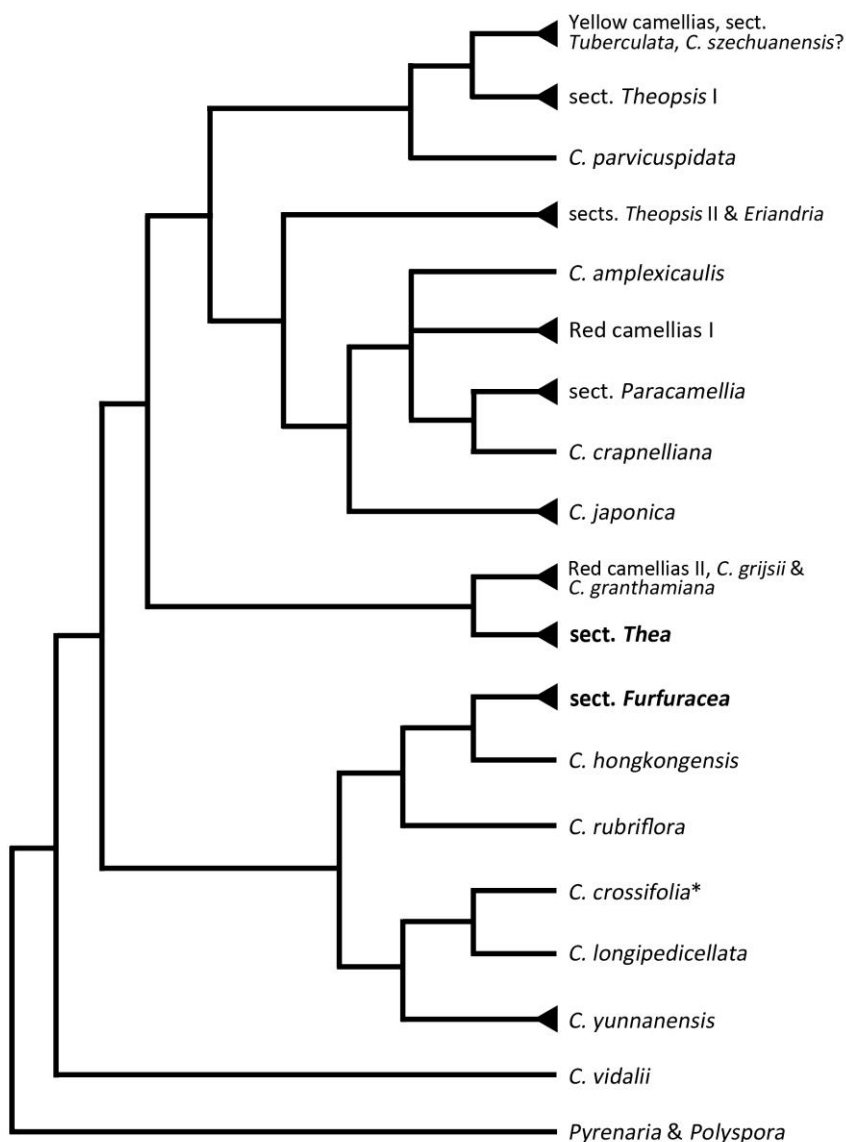


Figure 1.5. Revised one of the 144 equally most parsimonious trees generated by *RPB2* gene (intron 11-16 and intron 23) for *Camellia*, redrawn from Xiao (2001). Triangle at the tip of clade indicates the group has more than one species of *Camellia*. The bold type represents a clade that matches a previous classification. *I failed to find the name '*C. crossifolia*' in any other literature.

The topology of Xiao's (2001) phylogenetic tree (Figure 1.5) is inconsistent with any proposed classification of *Camellia*. No subgenus from either Zhang's (1981a) or Min's (2000) taxonomy is supported. *Camellia vidalii* Rosmann, a species distributed in southern Vietnam with a long leaf ($35\text{--}40 \times 6\text{--}8$ cm), yellow flower, long pedicel (3.5–4.5 cm), one or two bracteoles and five free styles (Rosmann 1999, 2000), appears sister to all other *Camellia* (Figure 1.5). *Camellia vidalii* had not been discussed by Zhang or Min. It was 'provisionally' placed in sect. *Archecamellia* when described (Rosmann 1999) whereas Gao et al. (2005) transferred it into sect. *Thea*. Moreover, according to the extant circumscriptions of sections, only sect. *Thea* and sect. *Furfuracea* are suggested to be monophyletic. Most species of sect. *Chrysanth* are clustered together, formed a clade with species from other sections. Min's sect. *Paracamellia* Sealy excluding *C. grijsii* Hance appears to be monophyletic. Section *Camellia* is polyphyletic and can be divided by geographic distribution. *Camellia hongkongensis* Seemann is closely related to sect. *Furfuracea* and should be excluded from sect. *Camellia*. Other sections are not supported by this analysis (Figure 1.5).

Another attempt to explore the phylogeny of *Camellia* was undertaken by Vijayan et al. (2009) using ITS and 112 species (representing Zhang's [1981a, 1998] 15 sections and Min's [2000] 11 sections). The summarized phylogenetic tree of this research is shown in Figure 1.6. Similarly, no subgenus of an extant classifications is supported. *Camellia pachyandra* Hu, a species occurring in southern Yunnan, China with a moderate size of leaf ($6.5\text{--}11 \times 3\text{--}4.5$ cm), subsessile white flower, six bracteoles and sepals and three free styles (Min 2000), is resolved as sister to all other *Camellia*. Unfortunately, *C. vidalii* was absent in the ITS analysis whereas *C. pachyandra* had not been sampled in the former *RPB2* investigation—both species represented several pairs of extreme variation of morphological character states based on extant classifications (Zhang & Bartholomew 1984, Min 2000). In terms of extant sections, ITS analysis only supports the monophyly of sect. *Thea* and implies that a combined group of both sections *Eriandria* and *Theopsis* is monophyletic (Figure 1.6, Vijayan et al. 2009). The latter result conflicts with that of the *RPB2* investigation (Xiao 2001). The ITS tree suggests that *C. hongkongensis* is a member of sect. *Furfuracea* (Figure 1.6), which concurred with that of *RPB2* research (Figure 1.5).

Single copy chloroplast DNA (cpDNA) markers have been widely used in plant phylogenetic analyses (CBOL Plant Working Group 2009). Fang et al. (2010) analysed 28 species of *Camellia* (representing four subgenera and 11 sections following Zhang [1981a]) using four cpDNA markers (*psbA-trnH*, *rpl16*, *rpl32-trnL* and *trnL-F*). The investigation (Fang et al. 2010) suggested that *C. hekouensis* C.J. Wang & G.S. Fan, a species occurring in southern Yunnan, China with a relatively large leaf ($16\text{--}25 \times 3.5\text{--}7$ cm), white flower, relatively long pedicel (2.5–3.5 cm), three bracteoles and three nearly free styles (Min 2000), was sister to all other *Camellia*. This species was absent in the nuDNA *RPB2* and ITS analyses while *C. vidalii* and *C. pachyandra* were also excluded in this cpDNA investigation. No defined subgenus was supported and sections *Chrysanth* and *Thea* were polyphyletic. Three species from sections *Eriandria* and *Theopsis* formed one clade, implying their

close relationship (Fang et al. 2010).

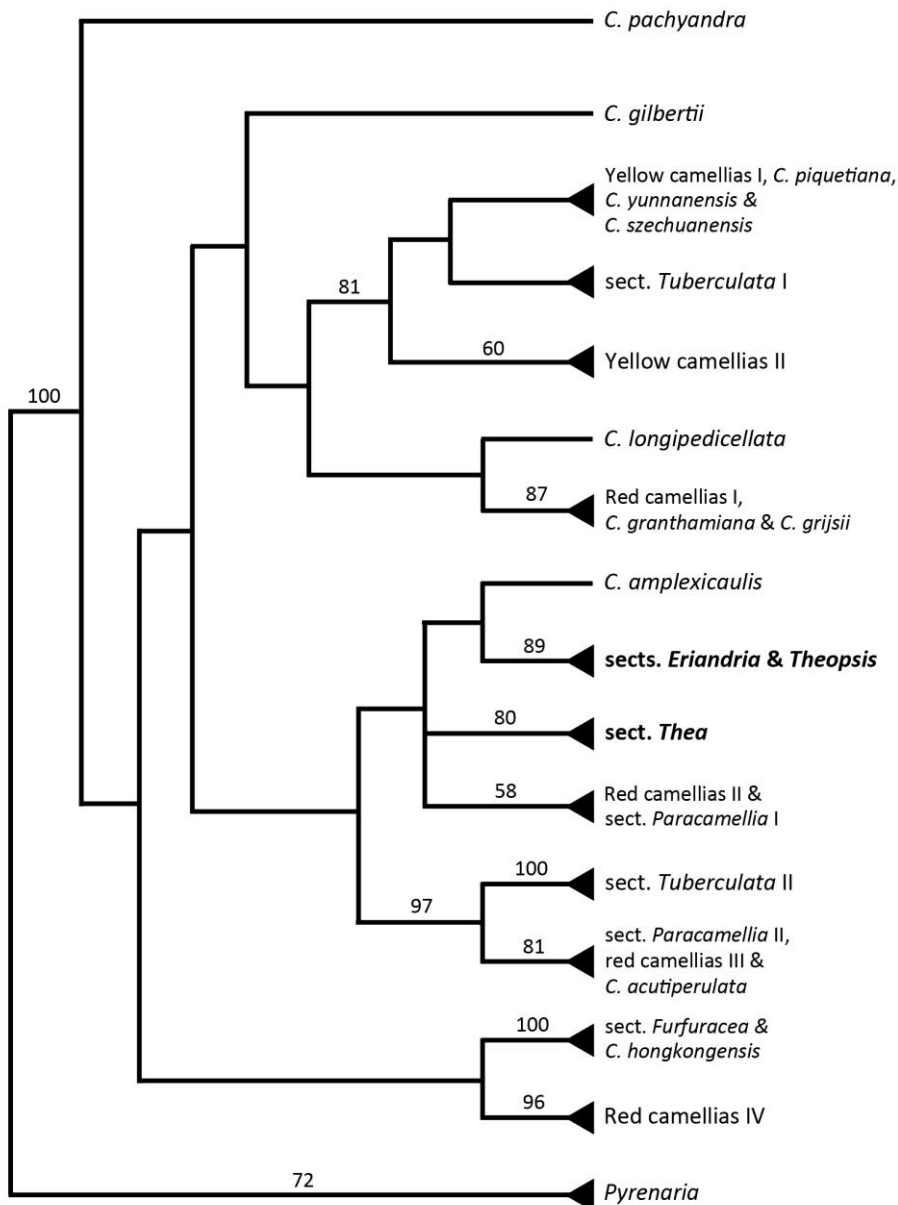


Figure 1.6. Revised most parsimonious tree of *Camellia* species generated by ITS, redrawn from Vijayan et al. (2009). Numbers on the branches represent jackknife values. Triangle at the tip of clade indicates the group has more than one species. The bold type represents a clade that matches a previous classification.

1.4.3 Phylogenetic classification of *Camellia*: difficulties and potential solutions

No new classification of *Camellia* has been proposed based on molecular phylogenetic analyses (Xiao & Parks 2003, Vijayan et al. 2009). Orel and Wilson (2010b: 281) thought that ‘the expected settlement of the majority of contentious taxonomic questions (of *Camellia*) via the molecular genetics based studies may still be far in the future, or may not be achievable at all’. The conflicts between extant classifications and molecular phylogenetic trees may stump those taxonomists who

wanted to establish a new ‘natural’ classification of *Camellia*. Based on the data amassed currently (Zhang & Bartholomew 1984, Min 2000, Xiao 2001, Vijayan et al. 2009, Fang et al. 2010, Zhang et al. 2014, Orel & Curry 2015), there are two main difficulties about the phylogenetic reconstruction of *Camellia*.

Firstly, conflicts occur between different gene trees of *Camellia* (Xiao 2001, Vijayan et al. 2009, Fang et al. 2010, Zhang et al. 2014). Genes may duplicate, mutate, be lost or horizontally transferred and may have their own unique evolutionary history (Rosenberg & Nordborg 2002, Degnan & Rosenberg 2009, Szöllősi & Daubin 2012). As outlined in Section 1.4.2, the difference between those analyses using nuDNA markers, *RPB2* (Xiao 2001) and ITS (Vijayan et al. 2009), can be seen in Figures 1.5–1.6. The incongruences of gene trees are shown in the results using nuDNA (Xiao 2001, Vijayan et al. 2009) and cpDNA markers (Fang et al. 2010, Zhang et al. 2014) as well.

Secondly, gene trees (Xiao 2001, Vijayan et al. 2009, Fang et al. 2010) contradict the proposed phylogenetic tree based on morphological data (Min 2000). Different DNA markers have their own evolution histories, which are so varied that they do not equally reflect or necessary concur with the evolutionary route of host species (Maddison 1997, Page & Charleston 1997, Szöllősi et al. 2015). Unfortunately, a clear ‘natural’ morphological character based tree has yet to be produced in *Camellia* so it is impossible to interpret or improve the gene trees with the help of such a tree. Conversely, a consensus gene tree with sufficient detail is also unavailable in *Camellia*. This dilemma suggests that neither gene trees reconstructed by molecular data nor phylogenetic trees proposed based on morphological data can be confidently used to establish a new phylogenetic classification.

However, I do not believe that the settlement of taxonomic controversies of *Camellia* will ‘not be achievable at all’ (Orel & Wilson 2010a: 281). When all the relevant data are collected and scrutinised comprehensively, critical problems can be identified and potential ways can be subsequently proposed to solve them. The following points are particularly relevant in this regard:

(a) More samples are needed, especially those from Indochina, to fill the data gaps in the gene trees. A comprehensive comparison between different gene trees is impossible because of the lack of critical samples of *Camellia*. For example, *C. pachyandra* should be added to the analysis using *RPB2* markers (Xiao 2001) whereas *C. vidalii* must be present in the tree generated by ITS data (Vijayan et al. 2009), then it may be clear which of these species appears sister to other *Camellia*. Moreover, species from Indochina, especially the endemic ones, were disproportionally neglected in previous molecular analyses which generally sequenced the taxa distributed in China (Xiao 2001, Vijayan et al. 2009). Filling the data gaps would dramatically improve the resolution and accuracy of gene trees (Hillis 1996, Graybeal 1998).

(b) Morphological characters are still vital in any new classification based on phylogenetic analysis

because they remain the primary and common means by which species are identified and classified (Judd et al. 2008). The value of morphology for phylogenetics might be questioned in *Camellia* since all subgenera and almost all sections are not supported to be monophyletic by molecular data (Xiao 2001, Vijayan et al. 2009). However, a careful re-examination and evaluation of widely used morphological characters is nevertheless needed to suggest the potential synapomorphies of different groups.

(c) All available data are needed. For example, intensive breeding experiments have been undertaken by the enthusiasts of *Camellia* (Hilsman 1966, Ackerman 1970, Charvet 2009, Gao et al. 2013). Species compatibility data are invaluable in understanding the relationship between various species (Ackerman 1973), which can cross validate other results from molecular and morphological investigations (Parks 1992). Moreover, phylogenetically closely-related species usually share similar chemical constituents and that has been employed to support the monophyly of sect. *Thea* (Li et al. 1998, Gao et al. 2008, Liu et al. 2009). Each kind of data can play a specific role in the interpretation of evolutionary history and therefore is critical to a comprehensive understanding of phylogeny.

1.5 Data used for taxonomy

Many characters have been employed to distinguish species and make interspecific relationships clear in *Camellia*. They are introduced below.

1.5.1 Macro-morphology

Macro-morphological characters are the fundamental traits by which taxonomists identify *Camellia* species in the field, as well as the main data used to produce different classifications (Sealy 1958, Zhang & Bartholomew 1984, Min 2000). The characters of flower, fruit and seed are more likely selected to categorise species into sections, while the characters of vegetative organs are mainly employed to distinguish different species (Sealy 1958, Zhang & Bartholomew 1984, Min 2000).

1.5.2 Leaf anatomy

Leaf epidermal characters, such as the shape of cells, pattern of anticlinal walls and stomatal apparatus have been studied in *Camellia* and their taxonomic value discussed, which suggested that these characters may be used to delimit species but fail to support the relationship of sections (Ao et al. 2002b, 2007). However, it indicated that *C. pachyandra* had special secretory cells and tetracytic stomatal apparatus, which were unique in *Camellia* (Ao et al. 2007). Remarkably, this result corresponded with that of ITS analysis of Vijayan et al. (2009), which may supply a unique insight into the taxonomy of *Camellia*. Pi et al. (2009) explored the delimitations of species in sect. *Camellia* with leaf anatomical characters and indicated that this section consists of about 50 species, which generally supported Zhang's (1998) concept of species. Meanwhile, they (Pi et al. 2009) also indicated that more characters were needed to firm up the boundaries of species in *Camellia*. Using secretory structures characters, Jiang et al. (2010) suggested that sect. *Chrysanth*

was distinct with sect. *Archecamellia* and that sect. *Heterogenea* was not supported.

Leaf architecture had ‘certain taxonomic and systematic significance’ in *Camellia* (Sun & Min 1995: 213) based on a classification to be published by Min (1999); however, the systematic value was vague because the character states could not support the subgenera and some of sections of Min’s (1999) taxonomy. Another paper on leaf architecture of *Camellia* with pattern recognition techniques roughly supported the classification of Zhang (1998) but with some species as outliers (Lu et al. 2012).

1.5.3 Pollen morphology

Individual reports of pollen morphology on several species from a single section may amass the data for future research of *Camellia* (Zou & Liang 1984, Wang 1985, Chen et al. 1997). However, a systematic study of palynology generally supported *Camellia* as a homogenous group which could be divided into six types (rugulate–verrucate, coarsely warty, granulate to rugulate–granulate, foveolate–reticulate, rugulate–fossulate, and rugulate with beaded muri) based on the exine sculpture (Wei et al. 1992). The exine sculpture of *C. lanceolata* was coarsely warty, which was unique in this genus. However, there was no correlation between these six palynological types and the classifications proposed by Sealy (1958) or Zhang (1981), a conclusion (Wei et al. 1992) generally supported by Ao et al. (2002a).

1.5.4 Chemistry

Many investigations have focused on the chemical components of leaf, flower and seed of *Camellia* species (Roberts et al. 1958, Gao et al. 2010, Feás et al. 2013). Though the analyses concentrated upon several economically important species, the chemical data did supply valuable information on taxonomy as well as indicating interspecific and intraspecific variation.

For example, caffeine was detected in *C. sinensis* (Nagata & Sakai 1984, Fujimori & Ashihara 1990, Chen et al. 2005) and *C. taliensis* (Nagata & Sakai 1984, Chen et al. 2005). *Camellia irrawadiensis* P.K. Barua, a synonym of *C. taliensis*, was suggested to be caffeine free (Nagata & Sakai 1984, Fujimori & Ashihara 1990) or with a very low concentration (Nagata & Sakai 1985), which was emphasised as evidence to support the idea that *C. irrawadiensis* was distinct from *C. taliensis* by Zhang et al. (1996). This stimulant was also detected in the sample of *C. ptilophylla* Hung T. Chang from Hunan, China (Li et al. 1998) and in *C. crassicolumna* Hung T. Chang (Chen et al. 2005), but it was absent in *C. ptilophylla* from Guangdong (Zhang et al. 1988) nor found in *C. crassicolumna* var. *multiplex* (Hung T. Chang & Y.J. Tan) T.L. Ming (Liu et al. 2009). Another alkaloid, theobromine, was reported occurring in *C. sinensis*, *C. taliensis* and *C. irrawadiensis* (Nagata & Sakai 1985). However, both alkaloids were absent in *C. sasanqua* and *C. japonica* (Nagata & Sakai 1985). Moreover, seed oil contents were reported to vary significantly between different *Camellia* species, as well as in various geographic populations of the same species (Su et al. 2014).

1.5.5 Species compatibility

Breeding tests can reveal the genetic distance between different species. Ackerman (1973) found that sections *Camelliopsis* and *Theopsis* had a close relationship and that the species of sect. *Camellia* hybridized readily with each other except those combinations involving *C. hongkongensis*, suggesting a large genetic distance between *C. hongkongensis* and other species of sect. *Camellia*. These conclusions were supported by subsequent molecular analyses (Xiao 2001, Vijayan et al. 2009). The difficulty of hybridisation within sect. *Theopsis* may indicate genetic isolation during speciation (Ackerman 1973). The hybrid between *C. chrysantha* and *C. vietnamensis* T. C. Huang ex Hu (Nadamitsu et al. 1986) or *C. japonica* (Yamaguchi et al. 1987), and that between *C. japonica* and *C. amplexicaulis* (Lin et al. 2013) individually supplied information on relative genetic distance between different groups within *Camellia*.

1.5.6 Molecular data

Thanks to the cost and labour efficiency, RAPD was once a popular approach employed to investigate the relationship between different species of *Camellia* (Shi et al. 1998, Chen et al. 2002, Chen & Yamaguchi 2005). Though these investigations provided some insights into the classification, the reproducibility of the results of RAPD were questionable (Atienzar & Jha 2006). Moreover, when one species was represented by a single sample in the interspecific analyses, it is not surprising that species can be easily distinguished and categorised into groups using a polymorphic marker system like RAPD (Williams et al. 1990): intraspecific variation should be detected and discussed properly. Another DNA marker based on the length variation of PCR products, microsatellites (or SSR, Tautz 1989), has also been used to distinguish *Camellia* because it has relatively broad transferability (Taniguchi et al. 2012). However, the rapidly evolving SSR marker was mainly employed to detect intraspecific variation, including the variation between different cultivars (Liu et al. 2008) or diversity of populations (Zhao et al. 2014). One critical hypothesis of these DNA markers, including ISSR (inter-simple sequence repeat) PCR (Mondal 2002), RAPD and SSR, is that PCR products with the same size are presumed to represent the same allele of a specific locus regardless of some mutations (e.g., transition and transversion) that may be occurred. This potentially erroneous assumption limited the use of these markers in phylogenetic analysis and they have been largely replaced by DNA sequencing which has become cost efficient.

Several nuclear and chloroplast DNA regions have been used to reconstruct phylogenetic trees in *Camellia* as elaborated in Section 1.4.2. Some analyses of *Camellia* found that the PCR products of ITS failed to be directly sequenced (Yang et al. 2006a, Orel & Curry 2013a). Technical investigation indicated that ITS had multiple copies in *Camellia* and the PCR error rate was high using *Taq* polymerase, so *Pfu* polymerase and cloning before sequencing were recommended (Vijayan & Tsou 2008, Vijayan et al. 2009). Similarly, the *LEAFY* gene also needed cloning before sequencing (Zhang et al. 2014). However, other nuDNA markers, *RPB2* (Su et al. 2009) and *waxy* (Yang et al. 2006a), can be successfully directly sequenced using PCR products. Analysis using

several cpDNA regions showed that these markers had a very slow rate of evolution in *Camellia*, which may not be sufficiently informative in phylogenetic analyses (Yang et al. 2006a, Fang et al. 2010, Zhang et al. 2014). There are also data of several *Camellia* species from *matK* (Prince & Parks 2001) and *matR* (Yang et al. 2006b) to be found in GenBank (<https://www.ncbi.nlm.nih.gov/genbank/>).

Currently, complete chloroplast genome analyses have been employed to reveal the phylogeny of *Camellia* with huge quantities of data from several species (Yang et al. 2013, Huang et al. 2014, Wang et al. 2017). It is a powerful approach that may give new insights into a unique part of the detailed evolutionary history of species because the chloroplast is a maternally inherited plastid in *Camellia* (Corriveau & Coleman 1988, Kaundun & Matsumoto 2011). Unfortunately, this method may need fresh leaf material (Yang et al. 2014a) and is of a much higher cost compared with that using several DNA regions.

1.5.7 Other data sources

Biochemical profiles produced using Fourier transform infrared spectroscopy was believed to be a dense source of data from cell components. Shen et al. (2008) found that the data generated by this approach showed some taxonomic value for 63 *Camellia* species. However, intraspecific variation was completely neglected in the experimental design of this research and the data should be interpreted with great caution.

Cytological studies may supply some systematic information, especially the character of chromosome number and structure and genome size (Huang et al. 2013). Most *Camellia* species are diploids with 30 chromosomes (Kondo 1977, Ackerman & Kondo 1980, Min 2000). However, some species of *Camellia* have varied ploidies in different populations. For example, *C. caudata* Wallich was reported to have both diploids (Bezbaruah 1971) and tetraploids ($2n = 60$, Gu & Sun 1997), and *C. forrestii* (Diels) Cohen-Stuart had diploids, tetraploids and hexaploids ($2n = 90$, Gu et al. 1988).

Allozyme or isozyme analysis using electrophoresis has been used in *Camellia* taxonomic investigations and showed its value on identifying different species (Nagato 1979, Chen et al. 2005) or intraspecific populations (Nagato & Osone 1982). This approach relied on band length comparisons (not protein sequences). It was generally replaced by sequencing of DNA regions because the latter can provide more accurate information regarding the nature of mutation leading to changes in proteins.

1.6 Biogeography of *Camellia*

Though many taxonomists have detailed their views of the origin of *Camellia* and the evolution and dispersal of different sections amid their arguments on its phylogeny, a detailed biogeographic outline of *Camellia* based on relatively objective data is still absent.

The origin of *Camellia* is uncertain because the fossil record of this genus has not been fully resolved. Min (2000: 59) inferred that the origin of *Camellia* was no later than the Cretaceous (ca. 145–66 Ma, Cohen et al. 2013) based on the fossil records of the Theaceae, an estimation with which Zhang (1981a: 11) agreed. However, this date was far earlier than the divergence time estimated using ten plastid markers and two fossil calibration points in which *Camellia* and *Pyrenaria* diverged at 7–22 Ma (Li et al. 2013). Analysis using the *LEAFY* gene and three fossil calibration points suggested that a clade containing *Camellia* may have emerged at 22 Ma and *Camellia* diversified about 12 Ma (Zhang et al. 2014).

However, a rough consensus about the geographic area of *Camellia*'s origin has been shared by different taxonomists. Based on the present-day diversity and distribution of known *Camellia* species, Sealy (1958: 22) considered that provinces Guangdong, Guangxi, Sichuan and Yunnan of China and Vietnam, which was 'the centre of distribution' of *Camellia*, might be the area of origin of this genus. Zhang & Bartholomew (1984: 18) proposed that the area including Guangdong, Guangxi and Yunnan of China was the 'modern and original centre of *Camellia*' based on their analyses of phylogeny and distribution patterns of this genus. A similar area of origin for *Camellia* was accepted by Min (2000: 56). The subtropical and tropical area of China was considered by Min (2000: 56) to be the modern distribution centre of *Camellia* and he (Min 2000: 56) also highlighted that the 'primitive' taxa of *Camellia* were centralized in the tropical areas of Indochina and China. These monographers elaborated the evolutionary routes of each section of *Camellia* (Zhang & Bartholomew 1984, Min 2000); however, their conclusions were heavily dependent on the views of phylogeny established using the evolutionary taxonomic method and temporally known diversity and distribution of *Camellia*. Unfortunately, whilst molecular methods with fossil calibration are currently so popular in deducing the biogeographic history of plant evolution and distribution (Renner 2005), the methods used by Sealy (1958), Zhang (1981a) and Min (2000) to discuss the biogeography of *Camellia* still prevail in some researches on this genus (Orel & Marchant 2006, Orel & Curry 2013b).

1.7 Threats and conservation

The economic value of *Camellia* has driven some species to the edge of extinction. For instance, the natural populations of yellow camellias have been exposed to a critical over-exploitation for a specious medical purpose or the horticultural reason (Tran & Le 2013). According to my field investigations in Guangxi, an area that has the greatest abundance of yellow camellias in China, some local people dug out the natural plants of yellow camellias and planted them in their own gardens. Many botanists told me that they had hardly found those camellias in the forests recently. In the craziest period of hyping of yellow camellia, I was told that a single flower of *C. petelotii* could value RMB 100 (about €13). The high price led to a widespread over-exploitation of natural yellow camellias in China and Vietnam (Tran & Le 2013). A similar phenomenon happened with the natural tea plants. Local people cut down the tall trees of *C. taliensis* in the forest to collect

their leaves for sale or dug the juveniles out and planted them in their own gardens (Zhao et al. 2014). These economically valued species were hardly protected in an efficient way in the native habitats because local people are usually very poor and eager to earn money through collecting from forests. Establishment of natural reserves, cracking down on the over-exploitation of wild resources and developing alternative businesses in those rural areas would be effective approaches to protect the natural gene pools of tea and camellias. Additionally, there exists the possibility of developing local community enterprises to utilise the important and highly desirable natural resources in a sustainable way that benefits local communities, for example through cultivation and propagation in community-run gardens.

1.8 Phylogenetics and evolution of *Camellia*: why Indochina?

Indochina is the most densely populated biodiversity hotspot in this world (Mittermeier et al. 2004). The rapid expansion of human population in these developing countries resulted in massive deforestation and over-exploitation (Achard et al. 2002, Middleton 2003, Tran & Le 2013, also see Section 1.7 above). Unfortunately, this area remains poorly collected (Parnell et al. 2003), suggesting that plant collecting and investigation are urgent and critical missions.

Camellia species in Indochina have not been investigated in a thorough way. Both Zhang (1981a) and Min (2000) paid much attention to the species of *Camellia* in China but cited very few collections from Indochina. Other researches provided *Camellia* names in checklists or Floras of Indochinese countries without detailed information (Table 1.3, Keng 1972, Hô 1991, Kress et al. 2003, Nguyễn 2003, Newman et al. 2007), especially of specimens examined. Many species of *Camellia* from Indochina were published with syntypes cited (Gagnepain 1942) or with no type material indicated (Loureiro 1790) and their type status remained unresolved in the previous works (Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 2000).

A revision of new *Camellia* species from Indochina is needed. Around 40 new species of *Camellia* have been described based on collections from Indochina, especially Vietnam (Orel & Curry 2015, Le et al. 2016, Luong et al. 2016, Luu et al. 2016), since the publication of the latest monograph of this genus (Min 2000). A thorough investigation is needed to clarify their nomenclatural status and taxonomic position.

Table 1.3. Number of *Camellia* species in each country of Indochina.

Country	No. of species	No. of endemic species	References
Cambodia	2	0	Min 2000
Laos	11	1	Newman et al. 2007
Myanmar	8	0	Kress et al. 2003
Thailand	6	1	Keng 1972
Vietnam	29	11	Hô 1991

Indochinese species can help fill the data gaps in phylogenetic analysis of *Camellia*. Molecular data of *Camellia* species in Indochina are critical for reconstructing a robust phylogenetic tree of this genus, which will be the keystone of a new classification of *Camellia*. However, many species endemic to this area were absent in previous analyses (Xiao 2001, Vijayan et al. 2009) which relied heavily on the samples from China. Indochina, especially Vietnam, has a high proportion of endemic species of *Camellia* (Table 1.3). These endemic species and the new species published after 2000 should be sampled to fill the gaps in molecular phylogenetic analysis. Detailed distribution data for each species in Indochina can be retrieved from the records on herbarium specimens and they are vital for understanding the origin and dispersal of *Camellia* species globally.

Tea, oil camellia and horticultural species of *Camellia* are widely enjoyed by people throughout the world. Many people may not care about the scientific names of the tea they drink, oil shrubs from which their cooking oil is extracted or even the flowers that please them; however, a clear taxonomy of *Camellia* is of fundamental importance for plant breeding of tea, oil camellia and horticultural species, conservation practice of economically important genetic resources and further scientific researches. Species of *Camellia* in Indochina play a unique role in the evolution of this genus and they should be clarified to facilitate related practices and academic investigations.

1.9 Aims

Generally, this Ph.D. project had four objectives:

- (a) Proposing a phylogenetic classification of *Camellia* to categorise the species in Indochina. Molecular phylogenetic trees based on various DNA markers and different methods are firstly reconstructed then jointly analysed with other data, especially morphological characters, to categorise taxa into appropriate ranks.
- (b) Discussing the evolution of *Camellia* in Indochina: its origin, character evolution and dispersal. The Indochinese species are analysed in a global context to infer their origin, their character evolution, and their dispersal based on fossil records, molecular dating and geographic distribution data.
- (c) Clarifying the nomenclatural status of *Camellia* names which were based on collections from Indochina or related to Indochinese species, including typifying previously published names if it is relevant and recognising the single correct name for each taxon (Art. 11.1) and its synonyms if they are available.
- (d) Providing an up-to-date taxonomic revision of *Camellia* in Indochina, including describing every known taxon from Indochina where specimens have been examined, mapping their geographic distribution, assessing their conservation status and discussing the morphologically diagnostic character states.

Chapter 2 Molecular phylogenetics

2.1 Introduction

Since about the 1980s, DNA sequences have gained great attention as a source of phylogenetically informative characters that are repeatable and give less ambiguous information on the phylogeny of plant groups (Ritland & Clegg 1987, Chase et al. 1993, Chaw et al. 1997). Of the three genomes in plants, mitochondrial DNA has a very slow nucleotide substitution rate (Wolfe et al. 1987) and is not as commonly used as cpDNA (CBOL Plant Working Group 2009) and nuDNA (China Plant BOL Group et al. 2011) in phylogenetic analyses.

2.1.1 CpDNA markers

Gene trees reconstructed using orthologous DNA regions rather than paralogous ones (Fitch 2000, Sonnhammer & Koonin 2002) can be used to infer species trees. Analyses of paralogs may be important to detect lineage-specific adaptations (Sonnhammer & Koonin 2002) but would fail to reflect the true evolutionary history of species (Theißen 2002). CpDNA provides single copy markers that are not prone to the problems of gene duplication that nuDNA regions can sometimes have. Thus, they seem to have a natural advantage for phylogenetic reconstruction (CBOL Plant Working Group 2009). However, relatively low substitution rates of cpDNA markers in *Camellia* (Fang et al. 2010, Zhang et al. 2014) suggest that several short sequences of cpDNA sometimes cannot resolve the intrageneric phylogenetic relationships with sufficient resolution.

To address this problem, complete chloroplast genomes of *Camellia* species have been used to conduct phylogenomic analyses (Yang et al. 2013, Huang et al. 2014, Wang et al. 2017), which detected massive numbers of parsimony-informative characters and yielded better-resolved phylogenetic trees with higher support values when compared to studies using fewer cpDNA fragments (Yang et al. 2013). Nevertheless, high-quality total genomic DNA extracted from fresh leaves was usually required when the entire chloroplast genome was sequenced (Yang et al. 2014a). Unfortunately, an intrageneric phylogenetic analysis is, as far as possible, based on a nearly exhaustive sampling strategy (Hillis 1996, Graybeal 1998). Using fresh leaf materials may pose a series of difficulties in practice, including the feasibility of sample preservation and shipping from a remote forest site to a qualified laboratory and customs issues, especially when species of *Camellia* are distributed in different countries—these difficulties, plus the unavailability of sufficient funding for molecular work, provisionally prevented conducting phylogenomic analysis based on the whole chloroplast genomes here.

Furthermore, cpDNA markers are maternally inherited in *Camellia* (Corriveau & Coleman 1988, Kaundun & Matsumoto 2011) and will therefore infer the evolutionary history of the maternal lineage. This can cause problems in phylogenetics if there has been hybridisation between species as the pollen donor is not recorded and the event not represented in the dataset (Hansen et al. 2007).

Nuclear markers, in contrast, come from both maternal and paternal lines. However, the uniqueness of cpDNA cannot be neglected in the phylogenetic research. Therefore, *rpl32-trnL* was used here to reconstruct gene trees potentially yielding phylogenetic information on *Camellia*. This cpDNA marker was chosen because it had been shown to be informative in a previous study on *Camellia* by Fang et al. (2010).

2.1.2 NuDNA multicopy regions

Zhang et al. (2014) used the nuDNA *LEAFY* region (Schultz & Haughn 1991), a multicopy marker that needed cloning before sequencing, to analyse the phylogenetic relationship of tribe Theeae (Theaceae). Their investigation suggested that *Camellia* was not monophyletic (Figure 2.1).

Remarkably, on the same tree indicating *Camellia* to be a paraphyletic group, four clones of *LEAFY* region from a single sample of *Apterosperma oblata* Hung T. Chang did not form a clade (Figure 2.1). They (Zhang et al. 2014) inferred that *A. oblata* may be an ancient hybrid between *Polyspora* and *Pyrenaria s.l.* and suggested the similar hybridisation ‘had once widely occurred between *Camellia* and *Pyrenaria s.l.*’. However, it is impossible to prove or disprove the occurrence of an ancient hybridisation as solid evidence is lacking on both sides. It is therefore unclear if the *LEAFY* region is suitable for phylogenetic analyses of *Camellia*.

Gene duplication rather than hybridisation may have added the copies of *LEAFY* region.

Sonnhammer & Koonin (2002) introduced two subtypes of paralog (inparalogs and outparalogs) to illustrate the lineage-specific adaptations of human and fly γ -butyrobetaine hydroxylases. My reanalysis of the *LEAFY* data (Zhang et al. 2014) using the same approach as Sonnhammer & Koonin (2002) generated a simpler and clearer explanation without needing to infer ancient hybridisation: *LEAFY* regions might undergo gene duplications more than once during the radiation (including speciation) of *Camellia* and its closely-related groups (Figure 2.1)—a situation similar to that reported in other plant groups (Frohlich & Meyerowitz 1997). Consider an ancient *LEAFY* region inherited in the common ancestor of tribe Theeae. The gene was duplicated into α (clade II C in Figure 2.1) and β (clade II D in Figure 2.1) forms (copy types) in a lineage, including *Apterosperma*, *Camellia*, *Parapyrenaria* and *Tutcheria*, from which *Polyspora* was split. During the subsequent radiation, α and β forms were duplicated independently again (and again...) in each lineage. In this scenario, the *LEAFY* region of *Polyspora* is orthologous to all α and β forms whereas all α subforms (α_1 , α_2 & α_3) are paralogous to all β subforms (β_1 & β_2). Since each speciation created orthologs while every gene duplication yielded paralogs (Fitch 2000, Sonnhammer & Koonin 2002), the inparalogs and outparalogs structure in clades II C (including α subforms) and II D (including β subforms) may be complicated (Figure 2.1).

Orthologous DNA makers rather than paralogous ones are most suitable for phylogenetic inferences (Sonnhammer & Koonin 2002, Judd et al. 2008). The *LEAFY* region might be useful in detecting lineage-specific adaptations (Sonnhammer & Koonin 2002) of tribe Theeae; however, a great caution is needed when using a gene tree of *LEAFY* sequences to infer the phylogeny of

Camellia. Another nuDNA marker, ITS (Baldwin et al. 1995), may also have the similar problems in *Camellia*.

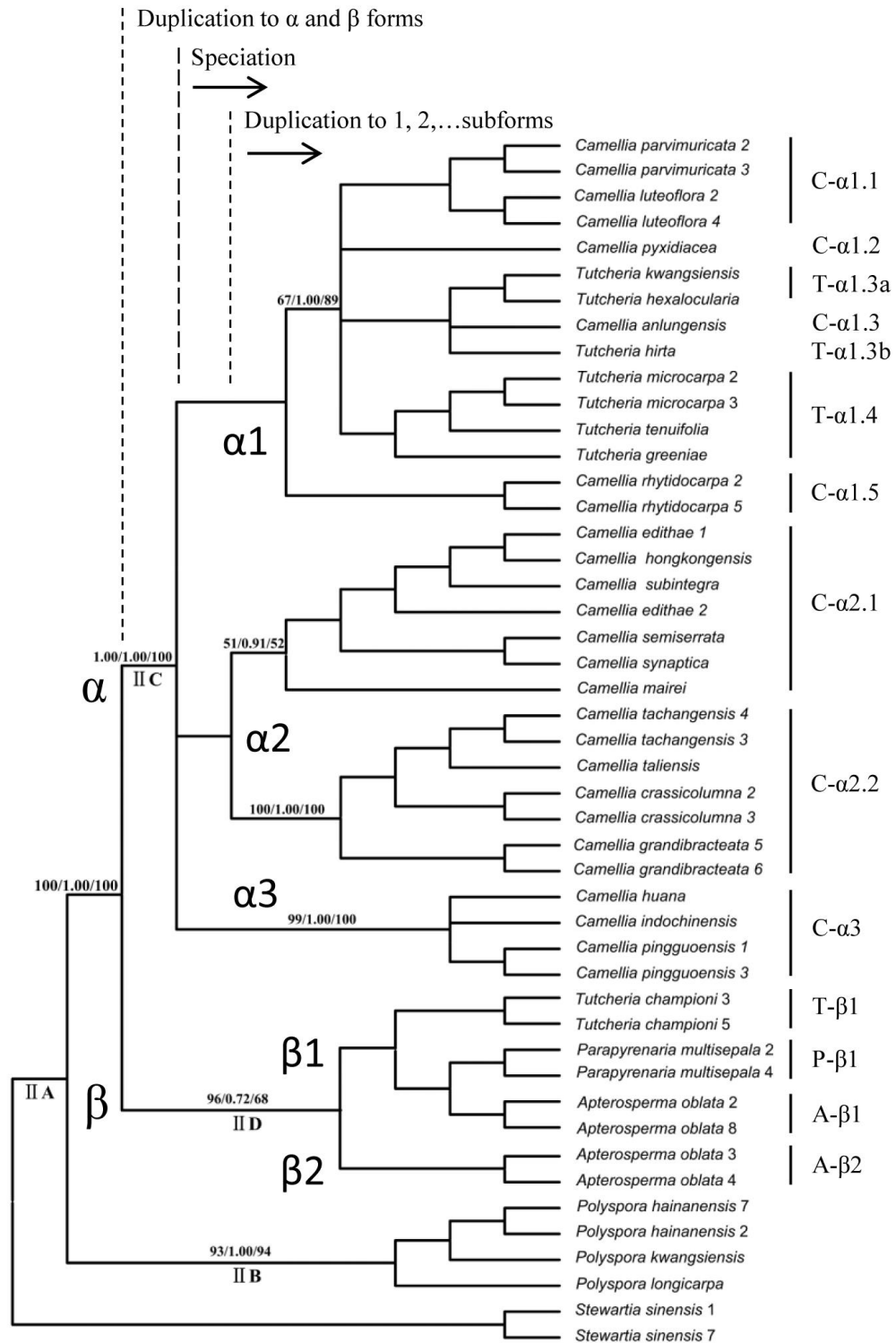


Figure 2.1. Analysis of paralogs of *LEAFY* sequences based on the maximum parsimony tree of the Theaceae, redrawn from Figure 2 of Zhang et al. (2014). Summarized subforms of *LEAFY* region are presented on the right side of species names (e.g., C- $\alpha 1.1$ indicates subform $\alpha 1.1$ of *LEAFY* region in *Camellia* [C]). Numbers on the branches indicate the bootstrap values for MP (>50%), the Bayesian posterior probabilities (>95%) and the ML bootstrap values (>50%), respectively. Numbers following a species name represent clone numbers.

Though ITS was reported as a multicopy region and cloning was needed before sequencing in *Camellia* (Vijayan & Tsou 2008), a phylogenetic analysis using only ITS was undertaken with 112 species of *Camellia* (Vijayan et al. 2009). Their work (Vijayan et al. 2009) was elaborated in Section 1.4.2 (Figure 1.6). Since there were much ITS data of *Camellia* in GenBank (Tang et al. 2004, Vijayan et al. 2009), adding Indochinese samples to the gene tree of ITS would be expected to yield some useful information on phylogeny with reasonable cost. Therefore, ITS was tried here with some critical samples regardless of its potentially paralogous nature in *Camellia*.

2.1.3 NuDNA single copy markers

The use of single copy nuDNA regions that can be directly sequenced in *Camellia*, like the *RPB2* intron 11–16 and intron 23 (Xiao 2001, Su et al. 2009), may avoid potential problems with paralogs. Therefore, they were sequenced in this research to reconstruct gene trees, which were in turn used to infer the species tree of *Camellia* with morphological data.

Ribonucleic acid (RNA) polymerase II, including 12 subunits in yeast, is one of three forms of DNA dependent RNA polymerase occurring in the nucleus (Larkin & Guilfoyle 1993). The sequence of its second largest subunit, *RPB2*, was initially reported in *Arabidopsis thaliana* (Linnaeus) Heynhold and it encoded 1188 amino acids (Larkin & Guilfoyle 1993), which may play a role to catalyse nucleotide binding and RNA chain elongation (Woychik & Young 1990, Denton et al. 1998). *RPB2* has 24 introns in *A. thaliana*. The first intron is 776 bp long and the others vary in size from 75 to 165 bp (Larkin & Guilfoyle 1993). The *RPB2* 11–16 and 23 intron regions have been recommended for plant phylogenetic analyses (Denton et al. 1998) and were subsequently used in *Camellia* (Xiao 2001, Xiao & Parks 2002, 2003, Su et al. 2009). Since there are many *RPB2* data of *Camellia* available and there are gaps of samples from Indochina in the reported phylogenetic trees (Xiao 2001, Su et al. 2009), *RPB2* intron 11–16 and intron 23 regions were used here to generate a more comprehensive dataset and for the sake of cost efficiency.

This chapter aimed to reconstruct a well-supported and resolved phylogenetic tree on which a new classification of *Camellia* in Indochina would be proposed. It includes more species from Indochina than previous studies.

2.2 Material and methods

2.2.1 Sampling

Samples were collected in natural forests, gardens or herbaria (Table 2.1). Clean, young and healthy fresh leaves were collected and dried in silica gel. Leaf fragments were removed from herbarium specimens by the staff members of relevant herbaria or by myself with specific permission. All samples were preserved at -30°C for DNA extraction. Voucher specimens are deposited in the herbaria shown in Table 2.1. Samples collected from Hanoi and Vinh Phuc of Vietnam were generally identified by Prof. Tran Ninh (**HN**) and those from Lam Dong by Mr Luong Van Dung (**DLU**). Others were identified using the classification of Zhang & Bartholomow

(1984). The taxonomy in FOC (Min & Bartholomew 2007) and relevant protologues were also used to identify taxa when names were unavailable in Zhang & Bartholomew (1984). Overall, a narrow species circumscription was used in the molecular analyses.

Table 2.1. Localities of samples.

Taxon	No.	Voucher	Herbarium	Locality
<i>C. amplexicaulis</i>	100(1)	Zhao et al. 100(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. caudata</i>	106(1)	Zhao et al. 106(1)	TCD	Vietnam, Vinh Phuc, Tam Dao.
<i>C. confusa</i>	98(1)	Zhao et al. 98(1)	TCD	Thailand, Chiang Mai, Doi Suthep-Pui.
<i>C. connata</i>	94	Zhao et al. 94	BKF, TCD	Thailand, Chiang Mai, Doi Inthanon.
<i>C. corallina</i>	G60	Yahara V2613	FU	Vietnam, Thua Thien Hue, Bach Ma.
<i>C. crassiphylla</i>	102(1)	Zhao et al. 102(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. cucphuongensis</i>	114	Zhao et al. 114	TCD	Vietnam, Hanoi, cultivated by Prof. Ngo Quang De of Vietnam National University of Forestry.
<i>C. dilinhensis</i>	120	DL 12.10.01	DLU	Vietnam, Lam Dong, cultivated by Mr Luong Van Dung (DLU).
<i>C. dormoyana</i>	121(1)	Zhao et al. 121(1)	TCD	Vietnam, Lam Dong, cultivated by Mr Luong Van Dung (DLU).
<i>C. drupifera</i>	26	Zhao et al. 26	BKF, TCD	Thailand, Loei, Phu Luang.
<i>C. euphlebia</i>	G88	Binh SH78	TCD, VNMN	Vietnam, Vinh Phuc, Tam Dao.
<i>C. fluviatilis</i>	149	Zhao & Ma 146	TCD	China, Yunnan, cultivated in Guangxi Oil Camellia Germplasm Banks.
<i>C. furfuracea</i>	117(1)	Zhao et al. 117(1)	TCD	Vietnam, Hanoi, cultivated by Prof. Ngo Quang De of Vietnam National University of Forestry.
<i>C. gaudichaudii</i>	G21	Chinh 37	DLU	Vietnam, Da Nang, Son Tra.
<i>C. gracilipes</i>	G69	Tagane V3721	FU	Vietnam, Hai Tinh, Vu Quang.
<i>C. hakodae</i>	110(1)	Zhao et al. 110(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
‘ <i>C. hamyensis</i> ’	112(1)	Zhao et al. 112(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. indochinensis</i>	G90	Van BC3	TCD, VNMN	Vietnam, Quang Ninh, Ba Che.
<i>C. irrawadiensis</i>	G56	Murata 22425	MBK, TCD	Myanmar, Chin, Mt. Victoria.
<i>C. kissi</i>	65	Zhao et al. 65	BKF, TCD	Thailand, Nakhon Ratchasima, Khao Yai.
<i>C. krempfii</i>	122(1)	Zhao et al. 122(1)	TCD	Vietnam, Lam Dong, cultivated by Mr Luong Van Dung (DLU).
<i>C. lanceolata</i>	G104	Yoshikawa s.n.	TCD	Japan, cultivated, originally from Philippines (Yoshikawa et al. 1997).
<i>C. longii</i>	118(1)	Zhao et al. 118(1)	TCD	Vietnam, Lam Dong, cultivated by Mr Luong Van Dung (DLU).
<i>C. longissima</i>	140	Photos	TCD	China, Yunnan, cultivated in Guangxi Oil Camellia Germplasm Banks.
‘ <i>C. ninhii</i> ’	G16	DL 15.11.01	DLU	Vietnam, Lam Dong, Cat Tien.
<i>C. osmantha</i>	146	Zhao & Ma 146	TCD	China, Yunnan, cultivated in Guangxi Oil Camellia Germplasm Banks.

Table 2.1 continued

Taxon	No.	Voucher	Herbarium	Locality
<i>C. pachyandra</i>	139(4)	Zhao et al. 139(4)	TCD	China, Yunnan, cultivated in Yunnan Tea Institute.
<i>C. petelotii</i>	108	Zhao et al. 108	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. phanii</i>	109(3)	Zhao et al. 109(3)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. piquetiana</i>	123	Zhao et al. 123	TCD	Vietnam, Lam Dong, cultivated by Mr Luong Van Dung (DLU).
<i>C. pubicosta</i>	107(1)	Zhao et al. 107(1)	TCD	Vietnam, Vinh Phuc, Tam Dao.
<i>C. rubriflora</i>	113(1)	Zhao et al. 113(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. sonthaiensis</i>	119	DL 13.04.01	DLU	Vietnam, Lam Dong, cultivated by Mr Luong Van Dung (DLU).
<i>C. sasanqua</i>	GT1	Tagane s.n.	TCD	Japan, Kagoshima.
<i>C. tamdaoensis</i>	101(1)	Zhao et al. 101(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
‘ <i>C. tienii</i> ’	111(1)	Zhao et al. 111(1)	TCD	Vietnam, Vinh Phuc, cultivated in Tam Dao.
<i>C. vidalii</i>	126	Zhao & Dung 126	TCD	Vietnam, Lam Dong, Dambri.

2.2.2 DNA extraction

Total genomic DNA was extracted using a modified 2×CTAB method (Murray & Thompson 1980, Hodkinson et al. 2007, Vijayan & Tsou 2008).

(a) Around 30 mg leaf material of each sample was frozen with liquid nitrogen and ground into a fine powder in a 13 ml polypropylene centrifuge tube. It was combined with 5 ml of preheated (at 65°C) 2×CTAB extraction buffer (2% CTAB [w/v], 20 mM EDTA- Na_2 , 2% Polyvinylpyrrolidone [w/v], 1.4 M sodium chloride, 100 mM Tris-Hydrochloric acid) and 20 μl β -mercaptoethanol. The slurry was well mixed and incubated at 65°C for one hour with shaking 3–5 times.

(b) After incubation, 5 ml of chloroform and isoamyl alcohol (24: 1) was added, gently mixed for 5–10 minutes, and the sample centrifuged at 3200 g for 10 minutes. The supernatant (aqueous phase) was transferred into a new tube, and this step was repeated once more.

(c) An equal volume of cold isopropanol (–20°C) was added to the supernatant and the sample was gently mixed and placed at –20°C overnight to further precipitate the DNA.

(d) The sample was centrifuged at 3200 g for 10 minutes to pelletise the precipitated DNA. The supernatant was carefully removed and 2 ml of 70% (v/v) ethanol added to wash the DNA and the inner wall of tube.

(e) The mixture was centrifuged again at 3200 g for 2 minutes. The supernatant was removed and 2 ml of absolute alcohol added to wash the DNA and the inner wall of tube once more.

(f) The mixture was centrifuged at 3200 g for 2 minutes, the supernatant removed, and the tube placed in fume hood to air-dry the DNA sample until no trace of ethanol could be smelt (needed

0.5–3 hours).

(g) The dried pellet was resuspended in 200 µl of TE buffer (10 mM Tris-Hydrochloric acid [pH 8.0] and 1 mM EDTA- Na_2). The quality and quantity of the DNA was estimated by electrophoresis on 1.2% agarose gel (w/v) with DNA ladder (THERMO #SM0333, 100–10000 bp) in 1×TBE buffer (89 mM Tris, 89 mM boric acid and 2 mM EDTA- Na_2).

(h) 30 µl of the DNA solution was transferred to a 1.5 ml centrifuge tube as a working solution (stored at 4°C or –20°C), the remainder was transferred to a 0.5 ml tube and stored at –30°C.

2.2.3 PCR and sequencing

PCR was carried out with *Taq* polymerase (Chien et al. 1976, Saiki et al. 1988, GoTaq® G2 Flexi DNA Polymerase, PROMEGA, M7805) in a 10 µl reaction mixture, including 2 µl of 5× GoTaq® Flexi Buffer (‘proprietary formulation supplied at pH 8.5’, PROMEGA), 0.25 µl of dNTPs (10 mM, INVITROGEN), 0.1 µl of each primer (20 µM, forward and reverse, synthesised in EUROFINS, Table 2.2), 1 µl of MgCl_2 Solution (25 mM, PROMEGA), 0.08 µl *Taq* (5 U/µl), 1 µl total genomic DNA solution (50–100 ng/µl) and 5.47 µl H_2O . Each component was added to a 200 µl PCR tube (SARSTEDT) on ice, mixed well and placed in a thermal cycler (Veriti® 96 well, APPLIED BIOSYSTEMS, #9902) with preheated lid using specific programs listed below.

(a) ITS (AB101–AB102): denaturing template DNA at 94°C for 90 seconds, followed by 32 cycles of 30 seconds at 94°C, 1 minute at 62°C and 1 minute at 72°C, then followed by an extension of 7 minutes at 72°C and ended at 4°C.

(b) ITS (leu1–4): denaturing template DNA at 94°C for 5 minutes, followed by 32 cycles of 1 minute at 94°C, 1 minute at 50°C and 1 minute at 72°C, then followed by an extension of 7 minutes at 72°C and ended at 4°C.

(c) *RPB2* intron 11–16 and intron 23: denaturing template DNA at 95°C for 3 minutes, followed by 35 cycles of 1 minute at 94°C, 80 seconds at 57°C and 90 seconds at 72°C, then followed by an extension of 7 minutes at 72°C and ended at 4°C. For *RPB2* intron 11–16, primers C-1-11F and C-1-16R (Xiao 2001) were used for all samples as the first primer set. If PCR failed using the first primer set, then a second set was used: C-1-11F2 and C-1-16R2 (Su et al. 2009). If the second primer set was failed, a third primer option was used (covering *RPB2* intron 13–16): C-1-503F and C-1-16R (Xiao 2001). For the *RPB2* intron 23, primers C-1-10AF and C-1-11R (Xiao 2001) were firstly used for all taxa. If PCR failed, then primers C-1-10AF1 and C-1-11R1 (Su et al. 2009) were used.

(d) *rpl32-F-trnL*^(UAG): denaturing template DNA at 95°C for 3 minutes, followed by 32 cycles of 1 minute at 94°C, 1 minute at 52°C and 1 minute at 72°C, then followed by an extension of 7 minutes at 72°C and ended at 4°C.

Table 2.2. PCR primers used in this research.

Name	Genome	Sequence (5'–3')	Source
ITS, AB101	nuDNA	ACGAATTCATGGTCCGGTGAAGTGTTTC	Sun et al. 1994, revised.
ITS, AB102	nuDNA	TAGAATTCCTCCGGTTCGCTCGCCGTTA	
ITS, leu1	nuDNA	GTCCACTGAACCTTATCATTTAG	Vijayan & Tsou 2008
ITS, 4	nuDNA	TCCTCCGCTTATTGATATGC	
<i>RPB2</i> , intron 11– 16, C-1-11F	nuDNA	CCACTTATGGGTATCGTCTGGCTG	Xiao 2001
<i>RPB2</i> , intron 11– 16, C-1-16R	nuDNA	GCCTGCTTACCCATTGCTGACTG	
<i>RPB2</i> , intron 11– 16, C-1-503F	nuDNA	GCACAGGTTGATGTCAATACC	
<i>RPB2</i> , intron 11– 16, C-1-11F2	nuDNA	AAGAATCTTGCATTGATGGT	Su et al. 2009
<i>RPB2</i> , intron 11– 16, C-1-16R2	nuDNA	ATATGTATTACGTGGGGACT	
<i>RPB2</i> , intron 23, C-1-10AF	nuDNA	CCCTCTCGAATGACTATTGG	Xiao 2001
<i>RPB2</i> , intron 23, C-1-11R	nuDNA	GATAGTATGTGGGACCAAGG	
<i>RPB2</i> , intron 23, C-1-10AF1	nuDNA	GTAAGGTTGCAGCTCACATG	Su et al. 2009
<i>RPB2</i> , intron 23, C-1-11R1	nuDNA	CCTGTGTGACCATTGTACAT	
<i>rpl32</i> -F	cpDNA	CTGCTTCCTAAGAGCAGCGT	Shaw et al. 2007
<i>trnL</i> ^(UAG)	cpDNA	CAGTTCCAAAAAACGTAATTC	

PCR products were electrophoresed on 1.2% agarose gel in TBE buffer, stained with GelRed™ Nucleic Acid Stain (BIOTIUM) and examined under ultraviolet light. The image was recorded using MiniBIS Pro (DNR Bio Imaging Systems Ltd.).

Initially, the annealing temperature of each primer set (including forward and reverse) was optimised by adding or reducing 1–3°C around the reported optimal values (Table 2.2). The annealing temperature that consistently yielded single amplification bands was adopted in the subsequent experiments.

Each PCR product ready for sequencing was cleaned up with Exonuclease I (20 U/μl, BioLabs Inc. #M0293L) and rAPid Alkaline Phosphatase (1 U/μl, ROCHE). 5 μl of PCR product was combined with 0.3 μl of Exonuclease I, 2 μl of rAPid Alkaline Phosphatase and 2.7 μl H₂O in a 200 μl PCR

tube on ice, mixed well and placed in a thermal cycler which was programmed at 37°C for 30 minutes, 82°C for 20 minutes and ended at 4°C. The cleaned PCR products were sent to MACROGEN (the Netherlands) for Sanger Big Dye terminator sequencing on a 3730xl DNA Analyzer (APPLIED BIOSYSTEMS).

2.2.4 DNA data assembly and alignment

The forward and reverse sequences of each PCR product was assembled using SeqMan of Lasergene (DNASTAR) to generate an unambiguous consensus contig. Any difference between forward and reverse sequences of the same PCR product was checked by examining the sequencing chromatograms and edited manually if necessary. The contigs were aligned using MEGA 7 (Kumar et al. 2016). Xiao's (2001) *RPB2* data were retrieved from the appendixes of his Ph.D. thesis and input to MEGA 7 manually. ITS (Vijayan et al. 2009) and *rpl32-trnL* (Fang et al. 2010) data were retrieved from GenBank® (<https://www.ncbi.nlm.nih.gov/genbank/>). *RPB2* data (intron 11–16 & intron 23) were concatenated using SequenceMatrix-Windows-1.8 (Vaidya et al. 2011).

Descriptive statistics of each DNA region and the concatenated data of *RPB2*, including alignment length, the number of variable characters and parsimony-informative characters, were calculated using PAUP on XSEDE (4.0b) (Swofford 2003) provided on the CIPRES Science Gateway (Miller et al. 2010, <https://www.phylo.org/>) during phylogenetic analysis (see below).

2.2.5 Phylogenetic analysis

The DNA datasets were used to reconstruct phylogenetic trees with Bayesian inference (Rannala & Yang 1996, Yang & Rannala 1997), maximum likelihood and maximum parsimony methods, which are based on different assumptions on the process of DNA substitution (Felsenstein 1988).

Bayesian inferences (BI) were performed using MrBayes on XSEDE (3.2.6) (Ronquist et al. 2012) provided on the CIPRES Science Gateway (Miller et al. 2010, <https://www.phylo.org/>). The input files with commands embedded were initially tried and optimised using MrBayes 3.2.6 (Ronquist et al. 2012) on a local computer. The best-fit models of nucleotide substitution out of 1624 different models were searched based on maximum likelihood analysis using jModelTest 2.1.10 (Guindon & Gascuel 2003, Darriba et al. 2012). Models with the lowest BIC (Bayesian Information Criterion) values (Schwarz 1978) were considered to describe the substitution pattern the best (Darriba et al. 2012). Two independent Metropolis-coupled Markov chain Monte Carlo (MCMCMC) analyses were run for each dataset. Each MCMCMC analysis was run for ten million generations with one cold and three heated Markov chains. The temperature parameter for heating the chains was set to 0.08. The prior branch length was set to 0.01 (Brlenspr = unconstrained: exponential [100.0]) to decrease the probability of being trapped in the 'land of long trees' (Marshall 2010). Convergence was estimated using the average standard deviation of split frequencies (when the values dropped below 0.01, it indicated that the Markov chains had reached 'stationarity', Marshall 2010). The Markov chain was sampled every 1000th generation and the first 25% of samples (2500 trees) was

discarded as burn-in. The post-burn-in samples were summarized as a 50% majority-rule consensus tree. The estimation of clade support is indicated by the Bayesian posterior probability (PP) (Yang & Rannala 1997, Larget & Simon 1999) with $PP \geq 0.99$ indicating high support, $0.99 > PP \geq 0.9$ indicating moderate support, and $PP < 0.9$ indicating poor support (Zhang et al. 2014).

Maximum likelihood (ML) analyses were conducted using RAxML-HPC2 on XSEDE (8.2.10) (Stamatakis 2014) through the CIPRES Science Gateway (Miller et al. 2010, <https://www.phylo.org/>). Identical sequences among samples, if there were any, were recognised by this program initially. The duplicates were removed and only a single sample of these identical sequences was retained in the datasets which were used in the subsequent Bayesian inference, maximum likelihood and maximum parsimony analyses. Here, a general time reversible (GTR) nucleotide-substitution model (Tavaré 1986) with rate heterogeneity among the sites was applied to the datasets with GTRCAT (GTR+CAT model [CAT is short for ‘categorization’, Stamatakis 2006], applied when number of sample > 50) or GTRGAMMA (GTR model with a gamma-shaped distribution of rates across sites, applied when number of sample ≤ 50) model for bootstrapping (Stamatakis 2006). Clade support was indicated by the value of rapid bootstrapping which was conducted with 1000 iterations (Stamatakis 2014). Bootstrap (BS) values equal to or higher than 50% were considered supported by the data (weak support: BS = 50%–74%; moderate support: BS = 75%–89%; strong support: BS = 90%–100%) and lower than 50% not supported.

Maximum parsimony (MP) analyses were carried out using PAUP on XSEDE (4.0b) (Swofford 2003) provided on the CIPRES Science Gateway (Miller et al. 2010, <https://www.phylo.org/>) with PAUP command embedded in the input files. PAUP command was initially tried and optimised using a test-version PAUP 4.0a152 (http://people.sc.fsu.edu/~dswofford/paup_test/). All characters were considered as independent and equally weighted. Gaps were treated as missing data. A heuristic search was conducted with 2000 random addition sequence replicates with ten trees saved at each step and TBR (tree-bisection-reconnection) branch-swapping algorithm. Kishino-Hasegawa tests (Kishino & Hasegawa 1989) were performed to compare pairs of topologies. A strict consensus tree was summarised from the most parsimonious trees. One thousand jackknife (JK) (Farris et al. 1996) replicates were performed with ‘JAC’ resampling, deletion probability of e^{-1} (ca. 36.7879%, Guo et al. 2017), 100 random addition sequence replicates with ten trees saved at each step and TBR branch-swapping algorithm. Jackknife values were manually transferred from the jackknife 50% majority-rule consensus tree to the single consensus tree based on the most parsimonious trees to indicate the clade supporting (Harrison & Langdale 2006) (no support: JK $< 50\%$; weak support: JK = 50%–74%; moderate support: JK = 75%–89%; strong support: JK = 90%–100%).

Final phylogenetic trees were displayed and optimised using FigTree v.1.4.3 (<http://tree.bio.ed.ac.uk/software/figtree/>) and Adobe Illustrator. Infrageneric monophyletic groups supported by molecular data and consistent with morphological analyses were labelled. Detailed

morphological investigations are elaborated in Chapter 4.

2.3 Results

2.3.1 DNA extraction, sequencing and data description

Total genomic DNA extracted from silica gel dried samples yielded high DNA concentrations (Figure 2.2). However, samples collected from herbarium specimen sheets usually failed to reach the standard required for successful PCR of the target regions because of a high degree of DNA degradation (samples G1, G23 & G43 in Figure 2.2).

PCR products of ITS (leu1–4) usually had double or more bands so another primer set of this region, ITS (AB101–AB102) (Sun et al. 1994), was tried. Nine PCR products of ITS (AB101–AB102) were sequenced: three of nine (119, 122[1] & 126) had clear nucleotide peaks in the sequencing chromatograms and the remainder (97[1], 107[1], 121[1], 140, G60 & G104) had too much noise to be read. Only these three successfully directly sequenced samples of ITS were added to data matrix with others from GenBank.

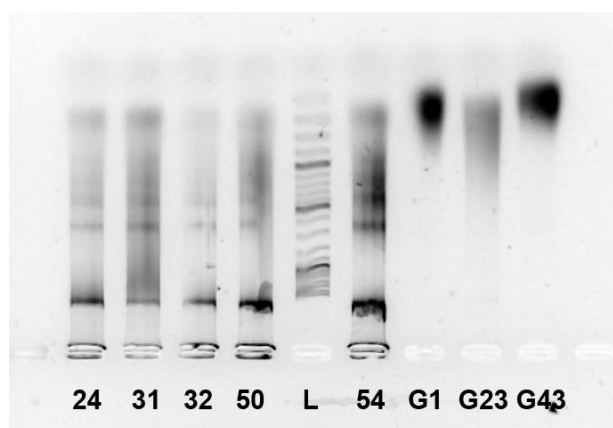


Figure 2.2. Electrophoresis result of the total genomic DNA of some samples on a 1.2% agarose gel (w/v) with DNA ladder (L, size [in bp] from top to bottom: 100, 200, 300, 400, **500**, 600, 700, 800, 900, **1000**, 1200, 1500, 2000, 2500, **3000**, 3500, 4000, 5000, 6000, 8000 & 10000), colour is inverted. Fresh leaf samples dried using silica gel (24, 31, 32, 50 & 54) and samples collected from herbarium specimens (G1, G23 & G43) shown here have not been sequenced so their information is not listed in Table 2.1.

The alignment length, percentages of variable characters and parsimony-informative characters of each data matrix are presented in Table 2.3 with the best-fitting substitution model estimated using jModelTest 2.1.10 (Guindon & Gascuel 2003, Darriba et al. 2012). NuDNA maker ITS has the highest proportions of variable characters (34.6%) and parsimony-informative characters (19.3%) whereas the cpDNA marker *rpl32–trnL* has the lowest values (7.0% & 2.4%, respectively). The identical sequences of each data matrix are shown in Table 2.4.

Table 2.3. Descriptive statistics and best-fitting substitution models for each DNA region and concatenated *RPB2* data.

DNA region	No. of samples (ingroup+outgroup)	Alignment length	Variable characters (%)	Parsimony- informative characters (%)	BIC model selection
<i>RPB2</i> intron 11–16	65 (60+5)	1048	188 (17.9)	83 (7.9)	HKY+G
<i>RPB2</i> intron 23	68 (63+5)	1026	344 (33.5)	170 (16.6)	012010+G+F
<i>RPB2</i> combined data	66 (61+5)	2074	521 (25.1)	247 (11.9)	012010+G+F
ITS	35 (34+1)	798	276 (34.6)	154 (19.3)	012212+G+F
<i>rpl32-trnL</i>	59 (57+2)	1086	76 (7.0)	26 (2.4)	001000+G+F

Table 2.4. Identical sequences found by RAxML (Stamatakis 2014). Bold type indicates the samples retained and used in subsequent analyses.

DNA region	Samples
<i>RPB2</i> intron 11– 16	98(1) = 146 = <i>C. brevistyla</i> _2y43 = <i>C. oleifera</i> _2y128 = <i>C. vietnamensis</i> _2y47 108 = 109(3) GT1 = <i>C. sasanqua</i> _2y23 <i>C. henryana</i>_9948C = <i>C. yunnanensis</i> _2y102
<i>RPB2</i> intron 23	113(1) = G88 <i>C. confusa</i> _2y2012 = <i>C. sasanqua</i> _2y33 = <i>C. vietnamensis</i>_2y47
<i>rpl32-trnL</i>	<i>C. chrysanthoides</i>_GQ487396 = <i>C. flavida</i> _GQ487401 = <i>C. micrantha</i> _GQ487412 <i>C. limonia</i> _GQ487409 = <i>C. parvipetala</i> _GQ487416 = <i>C. pubipetala</i>_GQ487417

2.3.2 Phylogenetic trees

Results of phylogenetic analyses using different datasets are presented below.

(a) Results of analyses based on the *RPB2* intron 11–16 data are presented in Figures 2.3–2.5. *Camellia* is monophyletic in all analyses but none of the subgenera of Zhang (1981a) or Min (2000) is supported (BS for maximum likelihood; JK for maximum parsimony; PP for Bayesian inference). Branch length information is shown for Bayesian analyses only for clarity. Consensus trees are thus provided for the other two analysis types.

On the Bayesian tree (Figure 2.3), *Camellia* consists of three clades each with PP = 1: sect. *Corallina* Sealy, sect. *Piquetia* and the remainder (which includes amended sections *Archeacamellia*, *Cylindriea* T.L. Ming, *Furfuracea*, *Heterogenea*, *Paracamellia*, *Stereocarpus* [Pierre] Sealy and *Thea*). The relationships between these three clades are unresolved. This topology is different from those of the ML (Figure 2.4) and MP (Figure 2.5) trees where sect. *Piquetia* is sister to other species of *Camellia* with only low to moderate support.

Nine clades indicating amended sections of *Camellia* are supported in each of the three methods of phylogenetic reconstruction (Figures 2.3–2.5, the circumscriptions of amended sections are discussed below and elaborated in Chapter 4): sect. *Archeacamellia* (BS = 74; JK = 90; PP = 0.99), sect. *Corallina* (BS = 98; JK = 100; PP = 1), sect. *Cylindriea* (BS = 98; JK = 100; PP = 1), sect. *Furfuracea* (BS = 52; JK = 71; PP = 0.89), sect. *Heterogenea* (BS = 63; JK = 100; PP = 0.97), sect. *Paracamellia* (BS = 97; JK = 100; PP = 1), sect. *Piquetia* (BS = 98; JK = 100; PP = 1), sect. *Stereocarpus* (BS = 81; JK = 100; PP = 1) and sect. *Thea* (BS = 99; JK = 100; PP = 1).

Amended sect. *Archeacamellia* contains *C. luteoflora* Y.K. Li, which was the type of sect. *Luteoflora* Hung T. Chang (Zhang & Zeng 1982) and later treated as a member of sect. *Stereocarpus* by Min (1999: 156). Section *Furfuracea* is distinct from sect. *Heterogenea*, the latter is amended here to include *C. connata* (Craib) Craib, a species was placed in sect. *Calpandria* (Zhang 1981: 108, Min 1999: 158). Amended sect. *Thea* is enlarged here to include *C. longissima* Hung T. Chang & S.Y. Liang, which was the type of sect. *Longissima* Hung T. Chang (Zhang 1981: 124) and had been transferred into sect. *Longipedicellata* Hung T. Chang by Min (1999: 153).

(b) Results of analyses based on *RPB2* intron 23 data matrix are shown in Figures 2.6–2.8. *Camellia* is monophyletic in all analyses and can be divided into four main clades on the Bayesian tree (Figure 2.6) but two on MP tree without clear support (Figure 2.8). On the ML tree (Figure 2.7), a clade formed by sect. *Stereocarpus*, sect. *Thea*, *C. albogigas* Hu and *C. grijsii* is sister to other species of *Camellia* but without strong BS support.

Ten amended sections of *Camellia* are supported (Figures 2.6–2.8)—sect. *Archeacamellia* (BS = 93; JK = 100; PP = 1), sect. *Camelliopsis* (BS = 100; JK = 100; PP = 1), sect. *Corallina* (BS = 100; JK = 100; PP = 1), sect. *Cylindriea* (BS = 96; JK = 100; PP = 1), sect. *Furfuracea* (BS = 99; JK = 100; PP = 1), sect. *Heterogenea* (BS = 91; JK = 99; PP = 1), sect. *Paracamellia* (BS = 100; JK = 100; PP = 1), sect. *Piquetia* (BS = 99; JK = 100; PP = 1), sect. *Stereocarpus* (BS = 100; JK = 100; PP = 1) and sect. *Thea* (BS = 72; JK = 100; PP = 0.94).

The monophyly of amended sect. *Camelliopsis* (= subg. *Metacamellia* Hung T. Chang) is supported by *RPB2* intron 23 data (Figures 2.6–2.8) but not by *RPB2* intron 11–16 data (Figures 2.3–2.5). Section *Camelliopsis* is sister to a clade (BS = 71; JK = 97; PP = 0.94) formed by *C. amplexicaulis*, *C. japonica* (type of *Camellia*) and sect. *Paracamellia* (Figures 2.6–2.8).

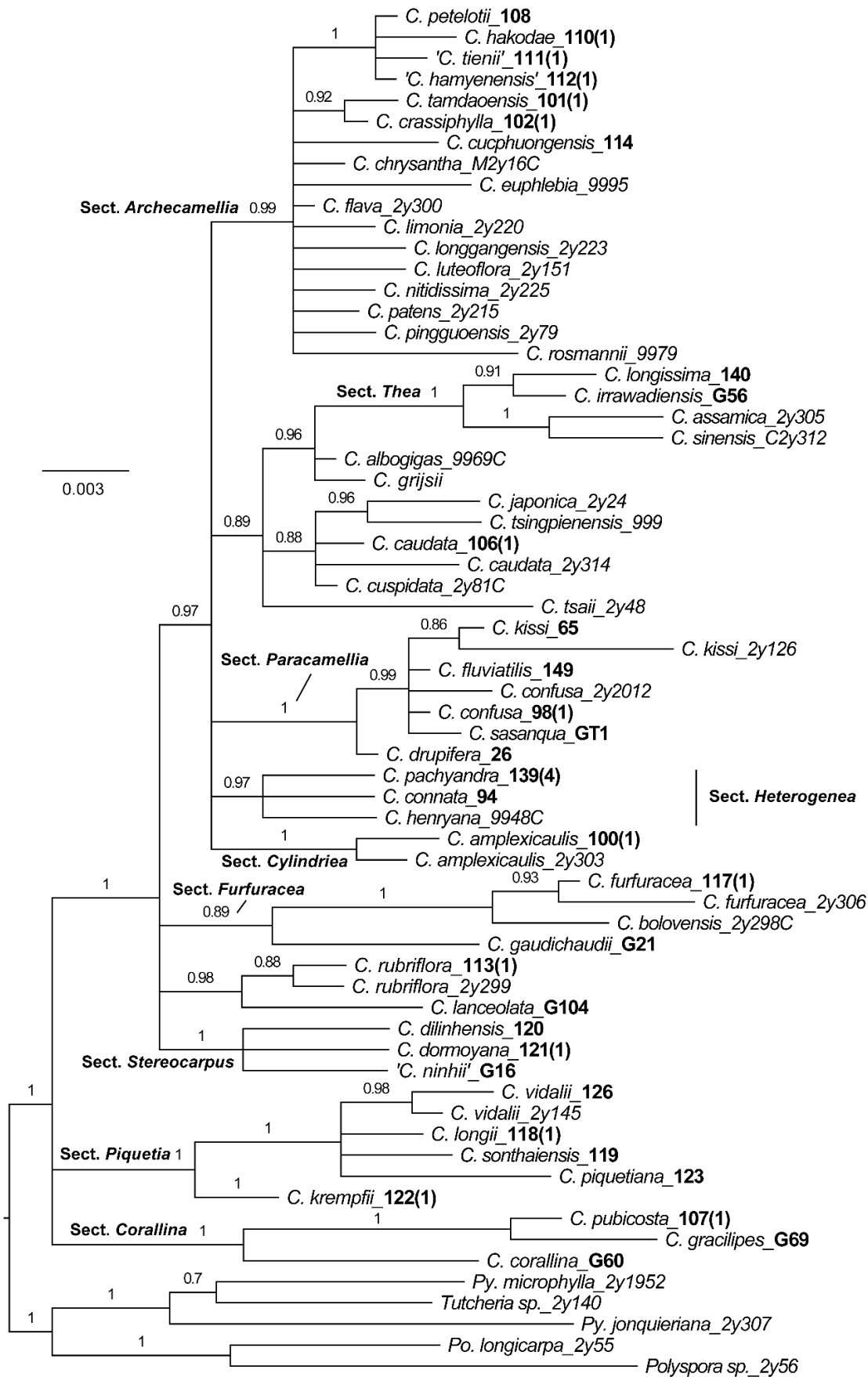
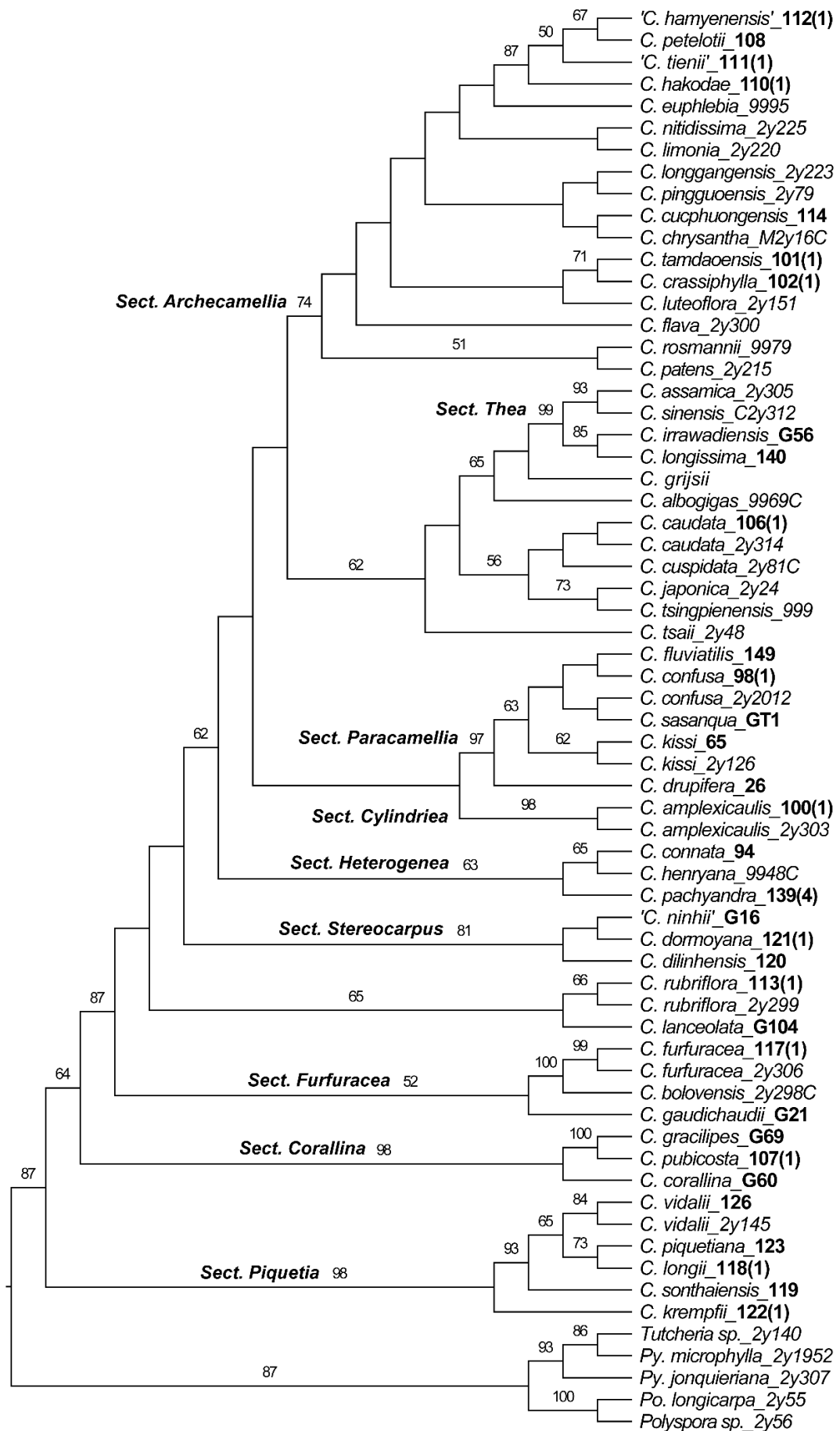


Figure 2.3. Bayesian consensus tree based on RPB2 intron 11–16 data. Bayesian posterior probabilities ≥ 0.5 are shown on clades. Branch lengths are proportional to the expected nucleotide substitutions per site. Numbers in bold indicate the samples sequenced here.

Figure 2.4. Maximum likelihood bootstrap consensus tree based on *RPB2* intron 11–16 data.Bootstrap values ≥ 50 are shown on clades. Numbers in bold indicate the samples sequenced here.

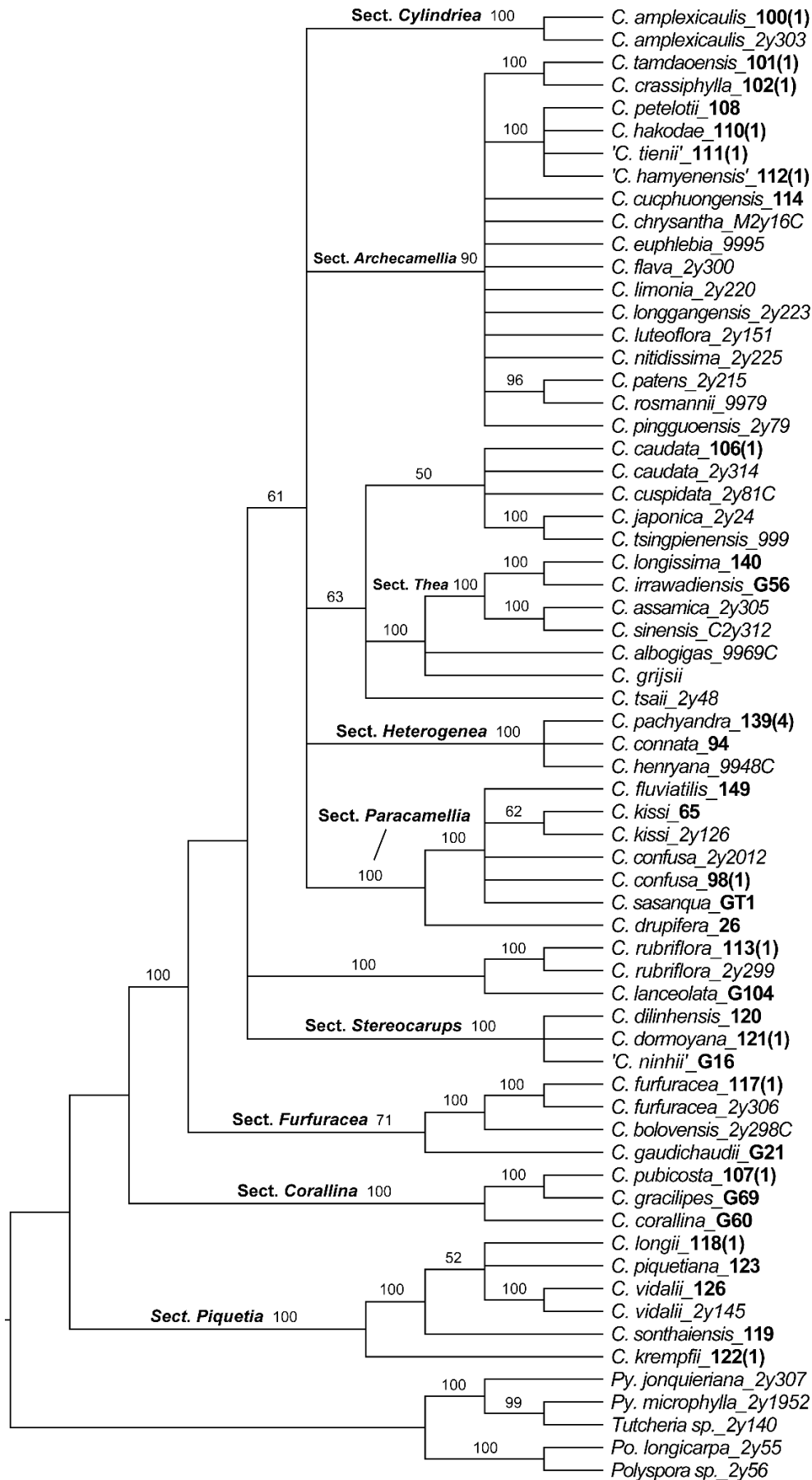


Figure 2.5. Maximum parsimony jackknife consensus tree based on *RPB2* intron 11–16 data. Jackknife values ≥ 50 are shown on clades. Numbers in bold indicate the samples sequenced here.

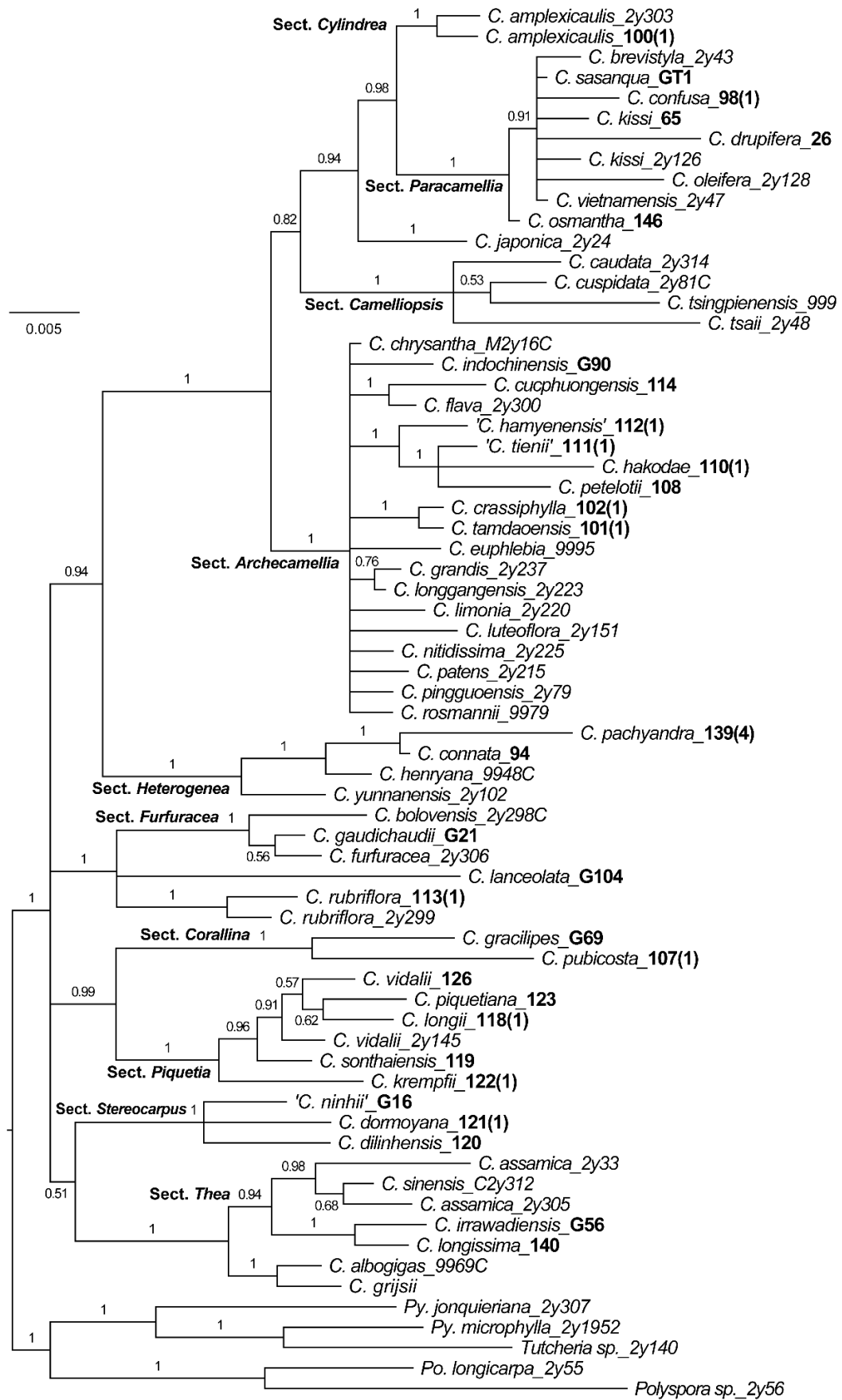


Figure 2.6. Bayesian consensus tree based on *RPB2* intron 23 data. Bayesian posterior probabilities ≥ 0.5 are shown along clades. Branch lengths are proportional to the expected nucleotide substitutions per site. Numbers in bold indicate the samples sequenced here.

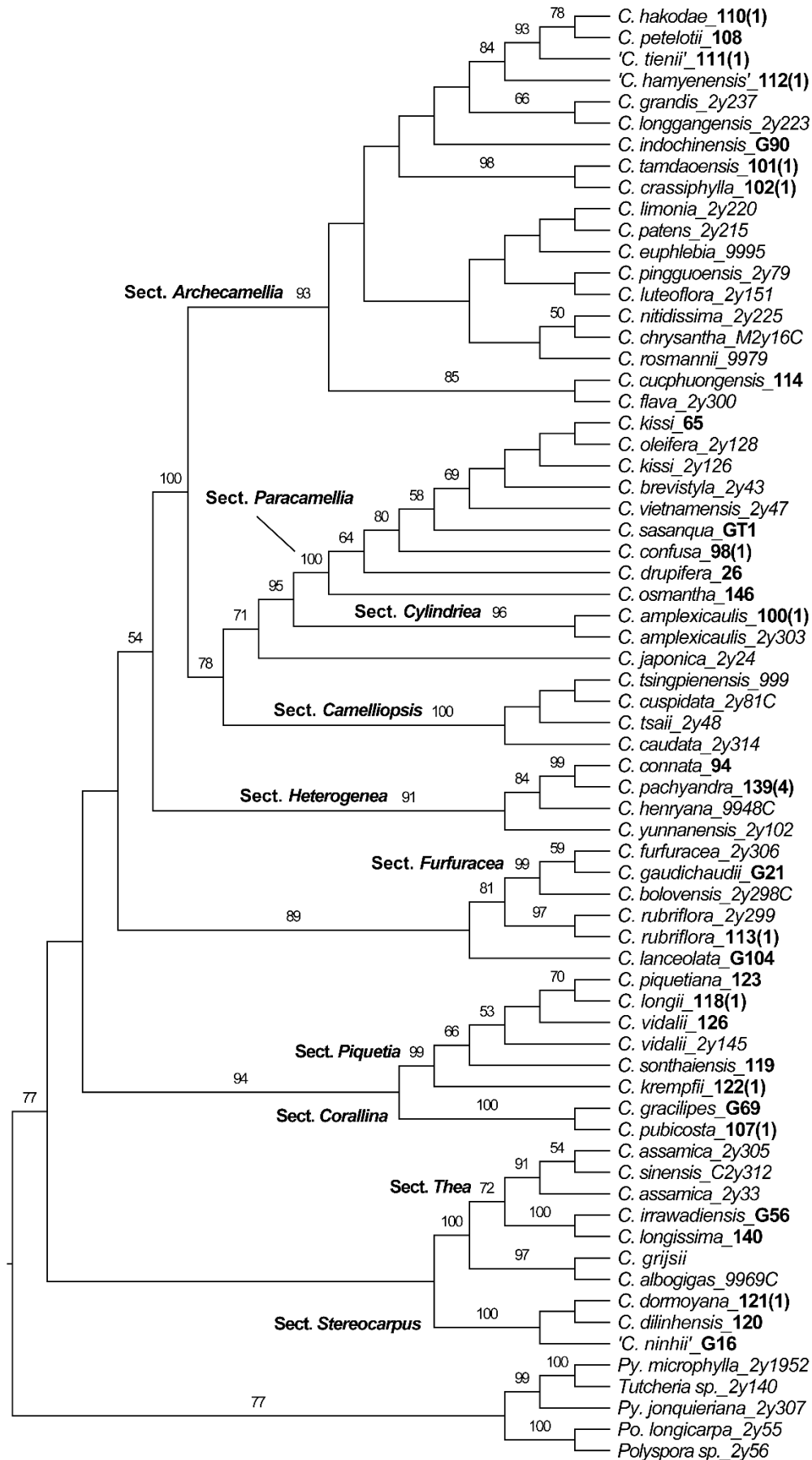


Figure 2.7. Maximum likelihood bootstrap consensus tree based on *RPB2* intron 23 data. Bootstrap values ≥ 50 are shown on clades. Numbers in bold indicate the samples sequenced here.

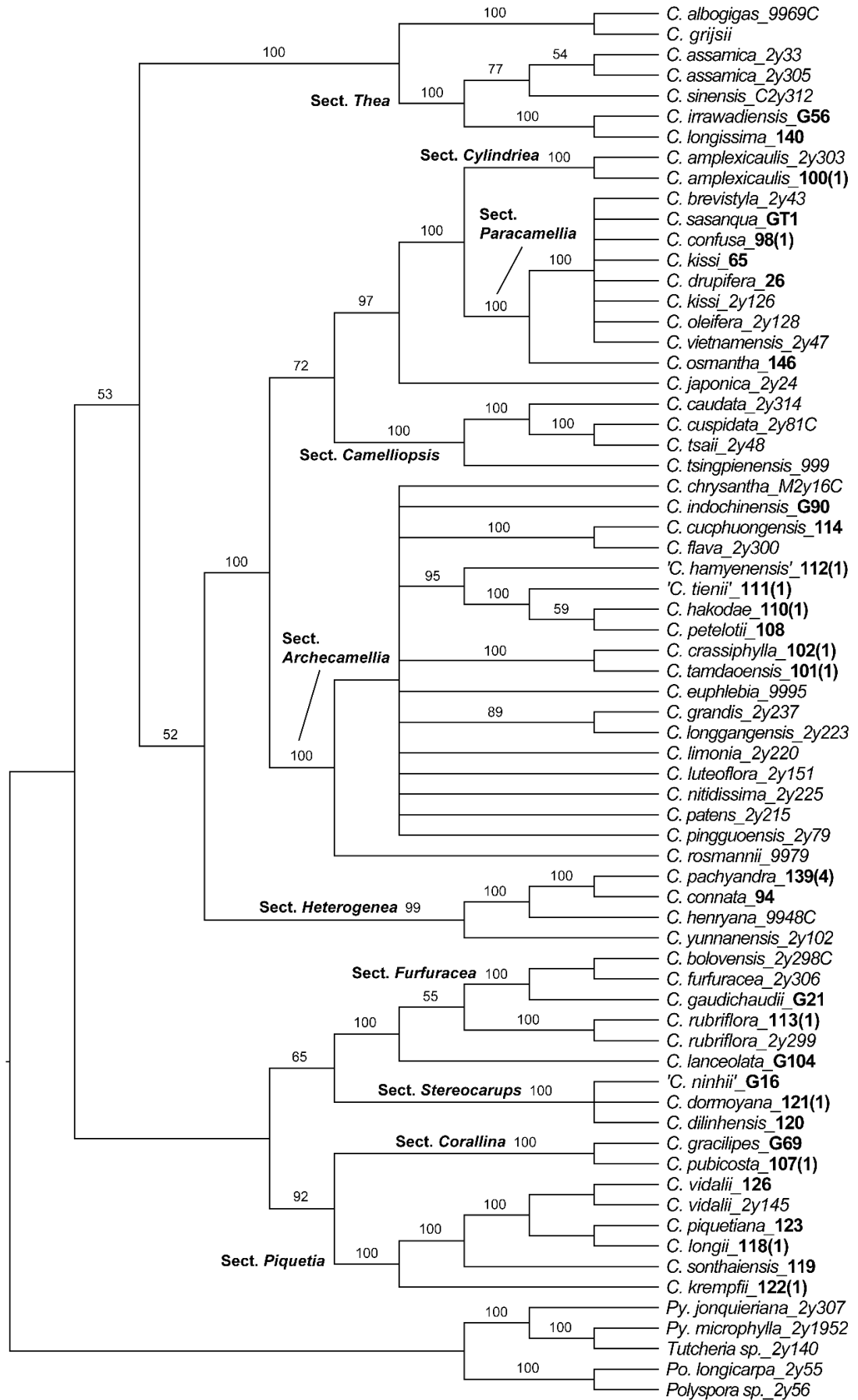


Figure 2.8. Maximum parsimony jackknife consensus tree based on *RPB2* intron 23 data. Jackknife values ≥ 50 are shown on clades. Numbers in bold indicate the samples sequenced here.

(c) Results of analyses based on the concatenated *RPB2* (intron 11–16 and intron 23) data are presented in Figure 2.9. The concatenated *RPB2* tree (Figure 2.9) was reconstructed using the largest dataset in this research. The Bayesian, ML and MP trees have the similar topology so they are represented by a single Bayesian tree with three types of support value (BS, JK and PP) labelled. *RPB2* data support that *Camellia* is clearly split from its phylogenetically closely-related genera *Pyrenaria* (including its synonym *Tutcheria*) and *Polyspora* that form a clade sister to *Camellia*. The clade (BS = 98; JK = 74; PP = 0.85) formed by sections *Corallina* and *Piquetia* is sister to the other species of *Camellia* (Figure 2.9).

In agreement with the results of the *RPB2* intron 23 region (Figures 2.6–2.8), ten amended sections of *Camellia* are supported (Figure 2.9): sect. *Archecamellia* (BS = 98; JK = 100; PP = 1), sect. *Camelliopsis* (BS = 98; JK = 100 [*C. caudata* is sister to other three species on the Bayesian and ML trees whereas *C. tsingpiensis* Hu is the outlying species on the MP tree]; PP = 1), sect. *Corallina* (BS = 100; JK = 100; PP = 1), sect. *Cylindria* (BS = 100; JK = 100; PP = 1), sect. *Furfuracea* (BS = 99; JK = 100; PP = 1), sect. *Heterogenea* (BS = 97; JK = 100; PP = 1), sect. *Paracamellia* (BS = 100; JK = 100 [*C. osmantha* C.X. Ye et al. is sister to other ten samples on the Bayesian and ML trees whereas *C. drupifera* is the outlying species on the MP tree]; PP = 1), sect. *Piquetia* (BS = 100; JK = 100; PP = 1), sect. *Stereocarpus* (BS = 100; JK = 100; PP = 1) and sect. *Thea* (BS = 99; JK = 100; PP = 1).

Camellia rubriflora Ninh & Hakoda and *C. lanceolata* form a clade (BS = 82; JK = 100; PP = 0.79) which is sister to sect. *Furfuracea* with strong support (BS = 98; JK = 100; PP = 1), suggesting a close relationship between them. *Camellia amplexicaulis* is sister to sect. *Paracamellia* with high support values (BS = 95; JK = 100; PP = 0.99), supplying a new insight into the taxonomic position of the former. *Camellia japonica*, the type of this genus, forms a clade (BS = 63; JK = 85; PP = 0.96) with sect. *Camelliopsis*—this relationship differs from any known taxonomic treatment (Figure 2.9).

(d) Results of analyses using ITS data are shown in Figures 2.10–2.12. Three species sequenced in this research, including *C. krempfii* (Gagnepain) Sealy, *C. sonthaiensis* Luu, V.D. Luong, Q.D. Nguyen & T.Q.T. Nguyen and *C. vidalii*, form a clade (BS = 100; JK = 100; PP = 1) which is sister to other samples from GenBank (Vijayan et al. 2009). The ITS sequence of *C. piquetiana* was reported by Vijayan et al. (2009). As the type of sect. *Piquetia*, *C. piquetiana* is not nested in the same clade with *C. krempfii*, *C. sonthaiensis* and *C. vidalii*, which is different with the topologies shown in the *RPB2* trees (Figures 2.3–2.9).

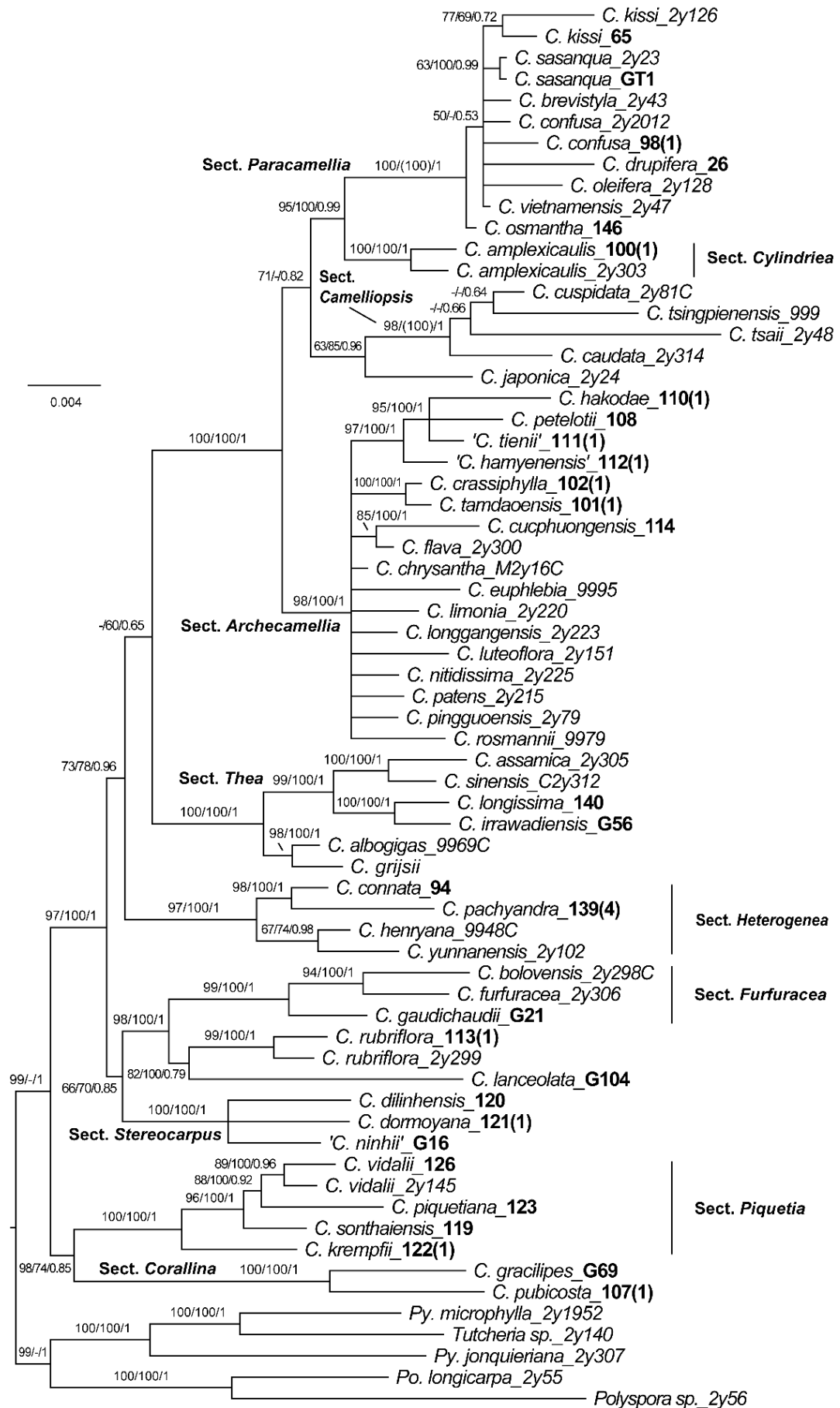


Figure 2.9. Bayesian consensus tree of concatenated RPB2 (intron 11–16 and intron 23) data. ML bootstrap values (BS) ≥ 50 , MP jackknife values (JK) ≥ 50 and Bayesian posterior probabilities

(PP) ≥ 0.5 are shown along clades: BS/JK/PP. Each value in the parentheses indicates a different outlying species resolved on the corresponding tree. Branch lengths are proportional to the expected nucleotide substitutions per site. Numbers in bold indicate the samples sequenced here.

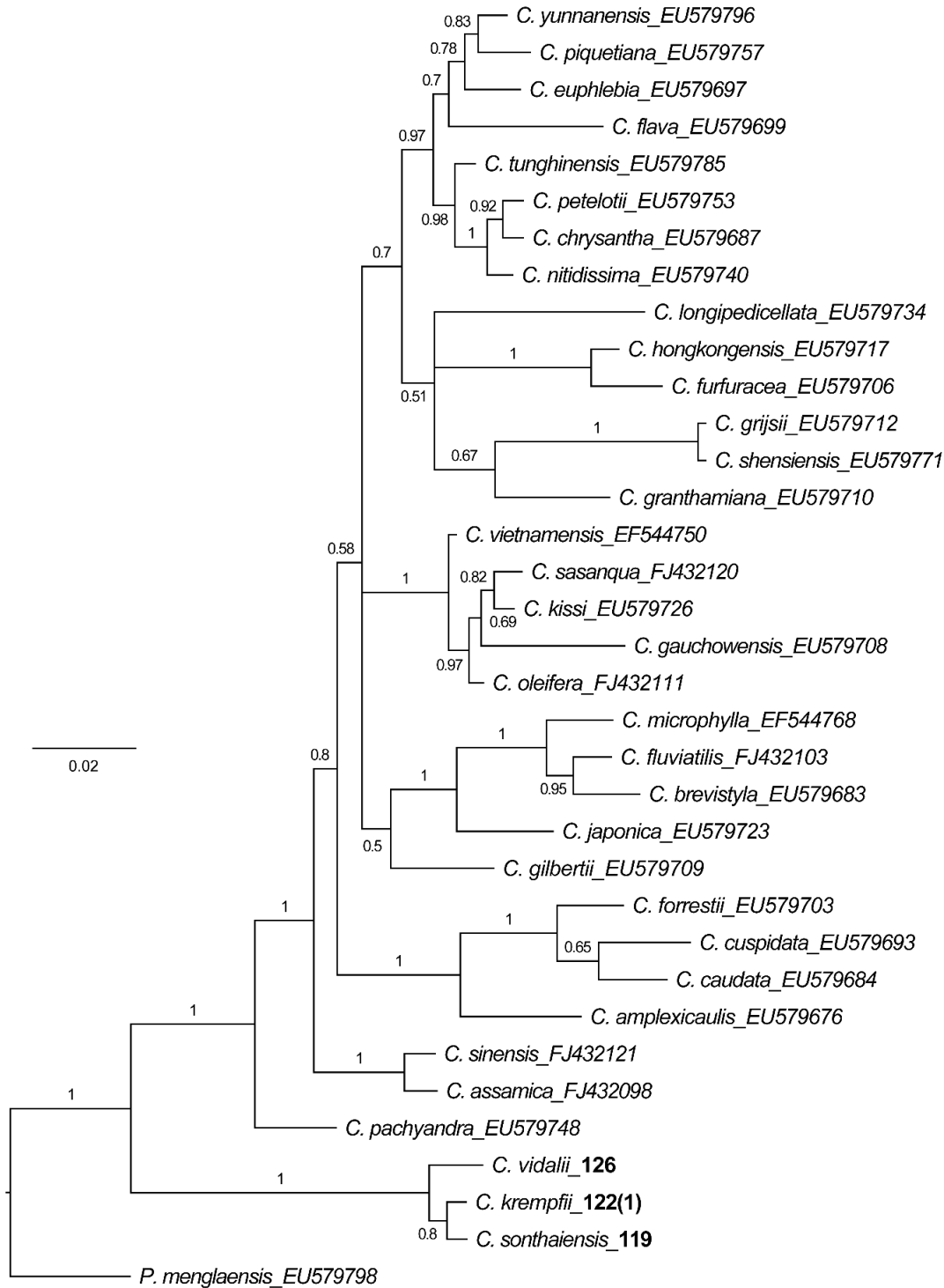


Figure 2.10. Bayesian consensus tree based on ITS data. Bayesian posterior probabilities ≥ 0.5 are shown along clades. Branch lengths are proportional to the expected nucleotide substitutions per site. Numbers in bold indicate the samples sequenced here.

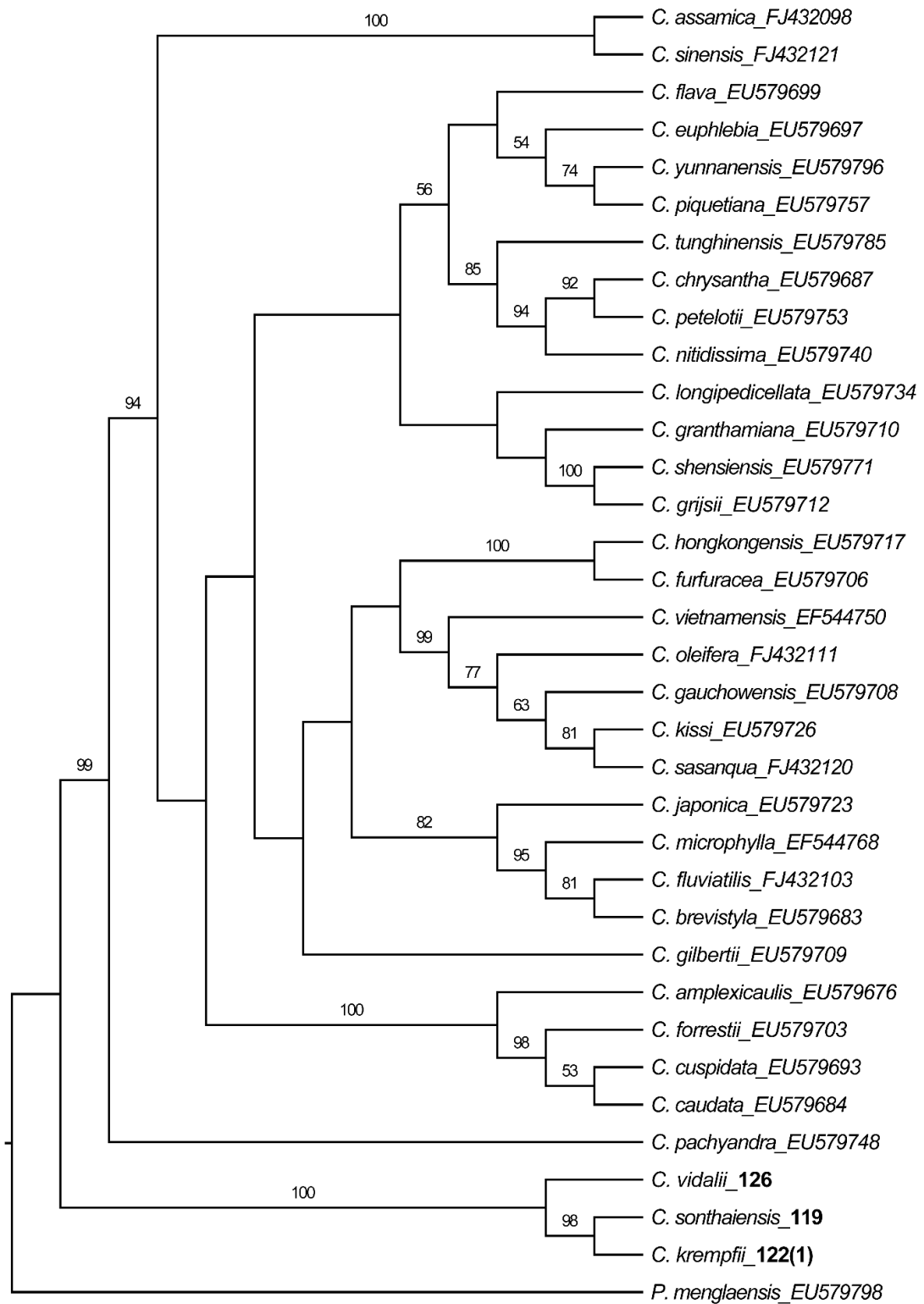


Figure 2.11. Maximum likelihood bootstrap consensus tree based on ITS data. Bootstrap values ≥ 50 are shown on clades. Numbers in bold indicate the samples sequenced here.

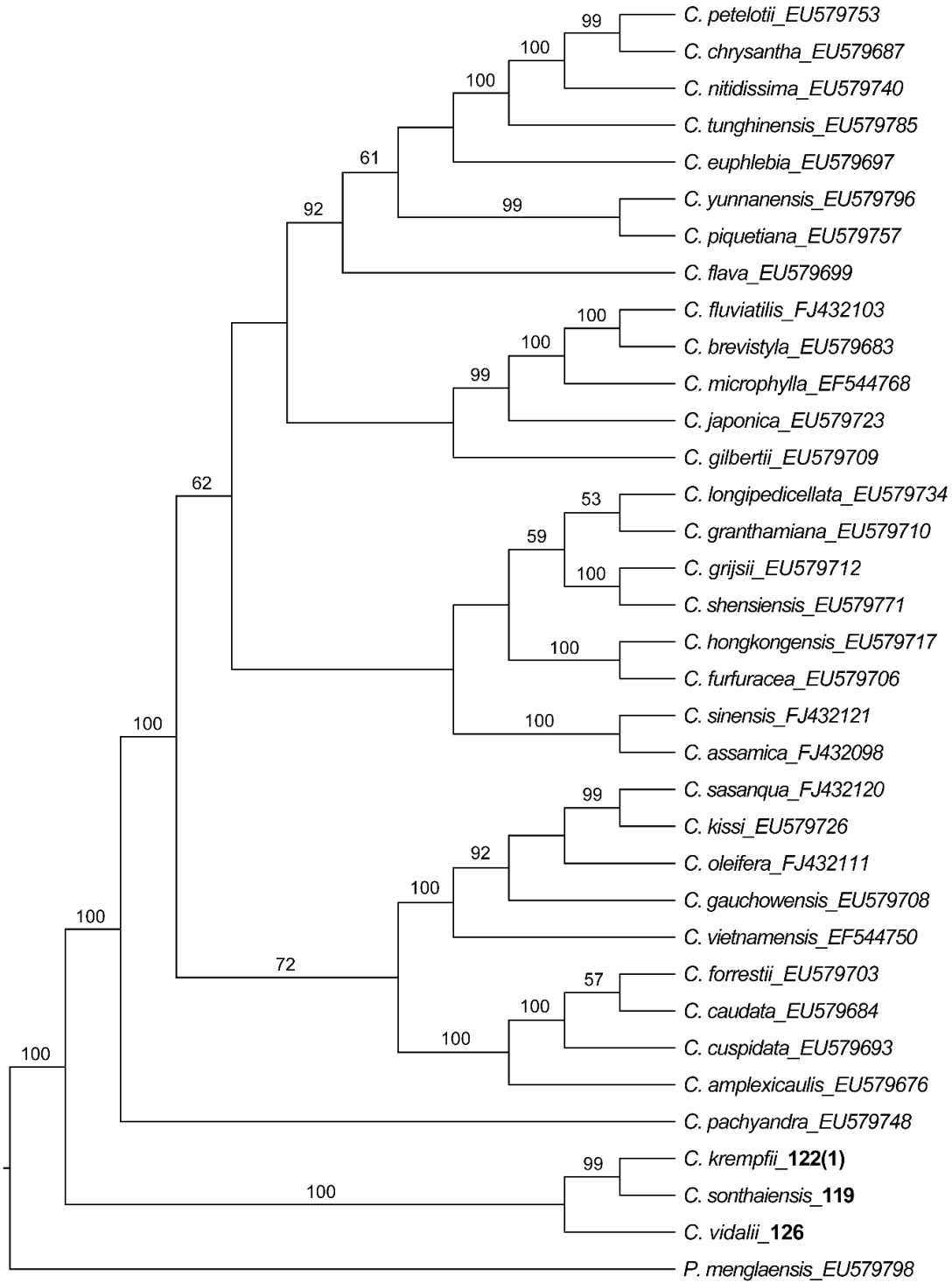


Figure 2.12. Maximum parsimony jackknife consensus tree based on ITS data. Jackknife values ≥ 50 are shown on clades. Numbers in bold indicate the samples sequenced here.

(e) Phylogenetic trees reconstructed using cpDNA *rpl32-trnL* data (Figures 2.13–2.15) show poor resolution. *Camellia* is monophyletic in all analyses but only sect. *Stereocarpus* is supported in ML and MP trees (BS = 61; JK = 100; PP = 0.85). *Camellia gracilipes* Merrill ex Sealy, *C. hekouensis* and *C. pubicosta* Merrill form a clade with high support (BS = 93; JK = 100; PP = 1).

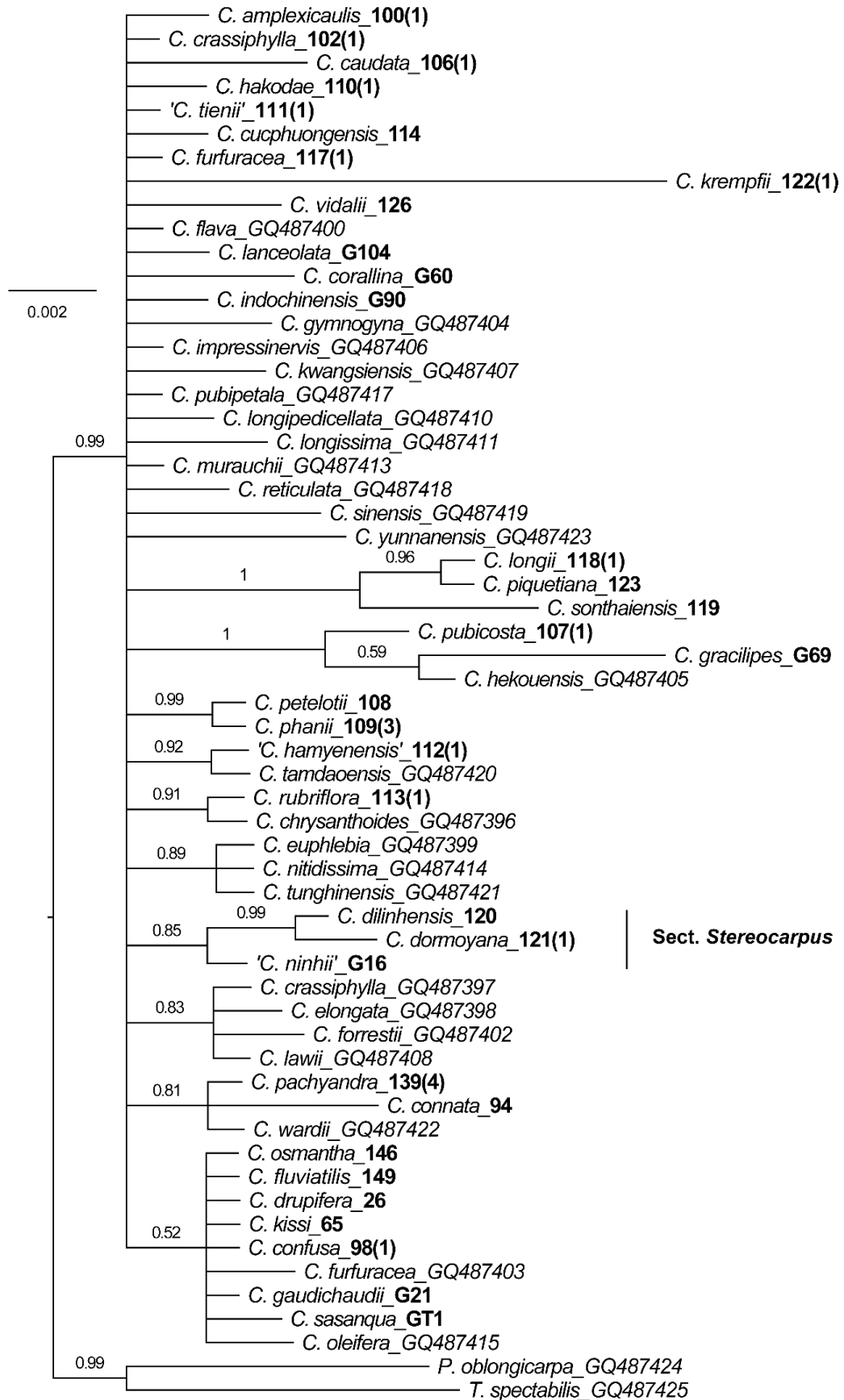


Figure 2.13. Bayesian consensus tree based on *rpl32-trnL* data. Bayesian posterior probabilities ≥ 0.5 are shown along clades. Branch lengths are proportional to the expected nucleotide substitutions per site. Numbers in bold indicate the samples sequenced here.

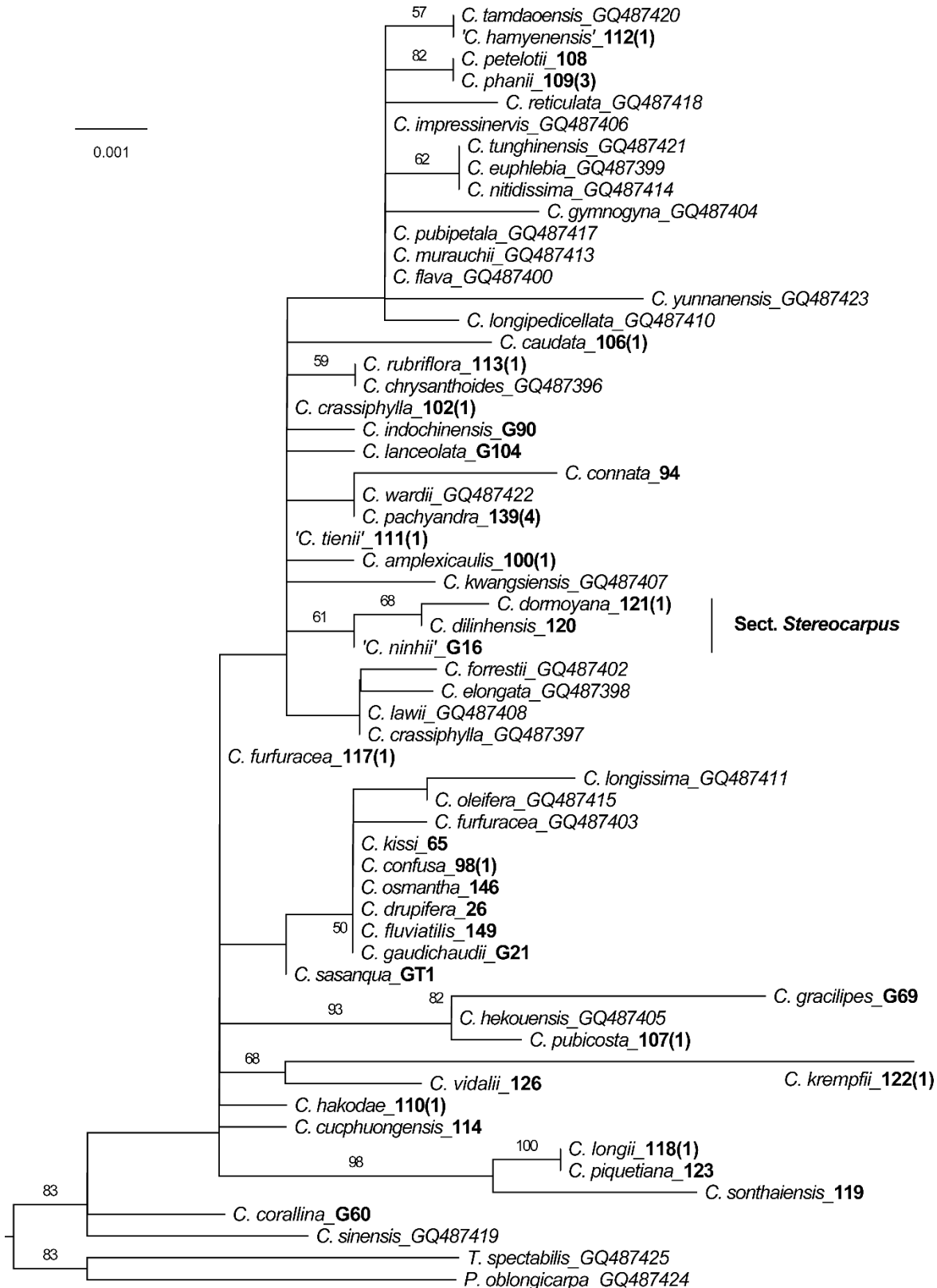


Figure 2.14. Maximum likelihood bootstrap consensus tree based on *rpl32-trnL* data. Bootstrap values ≥ 50 are shown along clades. Branch lengths are proportional to the expected nucleotide substitutions per site. Numbers in bold indicate the samples sequenced here.

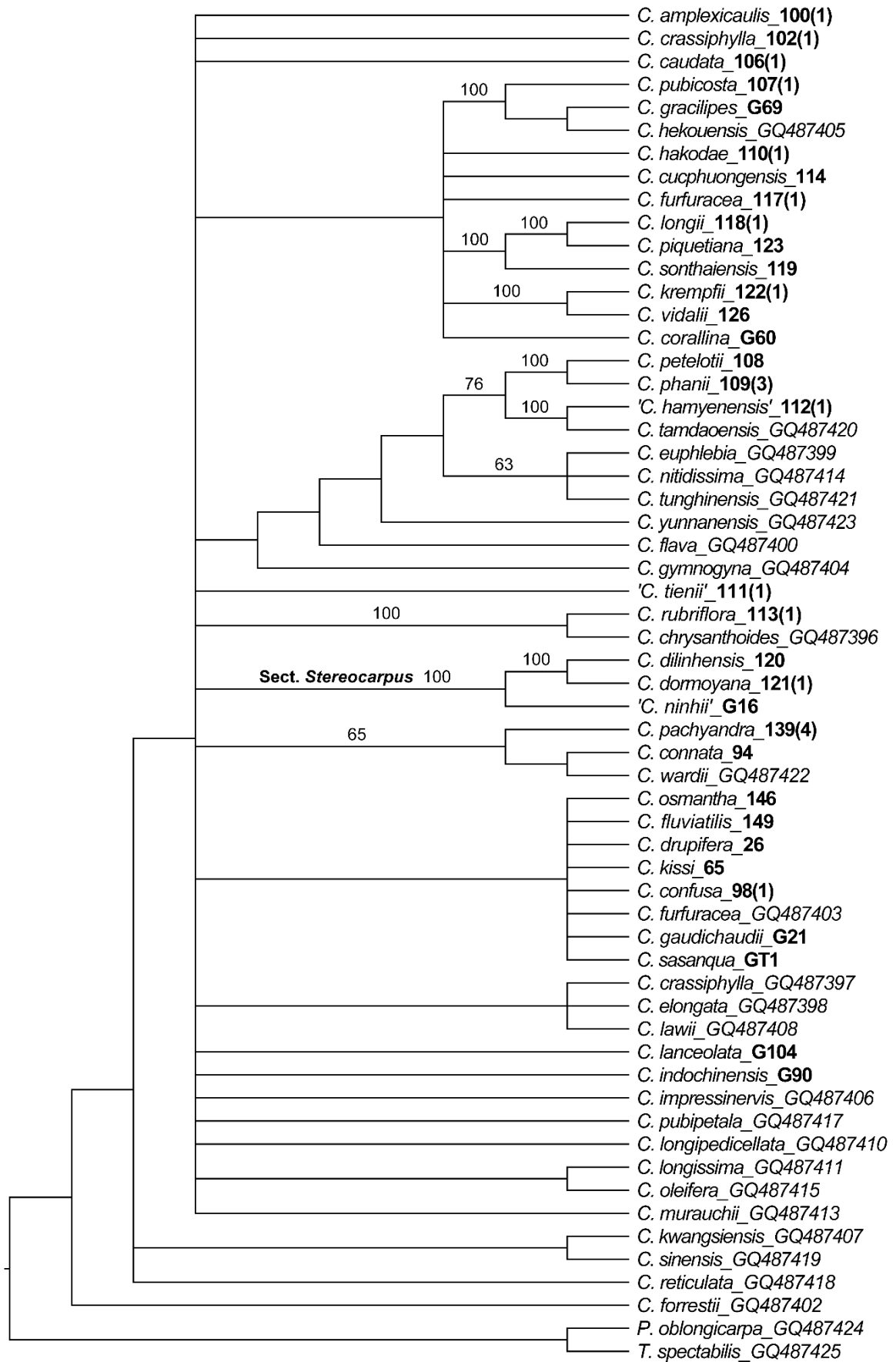


Figure 2.15. Maximum parsimony jackknife consensus tree based on *rpl32-trnL* data. Jackknife values ≥ 50 are shown on branches. Numbers in bold indicate the samples sequenced here.

2.4 Discussion

2.4.1 *RPB2* gene trees

The *RPB2* intron 23 gene region has more variable characters and parsimony-informative characters than the *RPB2* intron 11–16 region (Table 2.3). Therefore, trees reconstructed using *RPB2* intron 23 data (Figures 2.6–2.8) have more resolution than those of the *RPB2* intron 11–16 data (Figures 2.3–2.5). These two regions are linked markers because they are derived from the same *RPB2* gene (Denton et al. 1998). Unfortunately, I do not know in which chromosome of *Camellia* species this gene is located. The whole genome of *C. sinensis* var. *assamica* (Choisy) Kitamura was sequenced but no chromosome mapping information was reported (Xia et al. 2017). However, the concatenated *RPB2* (intron 11–16 and intron 23) data performs better in phylogenetic analyses than the individual *RPB2* intron 23 or intron 11–16 dataset because of increased character information and hence phylogenetic signal. The *RPB2* gene tree (Figure 2.9) reconstructed using this concatenated dataset has a better resolved topology and many clades have higher support values when compared to trees reconstructed using the individual gene dataset alone.

By adding Indochinese samples to fill the data gaps, the robust *RPB2* gene tree (Figures 2.9) supplies new and critical information on inferring the phylogeny of *Camellia*. Taxa used in former phylogenetic studies of *Camellia* (Xiao 2001, Xiao & Parks 2002, 2003, Vijayan et al. 2009) were mainly distributed in China. Gene trees reconstructed in these studies contradicted the extant taxonomies of *Camellia* (Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 2000) but no new intrageneric classification was proposed based on them (see Section 1.4.2). These earlier trees are short of phylogenetic accuracy because of a huge data gap of Indochinese species that are now provided here. In terms of resolving the general intrageneric classification of *Camellia*, phylogenetic accuracy and resolution are dramatically improved by adding critical samples from Indochina on *RPB2* tree (Figure 2.9) compared with trees reconstructed by Xiao (2001, Figure 1.5). Well supported clades that can be treated as sections with the support from morphological and other data are resolved here. A new taxonomic treatment of *Camellia* in Indochina is proposed in Section 2.4.4 below based on the *RPB2* gene tree (Figures 2.9), the other gene trees, morphology and other data.

2.4.2 ITS gene trees

ITS could be directly sequenced in other genera of the Theaceae, such as *Polyspora* and *Pyrenaria* (Li et al. 2011) but needed to be cloned before Sanger sequencing in many species of *Camellia* (Vijayan & Tsou 2008, Vijayan et al. 2009). This difference may suggest that the gene duplications of ITS might have occurred after *Camellia* split with other genera of the Theaceae. Furthermore, PCR products of *C. krempfii*, *C. sonthaiensis* and *C. vidalii* were successfully directly sequenced without cloning in this research, which may imply that these three species did not undergo the similar gene duplications that happened in other species of *Camellia* (Figures 2.10–2.12). Other

reasons may also account for the heterogeneous copies in ITS. Nuclear ribosomal DNA including the ITS region exists in tandem repeats that through a process of concerted evolution become homogenised. This homogenisation process is not always complete and multiple copies of the region can exist that require independent sequencing. Furthermore, because ITS is biparentally inherited, different allelic forms of different lengths can potentially exist which preclude direct Sanger sequencing from PCR products (Hodkinson et al. 2002, Judd et al. 2008).

Though ITS is a multicopy marker in many *Camellia* species, it supports the monophyly of sections *Thea*, *Furfuracea* (including *C. hongkongensis*) and *Camelliopsis* (= subg. *Metacamellia* Hung T. Chang) (Vijayan et al. 2009), which is consistent with the analyses using *RPB2* data here (Figures 2.6–2.9). Maybe a ‘cherry-picking’ way can be adopted to interpret the ITS tree of *Camellia*: highlighting the clades that could be confirmed by other data and ignoring the paraphyletic and polyphyletic sections. Taxonomists seem to have the privilege to make this kind of decision because of the ‘art’ nature of taxonomy (Hull 1967, Judd et al. 2008). I cannot deny the rationality of ‘cherry-picking’ since I also use it here to explain *RPB2* trees (Figures 2.3–2.9); however, the ITS marker in *Camellia* has a theoretical weakness for phylogenetic analysis as introduced in Section 2.1.2. The general topology of the ITS tree of *Camellia* may be affected by gene duplication rather than exclusively shaped by speciation.

2.4.3 CpDNA gene trees

Using four cpDNA markers, Fang et al. (2010) suggested that *C. hekouensis* was sister to all other samples of *Camellia*, including species of sections *Archecamellia*, *Camelliopsis*, *Furfuracea*, *Heterogenea*, *Paracamellia* and *Thea*. However, here *C. hekouensis* is shown to be closely related to *C. gracilipes* and *C. pubicosta*. No species or group is clearly supported as sister to all other *Camellia* (Figures 2.13–2.15). The *rpl32–trnL* region cannot supply enough variable or parsimony-informative characters (Table 2.3) to resolve the intrageneric phylogenetic relationship of *Camellia* in detail: more data are needed to achieve this aim. Nevertheless, no more cpDNA markers were added in this research because of budget limitations and a concern of the phylogenetic value of cpDNA in *Camellia*.

Several gene trees reconstructed using cpDNA regions of *Camellia* are incongruent with those using nuDNA markers (Xiao 2001, Vijayan et al. 2009, Fang et al. 2010) and the results of morphological, chemical, cross tests and other investigations. Maternally inherited cpDNA in *Camellia* (Corriveau & Coleman 1988, Kaundun & Matsumoto 2011) may reflect a unique but partial phylogenetic history and may infer a different phylogeny compared with nuDNA or morphological data (Hardig et al. 2000, Yu et al. 2013). The incongruence is not uncommon in *Camellia* (Yang et al. 2013, Zhang et al. 2014). For example, the monophyly of sect. *Thea* was supported by nuDNA ITS (Vijayan et al. 2009) and *RPB2* data (Figures 2.3–2.9, Xiao 2001) but affirmed neither by several cpDNA regions (Fang et al. 2010) nor complete plastid genomes (Huang et al. 2014, Wang et al. 2017, Yu et al. 2017). This incongruence can be specifically

illustrated by the relationship between *C. sinensis* and *C. taliensis*. These two species were treated as members of sect. *Thea* in each classification of *Camellia* (Sealy 1958, Zhang 1981a, 1998, Zhang & Bartholomew 1984, Min 2000, Min & Bartholomew 2007) and their close relationship was supported by the chemical data (Nagata & Sakai 1984), hybridisation tests (Takeda 1990) and the common utilization as beverage sources (Zhao et al. 2014). The relationship was also supported in the phylogenetic trees reconstructed using nuDNA markers (Vijayan et al. 2009). In Figures 2.3–2.9, *C. taliensis* is represented by its synonym *C. irrawadiensis* because a narrow species circumscription was used in the molecular analyses, see Section 2.2.1). However, on a tree reconstructed using the whole plastid genomes (Yu et al. 2017), *C. taliensis* was sister to all other samples of *Camellia*, including oil camellia, yellow and red camellias, *C. sinensis* and others. In another cpDNA phylogenomic analysis, *C. taliensis* formed a clade with *C. yunnanensis* Cohen-Stuart, a species of sect. *Heterogenea*, rather than *C. sinensis* (Huang et al. 2014). These incongruences might imply a unique evolutionary route of cpDNA in *Camellia*, but it weakened the value of cpDNA in the phylogenetic analyses of this genus.

2.4.4 New taxonomic treatment

No extant subgenus of *Camellia* (Zhang 1981a, Zhang & Bartholomew 1984, Min 2000) is supported by the concatenated *RPB2* gene tree (Figure 2.9). Though two main clades form the monophyletic group *Camellia* on the *RPB2* tree (Figure 2.9), they are not recognised as subgenera accordingly because the clade consisting of sections *Corallina* and *Piquetia* has only weak support in Bayesian and MP analyses (Figure 2.9, JK = 74, PP = 0.85). However, ten amended sections in Indochina with new circumscriptions are supported by the concatenated *RPB2* data (Figures 2.9) and they are discussed alphabetically by name below. The rank of ‘section’ rather than ‘subgenus’ or ‘series’ was chosen to represent these ten strongly supported clades based on the general circumscription and size of sections in previous works (Sealy 1958, Zhang 1981a, 1998, Zhang & Bartholomew 1984, Min 2000, Min & Bartholomew 2007). It is useful to maintain this continuity in the practice of taxonomy in this group and if future studies better resolve the relationships among these sections, they can, at that time, be combined into subgenera. It is premature to categorise sections into subgenera now. The diagnostic characters of each section and the complete species composition in Indochina of each section are elaborated in Chapter 4.

Additionally, sections that do not occur in Indochina, such as sect. *Camellia*, are not listed here because of the geographic scope of this research. Though the phylogenetic analyses (Figures 2.3–2.15) include data of many taxa that are endemic to non-Indochinese countries, such as China, and these data were either generated in this research (Table 2.1) or obtained from Xiao (2001), the sectional classification proposed here may still be considered a provisional one until a nearly exhaustive sampling of known species is employed in a phylogenetic analysis, which may give a greater stability to the classification of this genus.

(a) Section *Archecamellia*. Seventeen taxa form this clade on the combined *RPB2* gene tree (Figure

2.9). The circumscription of this section is amended to include a group of species with yellow flowers that are generally distributed in south-western China and northern Vietnam. On the one hand, the scope of this section is narrowed by excluding several species recognised by former monographers. When Sealy (1958: 36) established this section, he included *C. amplexicaulis* and *C. krempfii*. However, the former is transferred into sect. *Cylindriea* and the latter is placed in sect. *Piquetia* here. This section includes all species of sect. *Chrysanthia* established by Zhang (1979), whose illegitimate treatment of sect. *Archecamellia* (Zhang 1981a) has been introduced in Section 1.3.1 above. On the other hand, the circumscription of sect. *Archecamellia* is widened to include more species, such as *C. luteoflora*, which was the type of sect. *Luteoflora* (Zhang & Zeng 1982) and treated as a member of sect. *Stereocarpus* by Min (1999: 156).

(b) Section *Camelliopsis*. This clade contains four species on the *RPB2* tree (Figure 2.9). These four species represent Zhang's (1981a) subg. *Metacamellia*, which in turn contains species from both sections *Eriandria* (ovary hairy) and *Theopsis* (ovary glabrous) (Zhang & Bartholomew 1984, Min 2000). These two sections are distinguished from each other only by the indumentum of the ovary. The broad sect. *Camelliopsis* was also supported by ITS data (Vijayan et al. 2009) and their single loculed fruit (Min 2000).

(c) Section *Corallina*. Three species form this clade on *RPB2* intron 11–16 trees (Figures 2.3–2.5) but only two species on the concatenated *RPB2* tree (Figure 2.9). This is because *C. corallina*, the type of this section, was not successfully sequenced for the *RPB2* intron 23 region. Species of this section are generally distributed in northern and central Vietnam.

(d) Section *Cylindriea*. This branch contains only one species: *C. amplexicaulis*. The species was usually placed in sect. *Archecamellia* (Sealy 1958, Zhang 1996a, Min 2000). *Camellia amplexicaulis* differs from members of sect. *Archecamellia* by its flower colour (usually red). This species is clearly different from sect. *Archecamellia* and its most close-related group is sect. *Paracamellia* on the *RPB2* tree (Figure 2.9). Its genetic uniqueness was also supported by the ITS analyses (Figure 2.10, Vijayan et al. 2009).

(e) Section *Furfuracea*. Three taxa form this clade on the *RPB2* tree (Figure 2.9). Zhang (1981a) established this section but Min (2000) recognised it as a synonym of sect. *Heterogenea*. The monophyly of sect. *Furfuracea* was also supported by ITS data (Vijayan et al. 2009). Remarkably, a clade formed by *C. rubriflora* and *C. lanceolata* is sister to this section. It is possible that *C. rubriflora* and *C. lanceolata* could be placed in sect. *Furfuracea*; however, I have not seen the type of *C. rubriflora* and know very little about this species. Therefore, this section is not widened to include *C. rubriflora* and *C. lanceolata* provisionally.

(f) Section *Heterogenea*. This clade is formed by four species on the *RPB2* tree (Figure 2.9). Sealy (1958: 152) proposed this section to temporarily categorise 'a collection of diverse species' but Min (2000: 210) recognised it as a 'natural group' into which he transferred species of sect. *Furfuracea*. However, both *RPB2* (Figures 2.3–2.9) and ITS (Vijayan et al. 2009) data suggest that

Min's (2000) sect. *Heterogenea* is a polyphyletic group. Species of sect. *Furfuracea* are excluded from this section. Furthermore, *C. connata*, a species previously placed in sect. *Calpandria* (Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 1999, Min 2000), is now transferred into this section.

(g) Section *Paracamellia*. This clade is formed from eight taxa on the *RPB2* tree (Figure 2.9) and contains oil camellias. When Sealy (1958) established sect. *Paracamellia*, he placed *C. grijsii* in this section. Sealy's (1958) treatment was followed by Zhang (1981a) and Min (2000). However, *C. grijsii* is excluded from this section here because it nests in a different clade with species of sect. *Paracamellia* on the *RPB2* tree (Figure 2.9).

(h) Section *Piquetia*. This clade is formed by four taxa on the *RPB2* tree (Figure 2.9). Only the type species, *C. piquetiana*, was recognised in this section by previous monographers (Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 1999, Min 2000). It is enlarged here to include *Dankia* (Gagnepain 1939) and several species with yellow or red flowers, which are all distributed in southern Vietnam.

(i) Section *Stereocarpus*. Three taxa form this clade on the *RPB2* tree (Figure 2.9). Min's sect. *Stereocarpus* includes *C. luteoflora*, which is transferred into sect. *Archeacamellia* here.

(j) Section *Thea*. This clade is formed by four taxa on the *RPB2* tree (Figure 2.9). The species of sect. *Thea* usually can be used as beverage sources. Section *Thea* is enlarged here to include *C. longissima*, which may be a useful genetic resource to supply new characters for tea breeding. *Camellia longissima* is rare and endemic to Guangxi, China (Zhang 1981a, Min 2000). Its potential as a beverage source or its usage on the tea breeding is waiting to be explored.

2.5 Conclusions

Single copy nuDNA *RPB2* 11–16 and 23 intron regions were found to be very informative for the phylogenetic reconstruction in *Camellia* and particularly useful when used in combination. The phylogenetic accuracy and resolution of *RPB2* gene trees were effectively improved with the addition of Indochinese species of *Camellia* compared to the previous studies lacking these taxa. A new classification of *Camellia* is proposed here based on the *RPB2* and other gene trees, and the morphological and other data to generally categorise Indochinese species into ten amended sections: *Archeacamellia*, *Camelliopsis*, *Corallina*, *Cylindriea*, *Furfuracea*, *Heterogenea*, *Paracamellia*, *Piquetia*, *Stereocarpus* and *Thea*. Among them, sect. *Thea* is enlarged to include *C. longissima*, which has been barely investigated and may supply new genetic characters for tea breeding. Gene trees reconstructed using cpDNA markers in *Camellia* are usually incongruent with those of nuDNA and analyses using morphological, chemical, cross tests and other data. These incongruences maybe helpful to understand the evolution of plastid DNA in the group, the occurrence of hybridisation and introgression, and the potential incidence of chloroplast capture in lineages. Phylogenetic analysis using multicopy nuDNA markers, such as the *LEAFY* region and ITS, are affected by gene duplications in *Camellia* and need to be carefully interpreted.

Chapter 3 Molecular dating and evolution

3.1 Introduction

Zuckerkandl & Pauling (1965) showed that the differences of amino acids in protein molecules between two species changed roughly linearly with time, and this observation has been generalised to include DNA sequences and is now widely used to infer the timing of evolutionary events (Hasegawa et al. 1985, Sanderson et al. 2004, Rutschmann 2006, Kumar & Hedges 2016). This molecular clock hypothesis led to molecular dating which has already been employed in the Theaceae to estimate the time of divergence of different genera (Su et al. 2011, Li et al. 2013, Zhang et al. 2014). However, not only the topologies of gene trees but also the fossil calibration points selected determined the estimation of divergence times for different inferred clades (Welch & Bromham 2005, Hug & Roger 2007, Gandolfo et al. 2008). In Section 1.4.2 and Chapter 2, I have introduced and discussed the issues on topologies of gene trees reconstructed using cpDNA markers, nuDNA multicopy and single copy regions in *Camellia*. Here, the fossil records are examined to try to calibrate the molecular dated phylogenetic trees more accurately (Gandolfo et al. 2008).

As introduced in the beginning of Chapter 1, living species of *Camellia* are distributed in East, South and Southeast Asia (Min 2000). Roughly one third of known species occur in Indochina and two thirds in China (Min 2000). As they are evergreen shrubs or trees, species of *Camellia* can reach as far north as northern Honshu of Japan, where *C. japonica* can be found (Kirino 1998). Northern Honshu has an annual temperature average of about 9.7°C and that of coldest month (January) is −1.8°C (Kirino 1998). *Camellia* can be found as far south as Java in Indonesia, where *C. lanceolata* grows in the Southern Hemisphere (Min 2000). However, several fossils designated as *Camellia* were found outside its current distribution area (Wolfe 1968, Macovei & Givulescu 2006).

Camellia can be easily distinguished from other genera of Theaceae by its fruit and seed (Sealy 1958) but no credible fruit or seed fossil record of *Camellia* has been reported. Wolf (1968) reported *C. multiflora* (Potbury) J. Wolfe from the lower Oligocene (33.9–28.1 Ma, Cohen et al. 2013) at King County, Washington. The basionym of Wolfe's (1968: 25) new combination was *Euphorbiophyllum multiflorum* Potbury. Since there was debate on identifying this fossil between Wolfe and Potbury (Wolfe 1968) and no original material was available to me, this fossil record was not used here. In Romania, a foliar remnant from the uppermost Miocene (7.246–5.333 Ma, Cohen et al. 2013) was named *Camellia* sp. ('*Camelia* sp.' in the original paper—Macovei & Givulescu 2006). This fossil was described as a member of 'a forest of a warm temperate type with deciduous leaves' (Macovei & Givulescu 2006: 42), which might be like the habitat of *C. japonica*—since other modern *Camellia* species are generally distributed in the subtropical or tropical forests (Min 2000). However, there were much earlier records of fossils resembling *C.*

japonica reported from Asia.

In central Japan, Ishida (1970) found several foliar fossils of *C. protojaponica* Huzioka from the deposits of the Middle Miocene (15.97–11.608 Ma, Cohen et al. 2013) and considered that this species closely resembled *C. japonica*. I agree with his opinion based on the morphology of the leaf photos attached in the article. Another fossil species found in Japan, *C. japonoxyla* M. Suzuki & K. Terada, was described based on a piece of silicified wood from the lower Miocene Yanagida Formation (22.8 ± 0.8 – 19.3 ± 0.6 Ma, Suzuki & Terada 1996). The authors (Suzuki & Terada 1996) suggested that it was like *C. japonica* because both had abundant swollen crystalliferous ray cells. The silicified wood of *C. japonoxyla* was later found in Korea from the Early Miocene (23.03–15.97 Ma, Jeong et al. 2004, Cohen et al. 2013).

Wood fossils of *Camellia* have also been found in China. *Camellia kueishanensis* Ching Y. Li, C.M. Wang, J.Y. Hsiao & Chiou H. Yang, was described based on a piece of calcified wood with secondary xylem and bark from the Early Miocene (23.03–15.97 Ma, Cohen et al. 2013) in northern Taiwan (Li et al. 2003). It was believed that this fossil was like *C. sinensis* by ‘the ray width and the lack of spiral thickening in vessels’ (Li et al. 2003: 76). Recently, a mummified sample of wood from the late Oligocene (28.1–23.03 Ma, Cohen et al. 2013) was found in Guangxi and named as *C. nanningensis* Lu L. Huang, J.H. Jin, C. Quan & Oskolski, which resembled *C. sinensis*, *C. subacutissima* Hung T. Chang and *C. taliensis* by the ‘rays with equally wide multiseriate and uniseriate portions’ (Huang et al. 2016: 827).

Additionally, more calibration points can be added for molecular dating by using the fossils related to outgroups, *Polyspora* and *Pyrenaria*. A leaf fossil found at Klaus, Germany from the late Eocene (38.0–33.9 Ma, Cohen et al. 2013) was named *Po. saxonica* H. Walther & Kvaček (Kunzmann et al. 2016), which I do not recognise as *Polyspora* based on the leaf morphology. The fruit and seed fossils of *Gordonia warmanensis* Grote & Dilcher found in western Kentucky and Tennessee of USA from the middle Eocene (47.8–38.0 Ma, Grote & Dilcher 1992, Cohen et al. 2013) resemble *Polyspora* based on their morphology. *Gordonia* J. Ellis and *Polyspora* are morphologically like each other and can be distinguished by their geographic distribution: the former occurs in north America and the latter in Asia (Yang et al. 2004).

To infer the origin and diversification history of *Camellia* in Indochina, the concatenated *RPB2* (intron 11–16 and intron 23) data with fossil calibration points are here used to estimate the origin of this genus and patterns of intrageneric divergence. The evolutionary history of *Camellia* is discussed in light of the dated phylogenetic reconstruction and corresponding tectonic, climate and sea level changes during the Cenozoic.

3.2 Material and methods

The concatenated data of *RPB2* 11–16 and 23 intron regions was analysed using the BEAST v1.8.4 software package (Drummond & Rambaut 2007, Suchard & Rambaut 2009, Drummond et al.

2012) to date the phylogenetic history of *Camellia*. The model parameters were set in BEAUti (within BEAST package). A GTR model (Tavaré 1986) with estimated base frequencies, Gamma + invariant sites and gamma shape distribution (with four categories) was applied. A lognormal uncorrelated relaxed clock model (Drummond et al. 2006) and the Yule process (Yule 1925, Gernhard 2008) of speciation were applied to estimate the divergence times. A Metropolis-coupled Markov chain (MCMC) search was run for 50 million generations and the trees were saved every 1000 generations. If a final tree had an odd topology (e.g., some branches crossed each other), the MCMC search was run for 80 million generations.

Because setting fossil constraint points on a phylogenetic tree is always rife with uncertainty (Rutschmann et al. 2007), several combinations of fossils were tried to explore their effects on molecular dating by changing the number and position. They were set as follows:

- (a) A single fossil, *C. protojaponica* (15.97–11.608 Ma), was selected as the calibration points to constrain the stem age of *C. japonica* because of their similarity on leaf morphology, which I agreed with Ishida (1970). A lognormal prior distribution was employed to set the median time at 13.79 Ma and a 95% confidence interval of 11.91–15.96 Ma.
- (b) Two fossils, *C. japonoxyla* (Suzuki & Terada 1996) and *C. nanningensis* (Huang et al. 2016), were selected as the calibration points. As introduced above, both *C. protojaponica* and *C. japonoxyla* were similar to *C. japonica* but *C. japonoxyla* (22.8 ± 0.8 – 19.3 ± 0.6 Ma) was found to have occurred earlier than *C. protojaponica* (15.97–11.608 Ma). Therefore, *C. japonoxyla* was selected as the constraint point for the stem age of *C. japonica* with the median time at 21.05 Ma and a 95% confidence interval of 19.36–22.89 Ma. Similarly, *C. nanningensis* (Huang et al. 2016) was like members of sect. *Thea* and occurred earlier than *C. kueishanensis* (Li et al. 2003), so it was adopted to set the stem age of sect. *Thea* with the mean at 25.56 Ma and a 95% confidence interval of 23.23–28.12 Ma.
- (c) Three fossils, setting A. Settings of *C. japonoxyla* and *C. nanningensis* were the same as those shown in combination (b) above. Another fossil, *G. warmanensis* (47.8–38.0 Ma, Grote & Dilcher 1992) was selected to constrain the stem age of *Polyspora* with the mean at 42.91 Ma and a 95% confidence interval of 38.55–47.75 Ma.
- (d) Three fossils, setting B. *Camellia nanningensis* was selected to constrain the stem age of sect. *Thea*, *C. grijsii* and *C. albogigas* because it resembled the species of both sect. *Thea* and sect. *Camelliopsis* (Huang et al. 2016). *Camellia japonoxyla* was selected to constrain the stem age of *C. japonica*. The crown age of sect. *Thea* was constrained by *C. kueishanensis* (23.03–15.97 Ma) with the mean at 19.49 Ma and a 95% confidence interval of 16.48–23.05 Ma.
- (e) Four fossils, setting A. The setting of combination (d) were used, plus the fossil *G. warmanensis* was added to constrain the stem age of *Polyspora*.
- (f) Four fossils, setting B. The setting of combination (c) were used, plus the fossil *C.*

kueishanensis was added to constrain the stem age of *C. sinensis* and *C. assamica* (Choisy) Hung T. Chang.

The XML files of *RPB2* data with the above settings were created and initially tried in BEAST on a local computer and subsequently run using BEAST on XSEDE provided on the CIPRES Science Gateway (Miller et al. 2010, <https://www.phylo.org/>). The convergence of Bayesian MCMC runs was analysed using Tracer v.1.6 (<http://tree.bio.ed.ac.uk/software/tracer/>). The trees were summarized with a 10% burn-in using TreeAnnotator (within BEAST package) to generate the maximum clade credibility tree. The final trees were displayed and optimised using FigTree v.1.4.3 (<http://tree.bio.ed.ac.uk/software/figtree/>) and Adobe Illustrator. Recognised sections were labelled along clades.

The analysis with setting of fossils that generates an incongruent topology with Figure 2.9 was considered unreliable. If a setting has both the most fossil calibration points and the same topology as Figure 2.9, it would be treated as a most reliable solution.

After the analyses of molecular dating with six different combinations of fossil calibration points, the most reliable tree was employed to discuss the character evolution in *Camellia*. The morphological characters that were frequently used to distinguish the subgenera, sections or species in the current classifications (Sealy 1958, Zhang 1981a, Min 2000), including whether leaf blade was punctate on abaxial surface, the status of bracteoles and sepals after flowering, flower colour, whether the outer filaments completely united into a tube and the indumenta of filaments and ovary of each taxon, were illustrated on the tree to explore their evolutionary history.

3.3 Results

Analyses with six different combinations of fossil calibration points are shown as follows.

(a) The analysis using a single fossil, *C. protojaponica*, in combination (a) yielded an odd topology of the *RPB2* tree when 50 million generations of MCMC search was employed: the branch of *C. japonica* crossed with the clade of sect. *Paracamellia*. When a longer MCMC search of 80 million generations was used, the monophyletic topology of *Camellia* collapsed. Since molecular dating with combination (a) could not yield a *RPB2* gene tree with a reasonable topology, the final trees are not shown here.

(b) The analysis using two fossils, *C. japonoxyla* and *C. nanningensis*, in combination (b) yielded a well resolved *RPB2* tree (Figure 3.1), whose main topology, especially the relationship of the recognised sections, is same as that of Figure 2.9. The crown age of *Camellia* was estimated at 51.26 Ma with a 95% highest posterior density (HPD) of 37.37–67.06 Ma, which is mainly located in the Paleocene (66–56 Ma) and Eocene (56–33.9 Ma). The clade formed by sections *Corallina* and *Piquetia* (45.31 Ma with 95% HPD of 29.4–62.23 Ma), which were generally distributed in Vietnam, diversified earlier than that including the rest of *Camellia* (44.45 Ma with 95% HPD of 33.28–57.62 Ma). The divergence time of members in section *Piquetia* was estimated at 22.94 Ma

(with 95% HPD of 12.36–36.53 Ma), which was the oldest in terms of the median of the estimated crown age in different sections (Figure 3.1, Table 3.1). The youngest section, *Cylindria*, included only one species, *C. amplexicaulis*, and its crown age (6.65 Ma with 95% HPD of 1.8–13.26) suggested the time of intraspecific diversification. All recognised sections generally diversified during the Miocene (Figure 3.1, Table 3.1).

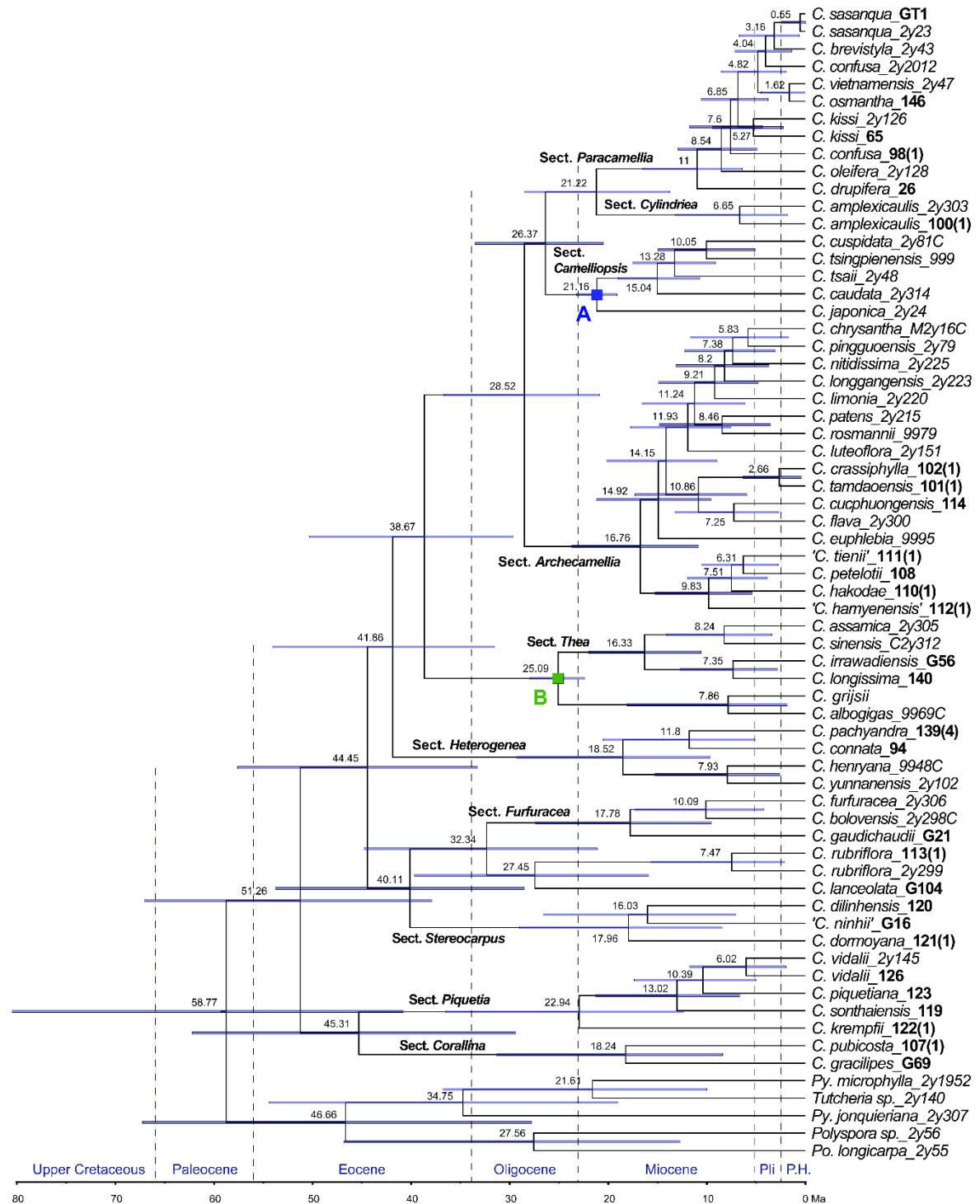


Figure 3.1. Maximum clade credibility tree reconstructed using the concatenated RPB2 (intron 11–16 and intron 23) data and two fossil calibration points (marked by squares, blue A: *C. japonoxyla*; green B: *C. nanningensis*). Blue bars indicate the 95% HPD intervals of node ages. The geological

epochs are shown above the time axis (Pli: Pliocene; P.H.: Pleistocene and Holocene, Cohen et al. 2013). Numbers in bold indicate the samples sequenced here.

Table 3.1. Estimated crown age of each recognised section of *Camellia* in Indochina with different fossil calibration combinations. Data in bold indicate the results from the most reliable analysis. Fossil settings (a), (d) and (e) are excluded here because they are considered not reliable (see Section 3.4).

Section	Combination of fossil points	Estimated crown age (Ma)	95% HPD (Ma)
<i>Archecamellia</i>	(b), 2 fossils, Figure 3.1	16.76	10.85–23.71
	(c), 3 fossils, Figure 3.2	16.06	10.69–22.51
	(f), 4 fossils, Figures 3.5–3.6	15.93	10.84–21.72
<i>Camelliopsis</i>	(b), 2 fossils, Figure 3.1	15.04	10.74–18.99
	(c), 3 fossils, Figure 3.2	14.81	10.57–18.91
	(f), 4 fossils, Figures 3.5–3.6	14.7	10.47–18.76
<i>Corallina</i>	(b), 2 fossils, Figure 3.1	18.24	8.39–31.36
	(c), 3 fossils, Figure 3.2	17.92	8.12–30.86
	(f), 4 fossils, Figures 3.5–3.6	17.07	8.36–28.09
<i>Cylindria</i>	(b), 2 fossils, Figure 3.1	6.65	1.80–13.26
	(c), 3 fossils, Figure 3.2	6.42	1.76–12.84
	(f), 4 fossils, Figures 3.5–3.6	6.31	1.88–12.89
<i>Furfuracea</i>	(b), 2 fossils, Figure 3.1	17.78	9.57–27.40
	(c), 3 fossils, Figure 3.2	16.91	9.39–25.93
	(f), 4 fossils, Figures 3.5–3.6	16.67	9.24–24.95
<i>Heterogenea</i>	(b), 2 fossils, Figure 3.1	18.52	9.71–29.31
	(c), 3 fossils, Figure 3.2	17.69	9.64–27.57
	(f), 4 fossils, Figures 3.5–3.6	17.33	9.71–26.85
<i>Paracamellia</i>	(b), 2 fossils, Figure 3.1	11.00	6.42–16.52
	(c), 3 fossils, Figure 3.2	10.58	6.27–15.89
	(f), 4 fossils, Figures 3.5–3.6	10.50	6.32–15.28
<i>Piquetia</i>	(b), 2 fossils, Figure 3.1	22.94	12.36–36.53
	(c), 3 fossils, Figure 3.2	22.15	12.12–34.76
	(f), 4 fossils, Figures 3.5–3.6	21.62	12.44–32.98
<i>Stereocarpus</i>	(b), 2 fossils, Figure 3.1	17.96	8.44–28.99
	(c), 3 fossils, Figure 3.2	17.28	8.73–27.91
	(f), 4 fossils, Figures 3.5–3.6	16.76	9.04–26.84
<i>Thea</i>	(b), 2 fossils, Figure 3.1	16.33	10.57–21.98
	(c), 3 fossils, Figure 3.2	16.04	10.34–21.81
	(f), 4 fossils, Figures 3.5–3.6	18.43	15.49–21.53

(c) The analysis using three fossils, *C. japonoxyla*, *C. nanningensis* and *G. warmanensis*, in

combination (c) yielded a tree (Figure 3.2) with same topology as that using two fossils in Figure 3.1. The crown age of *Camellia* was estimated at 47 Ma with a 95% HPD of 36.34–58.11 Ma, which covered the Paleocene and Eocene. Similar to that in Figure 3.1, the clade consisting of sections *Corallina* and *Piquetia* (44.02 Ma with 95% HPD of 31.15–56.76 Ma) diversified earlier than that of other *Camellia* (43.16 Ma with 95% HPD of 33.5–54.03 Ma). Section *Piquetia* (22.15 Ma with 95% HPD of 12.12–34.76) and sect. *Cylindriea* (6.42 Ma with 95% HPD of 1.76–12.84) have the oldest and youngest estimated crown age among sections, respectively. All recognised sections mainly diversified during the Miocene (Figure 3.2, Table 3.1).

(d) The analysis using three fossils, *C. japonoxyla*, *C. kueishanensis* and *C. nanningensis*, in combination (d) suggested that the crown age of *Camellia* was 37.35 Ma with a 95% HPD of 30.39–46.59 Ma, which is in the Eocene and Oligocene (Figure 3.3). However, this tree (Figure 3.3) has a different topology compared with that of *RPB2* tree in Figure 2.9, where *C. japonica* is sister to sect. *Camelliopsis* (Figure 2.9). Here in Figure 3.3, *C. japonica* is sister to a clade formed by sections *Cylindriea* and *Paracamellia*.

(e) The analysis using four fossils, *C. japonoxyla*, *C. kueishanensis*, *C. nanningensis* and *G. warmanensis* in combination (e) suggested that the crown age of *Camellia* was 40.62 Ma with a 95% HPD of 33.66–49.18 Ma, which covered the Eocene (Figure 3.4). However, the tree in Figure 3.4 has a different topology compared with that of *RPB2* tree in Figure 2.9, where the clade formed by *C. japonica* and sect. *Camelliopsis* is sister to that formed by sections *Cylindriea* and *Paracamellia* (Figure 2.9). By contrast, the clade formed by *C. japonica* and sect. *Camelliopsis* is sister to sections *Archecamellia*, *Cylindriea* and *Paracamellia* in Figure 3.4.

(f) The analysis using four fossils, *C. japonoxyla*, *C. kueishanensis*, *C. nanningensis* and *G. warmanensis*, in combination (f) yielded a tree (Figures 3.5–3.6) with the same topology as those using two fossils in Figure 3.1 and three fossils in Figure 3.2. The crown age of *Camellia* was estimated at 48.5 Ma with a 95% HPD of 39.25–58.92 Ma, which covered the Paleocene and Eocene. Like those in Figures 3.1–3.2, the clade consisting of sections *Corallina* and *Piquetia* (43.24 Ma with 95% HPD of 32.23–55.28 Ma) diversified earlier than that of the rest of *Camellia* (41.88 Ma with 95% HPD of 34.22–50.48 Ma). Section *Piquetia* (21.62 Ma with 95% HPD of 12.44–32.98) and sect. *Cylindriea* (6.31 Ma with 95% HPD of 1.88–12.89) have the oldest and youngest estimated crown age among sections, respectively. All recognised sections generally diversified during the Oligocene and Miocene (Figures 3.5–3.6, Table 3.1).

The analyses using fossil calibration points in combination (b), (c) and (f) yielded trees (Figures 3.1–3.2, 3.5–3.6, Table 3.1) with a single topology that is congruent with that of Figure 2.9. However, combination (f) had the most fossil calibration points and may provide more reliable molecular dating information (Figures 3.5–3.6) than the other two. Therefore, it may be the most reliable choice and its tree was used to illustrate character evolution in *Camellia* (Figures 3.5–3.6).

Seven morphological characters were plotted on the most reliable tree of molecular dating (Figures

3.5–3.6). All character states were revealed to be the result of convergent evolution in *Camellia*, including the punctuate or non-punctuate leaves, the caducous or persistent bracteoles and sepals, the red, white or yellow flower, the filaments that completely form a tube or not, and the glabrous or hairy filaments and ovary (Figures 3.5–3.6).

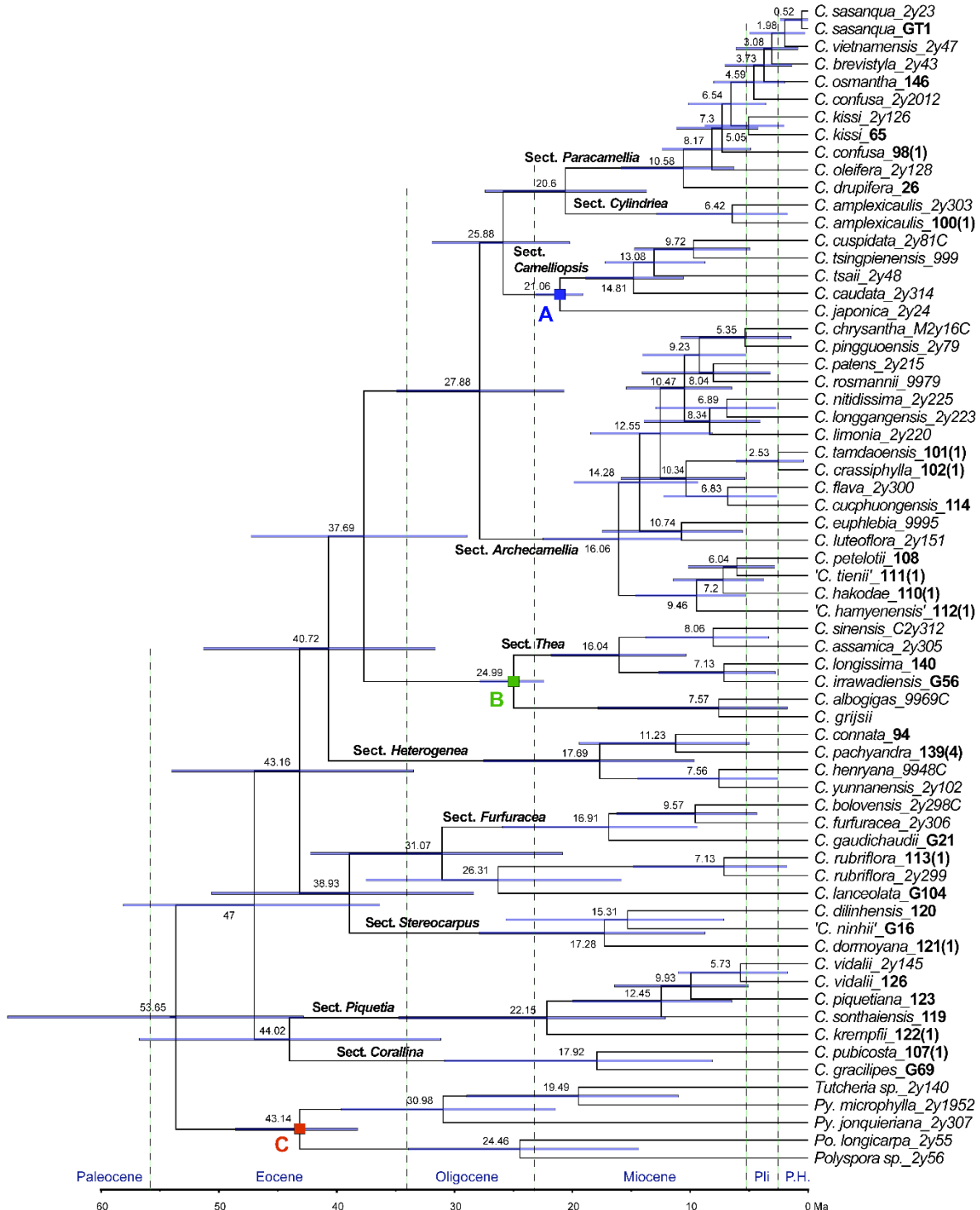


Figure 3.2. Maximum clade credibility tree reconstructed using the concatenated *RPB2* (intron 11–16 and intron 23) data and three fossil calibration points (marked by squares, blue A: *C. japonoxyla*; green B: *C. nanningensis*; red C: *G. warmanensis*). Blue bars indicate the 95% HPD intervals of node ages. The geological epochs are shown above the time axis (Pli: Pliocene; P.H.: Pliocene/Holocene).

Pleistocene and Holocene, Cohen et al. 2013). Numbers in bold indicate the samples sequenced here.

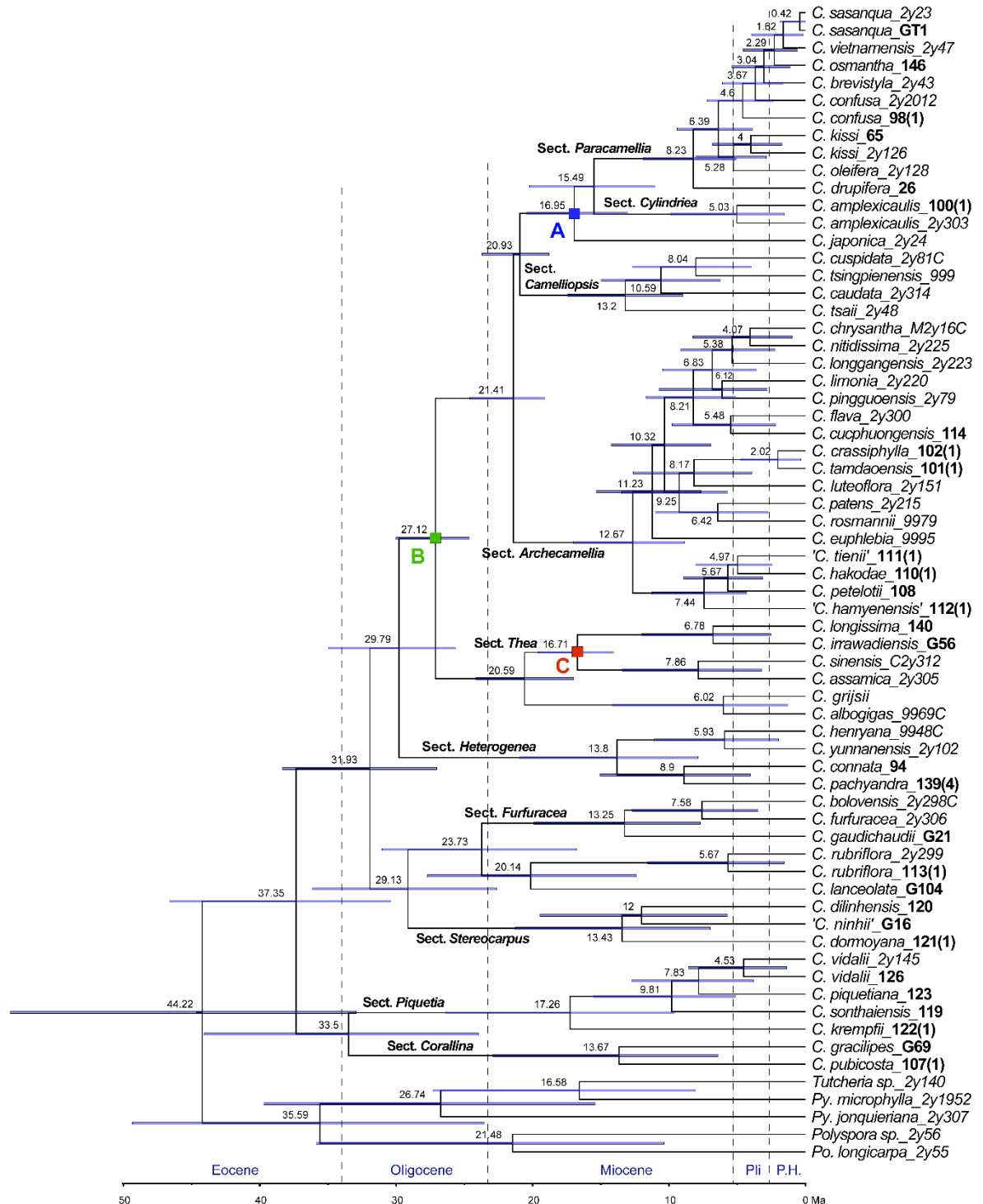


Figure 3.3. Maximum clade credibility tree reconstructed using the concatenated *RPB2* (intron 11–16 and intron 23) data and three fossil calibration points (marked by squares, blue A: *C. japonoxyla*; green B: *C. nanningensis*; red C: *C. kueishanensis*). Blue bars indicate the 95% HPD intervals of node ages. The geological epochs are shown above the time axis (Pli: Pliocene; P.H.: Pleistocene and Holocene, Cohen et al. 2013). Numbers in bold indicate the samples sequenced here.

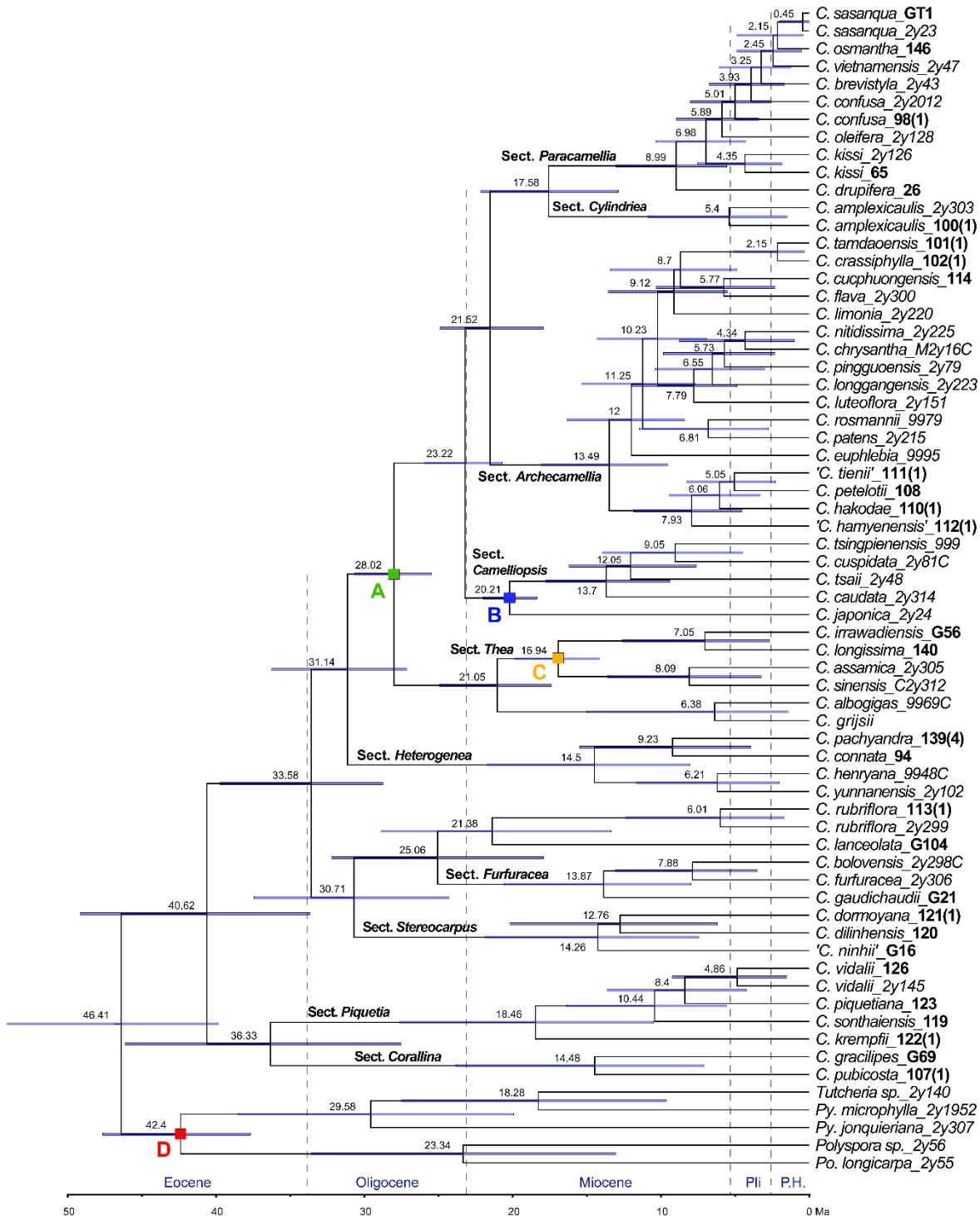


Figure 3.4. Maximum clade credibility tree reconstructed using the concatenated *RPB2* (intron 11–16 and intron 23) data and four fossil calibration points (marked by squares, green A: *C. nanningensis*; blue B: *C. japonoxyla*; yellow C: *C. kueishanensis*; red D: *G. warmanensis*). Blue bars indicate the 95% HPD intervals of node ages. The geological epochs are shown above the time axis (Pli: Pliocene; P.H.: Pleistocene and Holocene, Cohen et al. 2013). Numbers in bold indicate the samples sequenced here.

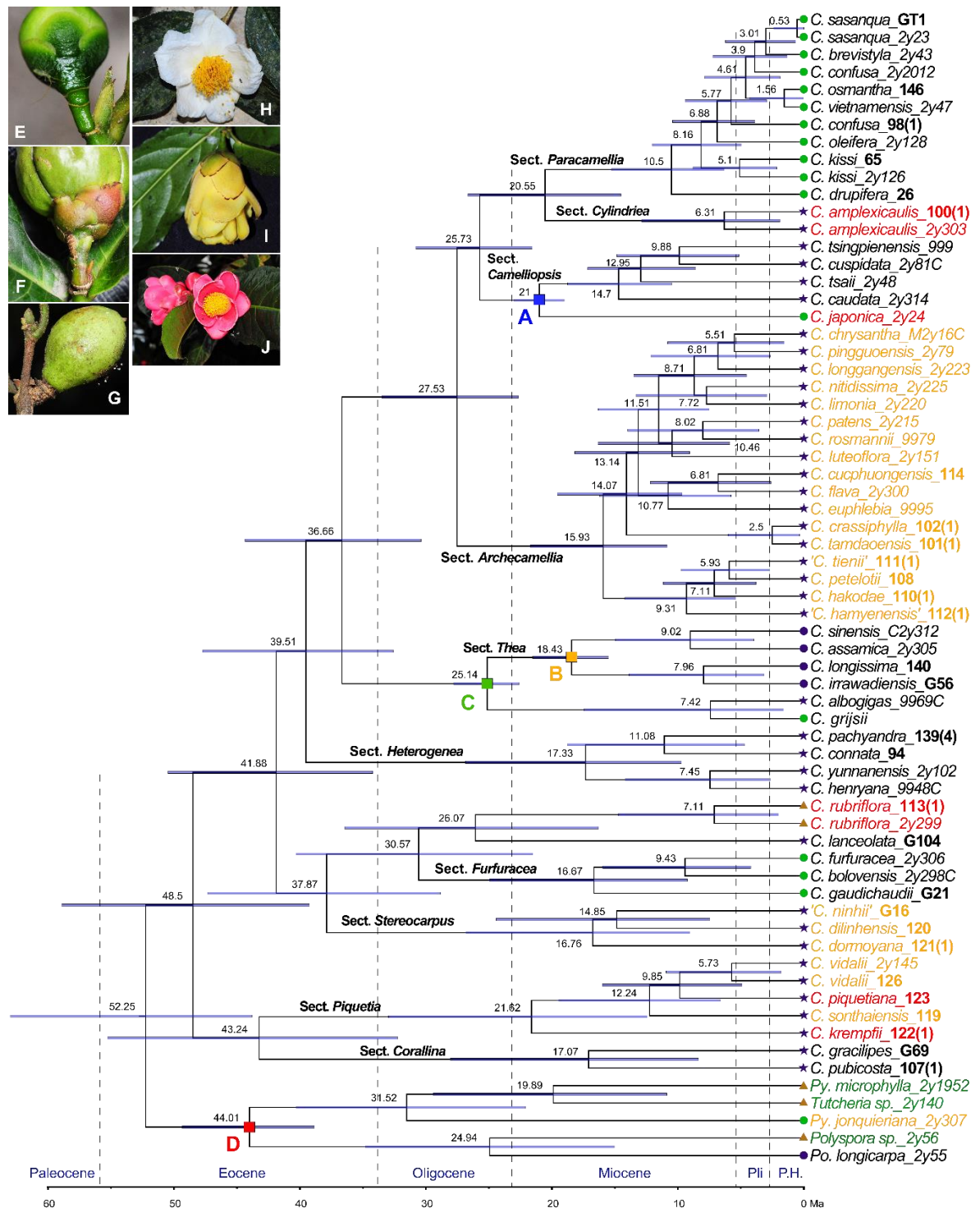


Figure 3.5. Maximum clade credibility tree reconstructed using the concatenated RPB2 (intron 11–16 and intron 23) data and four fossil calibration points (marked by squares, blue A: *C. japonoxyla*; yellow B: *C. kueishanensis*; green C: *C. nanningensis*; red D: *G. warmanensis*). Blue bars indicate the 95% HPD intervals of node ages. The shape and its colour on the tip of each branch indicate the states of bracteoles (circle: caducous [e.g., E: *C. sinensis* var. *assamica*]; star: persistent [e.g., F: *C. amplexicaulis*]; triangle: unknown) and sepals (green: caducous [e.g., G: *C. drupifera* var. *kissi*]; purple: persistent [e.g., F]; brown: unknown) after flowering of corresponding taxa, respectively. The name of each taxon is coloured to represent the colour of its flower (black name: white [e.g., H: *C. drupifera*]; orange name: yellow [e.g., I: *C. flava*]; red name: red [including pink or purplish red, e.g., G: *C. amplexicaulis*]; green name: unknown). The geological epochs are shown above the time axis (Pli: Pliocene; P.H.: Pleistocene and Holocene, Cohen et al. 2013). Numbers in bold indicate the samples sequenced here.

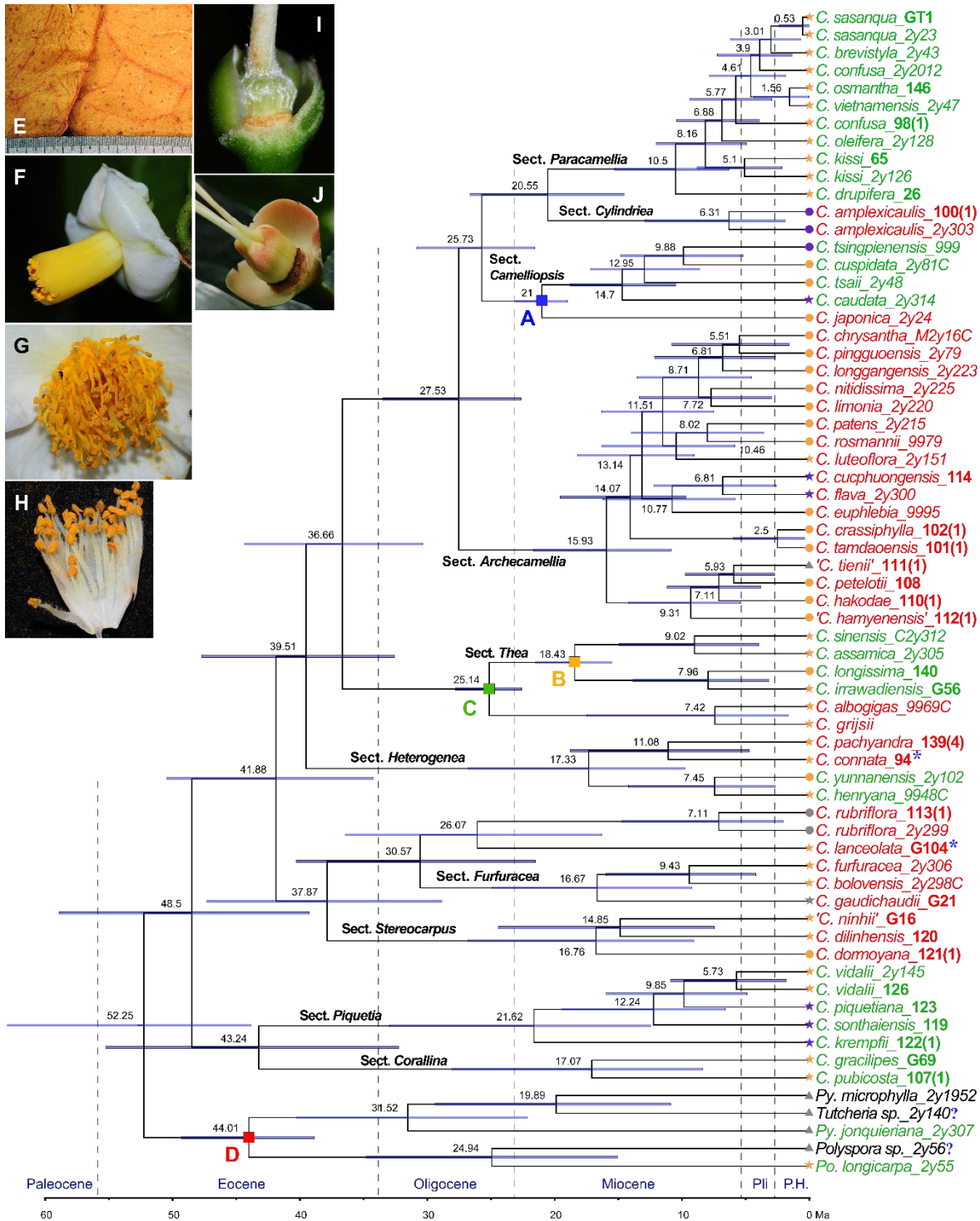


Figure 3.6. Four more morphological characters illustrated on the same tree of Figure 3.5 except that: the name of each taxon is coloured to indicate whether its leaf blade is punctate on the adaxial surface (red: punctate [e.g., E: *C. sealyana*]; green: non-punctate; black: unknown), the punctuations following taxa represent whether the outer filaments completely form a tube (*: yes [e.g., F: *C. connata*]; absent: no (e.g., G: *C. drupifera*; H: *C. tsingpiensis*); ?: unknown), and the shape and its colour on the tip of each branch indicate the indumenta of ovary (star: hairy [e.g., I: *C. sinensis* var. *assamica*]; circle: glabrous [e.g., J: *C. amplexicaulis*]; triangle: unknown) and filaments (orange: glabrous [e.g., G]; purple: hairy [e.g., H]; grey: unknown), respectively.

3.4 Discussion

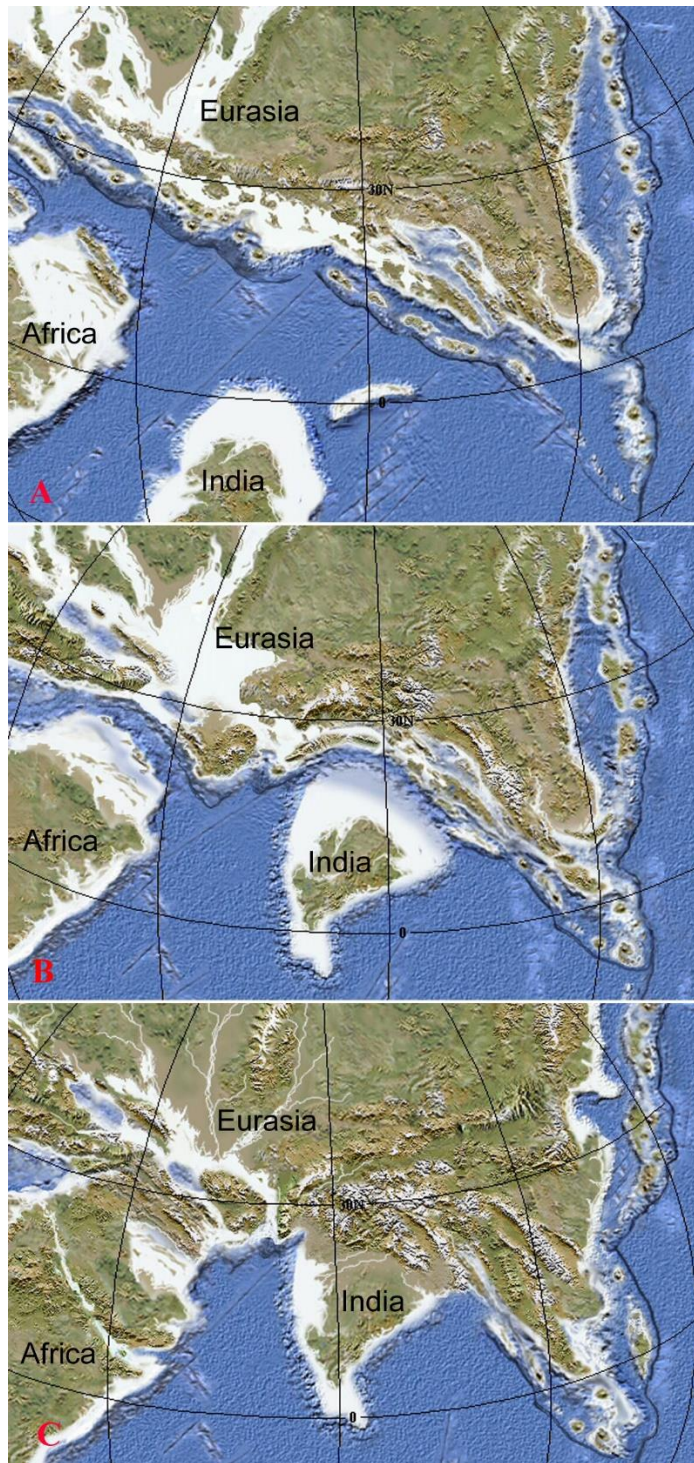
The molecular dating analyses using fossil calibration points in combination (a), (d) and (e) generated trees (e.g., Figures 3.3–3.4) with different main topologies compared with the combined *RPB2* gene tree using Bayesian, ML and MP approaches in Figure 2.9. This incongruence may suggest that combination (a), (d) and (e) are not suitable choices. Therefore, the detailed results of analyses using these combinations were not shown in Table 3.1 and the morphological characters were not illustrated on those trees.

3.4.1 Origin of *Camellia*

The crown age of *Camellia* inferred here (48.5 Ma with a 95% HPD of 39.25–58.92 Ma, Figures 3.5–3.6) is much earlier than those estimated in Li et al. (2003, 7–22 Ma) and Zhang et al. (2014, ca. 12 Ma). Only a single species was represented for *Camellia* in the research of Li et al. (2003) which used ten plastid markers and constrained the crown age of Theaceae at 49 Ma with a fossil from the early Eocene. The same fossil *C. japonoxyla* was used in the nuDNA *LEAFY* region analysis by Zhang et al. (2014) but they applied it to constrain the stem age of *Camellia* at 20 Ma. It is always a challenge to place the fossil at the right position on a phylogenetic tree (Hug & Roger 2007, Gandolfo et al. 2008). However, other data may be used to test the initial hypothesis of molecular dating and help us to improve the accuracy of taxonomic placement of fossil calibrations.

On the one hand, *Camellia japonoxyla* was inferred as a member of the temperate deciduous forests mixed with conifers and evergreen dicotyledons from the lower Miocene in the Noto Peninsula of central Japan (ca. 37°N, Suzuki & Terada 1996). However, the evergreen nature of *Camellia* may suggest that this genus was highly unlikely to be derived from a temperate forest that occurred as north as central Japan, which is far from the centre of the current distribution area of *Camellia* (Min 2000). It would call into question the placement of *C. japonoxyla* at the stem of *Camellia* in the molecular dating analyses.

On the other hand, *C. kueishanensis* occurred in northern Taiwan (Li et al. 2003) at a similar period to *C. japonoxyla*. Additionally, *C. nanningensis* was found in Guangxi from the deposits of the late Oligocene (Huang et al. 2016). These fossil records may suggest that *Camellia* had been distributed in a large area of East Asia and undergone some diversification in the Early Miocene. Therefore, I estimate, based on available evidence, that *Camellia* originated earlier than those dates inferred by Li et al. (2003) and Zhang et al. (2014).



Map 3.1. Paleogeography of Asia. A: Late Cretaceous (100.5–66 Ma); B: Eocene (56–33.9 Ma); C: Miocene (23.03–5.333 Ma). Original maps from ‘Sedimentation, Tectonics, and Paleogeography of Asia’: http://jan.ucc.nau.edu/rcb7/paleogeographic_asia.html.

The *RPB2* gene tree (Figures 2.9) and molecular dating analysis (Figures 3.1–3.2, 3.5–3.6) showed that a clade formed by sections *Corallina* and *Piquetia*, whose members were generally distributed in Vietnam at present, was the first to split from the rest of *Camellia*. This divergence may help imply the potential ancestral areas of *Camellia*. However, I have not found any credible fossil record of *Camellia* reported from Vietnam. Without fossils, it can be very dangerous to infer the

ancestral areas using present-day distribution data since there may be many extinction and colonization events accompanied by huge changes of geology and climate (Zachos et al. 2001) during tens of million years (Map 3.1, Meseguer et al. 2014). The estimated origin time of *Camellia* (48.5 Ma with a 95% HPD of 39.25–58.92 Ma, Figures 3.5–3.6) covers the late Paleocene and early and middle Eocene, which contain the Paleocene-Eocene Thermal Maximum (ca. 56 Ma, Koch et al. 1992, McInerney & Wing 2011), the Early Eocene Climatic Optimum (ca. 50–53 Ma, Zachos et al. 1994, Yapp 2004) and the Mid-Eocene Climatic Optimum (ca. 41.5 Ma, Jovane et al. 2007). Compared with the present, this period had a higher atmospheric concentrations of greenhouse gases and a warmer global environment with little or no ice at the poles (Zachos et al. 2001, 2008). A higher global mean temperature may allow the subtropical and tropical taxa, such as *Camellia*, to occur at higher latitudes or disperse northward (Wing et al. 2005). Subsequent cooling processes may in turn drive those plants southward accompanied with extinctions in the high latitudes. Therefore, the ancestral areas of *Camellia* can be hardly inferred without credible fossil records.

3.4.2 Diversification of *Camellia*

The India-Eurasia collision began about 40–50 Ma (Map 3.1, Searle et al. 1987, Harrison et al. 1992, Molnar et al. 1993), which may overlap with the origin and diversification time of *Camellia* (Figures 3.5–3.6). In the Early Miocene, the rapid uplift of the Qinghai-Tibetan Plateau (Harrison et al. 1992, Favre et al. 2015) and a series of mountain building events (Map 3.1) owing to the collision (Royden et al. 2008) brought about dramatic changes in climate and drainage systems in Indochina (Hall 1998). Various habitats and natural barriers afforded by these changes supplied great ecological opportunities to drive speciation (Hughes & Eastwood 2006). The radiation of many sections of *Camellia* coincides with this period of geological change in the Early and Middle Miocene (Figures 3.5–3.6, Table 3.1).

Morphological characters of *Camellia* greatly diversified over time. For example, the status of sepals after flowering was recognised by Min (2000) as a subgeneric diagnostic character, which was not supported by the molecular analysis here (Figure 3.5). The early diverging clade including sections *Corallina* and *Piquetia* has persistent sepals, which were also found in five of the other eight sections recognised here. Only sections *Furfuracea* (17.99 Ma with 95% HPD of 9.81–27.47 Ma) and *Paracamellia* (11.26 Ma with 95% HPD of 6.73–16.68 Ma) have sepals that were caducous after flowering (Figure 3.5). This difference may imply that the most recent common ancestor of *Camellia* might have possessed persistent sepals while the caducity of sepals was a new character state which evolved convergently in sections *Furfuracea* and *Paracamellia*. Similarly, the caducous bracteoles may also have evolved independently in *C. grijsii*, *C. japonica* and sections *Furfuracea*, *Paracamellia* and *Thea* because the rest of *Camellia*, including the early diverged sections *Corallina* and *Piquetia*, have persistent bracteoles. Whether the leaf blade is punctate on the abaxial surface is another example of convergent evolution in *Camellia* (Figure

3.6). The outgroup and early diverged sections *Corallina* and *Piquetia* have non-punctate leaves, which can also be found in sections *Camelliopsis*, *Paracamellia* and *Thea*. By contrast, sections *Archecamellia*, *Cylindria*, *Furfuracea* and *Stereocarpus* have leaves that are punctate on abaxial surfaces. Interestingly, members of sect. *Heterogenea* have both character states: *C. connata* and *C. pachyandra* have punctate leaves whereas *C. henryana* and *C. yunnanensis* have non-punctate ones (Figure 3.6). Additionally, completely united filament tubes evolved independently in *C. connata* and *C. lanceolata* (Figure 3.6), which were recognised as the only two species of sect. *Calpandria* by the character state of a filament tube (Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 2000). Glabrous ovaries may also have evolved convergently in *Camellia* (Figure 3.6). Many species of *Camellia*, including sections *Corallina*, *Furfuracea*, *Paracamellia* and *Piquetia*, have a hairy ovary whereas the glabrous ovary independently evolved in some species of the sections *Archecamellia*, *Camelliopsis*, *Cylindria*, *Heterogenea*, *Stereocarpus* and *Thea* (Figure 3.6).

However, the evolution of flower colour in *Camellia* may tell a different story. The earliest diversified sect. *Piquetia* has red or yellow flowers (Figure 3.5, Table 3.1) whereas other sections seem to possess a single flower colour, such as sections *Archecamellia* (yellow), *Heterogenea* (white), *Stereocarpus* (yellow) and *Thea* (white). Similarly, both hairy and glabrous filaments can be found in sections *Archecamellia*, *Camelliopsis* and *Piquetia* whereas the rest of *Camellia* in Indochina, except *C. amplexicaulis* whose filaments are puberulent, all have glabrous filaments (Figure 3.6).

3.4.3 Dispersal of *Camellia*

The seeds of *Camellia* are wingless, relatively large (1–2.5 cm in diam., Min 2000) and heavy (1.5–2.5 g per seed, Bhattacharya et al. 2002, Yang et al. 2008) so they cannot be readily dispersed by wind (anemochory) or by floating in water for a very long distance. However, I found that some taxa, such as *C. drupifera* var. *kissi* (Wallich) D. Wei Zhao, were sometimes distributed along sandy or rocky banks of rivers in the forests during my field collecting expedition. The habitat of *C. drupifera* var. *kissi* may imply that water currents could at least disperse seeds for a considerable distance. The damp environment would prevent dehydration of *Camellia* seeds which cannot tolerate much desiccation without loss of viability (Chandel et al. 1995, Chen et al. 2015).

Additionally, some scatter-hoarding rodents were reported to transport the seeds of *Camellia* for caching and consuming (Xiao et al. 2004, 2006, 2013, Abe et al. 2006) by which the seeds could be dispersed further than by gravity (barochory) alone (Abe et al. 2006). However, the zoochorous distance is generally below 40 m (Achard et al. 2002, Xiao et al. 2004). These modes of seed dispersal may imply that *Camellia* species may be capable of a long-distance terrestrial dispersal over millions of years.

An example is *C. lanceolata*, a single species of *Camellia* that occurs in Indonesia, East Malaysia and Philippines (Min 2000). Monographers of *Camellia*, including Sealy (1958), Zhang (1981a) and Min (2000), all thought its most closely-related species was *C. connata* because both had

filaments that were united into a tube (see Section 3.4.2, Figure 3.6) though the latter was endemic as far as northern Thailand (Craib 1914). However, the *RPB2* gene tree (Figure 2.9) and molecular dating analysis (Figure 3.6) suggest that *C. connata* and *C. lanceolata* are nested in different clades. *Camellia lanceolata* and *C. rubriflora* form a clade whose crown age is 26.07 Ma (with 95% HPD of 16.31–36.45 Ma, Figures 3.5–3.6). Nevertheless, *C. rubriflora* is only known from northern Vietnam (Tran & Hakoda 1998b) from which the South China Sea needs to be crossed to reach the distribution areas of *C. lanceolata*. However, it suggested that land spread from Indochina (through Vietnam) to Indonesian Archipelago during a period of 20–30 Ma (Ramstein et al. 1997, Hall 1998, De Bruyn et al. 2014). This land bridge would have allowed species of *Camellia* to disperse to the Indonesian Archipelago. Subsequently, the South China Sea submerged the land bridge (Hall 1998, De Bruyn et al. 2014) and prevented gene flow between the ancestor of *C. lanceolata* and other species in Indochina. The genetic isolation would have promoted the allopatric speciation of *C. lanceolata*.

3.5 Conclusions

Not only the topologies of gene trees discussed in Chapter 2 but also the fossil calibration points selected can affect the results of molecular dating. To minimize the potential problems of calibration, six different combinations of calibration points using between two and four fossils, including *C. japonoxyla* from the lower Miocene, *C. kueishanensis* from the Early Miocene, *C. nanningensis* from the late Oligocene and *G. warmanensis* from the middle Eocene, were analysed using the concatenated *RPB2* 11–16 and 23 intron regions data. Three of the six combinations of fossil points yielded trees with different topologies compared with the combined *RPB2* gene tree in Chapter 2, so these combinations were considered unsuitable. Analyses using the rest of the combinations yielded trees with the same topology that was congruent with that of the combined *RPB2* tree. Among them, the one with most fossil points was considered the most reliable result because it has more reliable molecular dating information than the other two. It suggested that the crown age of *Camellia* was 48.5 Ma with a 95% HPD of 39.25–58.92 Ma. It was earlier than that estimated previously by the nuDNA *LEAFY* region analysis in which the fossil *C. japonoxyla* was applied to constrain the stem age of *Camellia*. However, the ancestral areas of *Camellia* cannot be simply inferred by the molecular dating analyses using the present distribution data because of a lack of fossil records and a changeable climatic and geographic history. Most of the recognised sections diversified in the Early and Middle Miocene probably due to the rapid uplift of Qinghai-Tibetan Plateau and a series of mountain building events introduced by the India-Eurasia collision which created great ecological opportunities to drive speciation in Indochina. The types of seed dispersal of *Camellia* would allow a long-distance terrestrial dispersal over millions of years. When there was a land bridge between Indochina and Indonesian Archipelago at 20–30 Ma, some species of *Camellia* might colonize the islands of the latter and subsequently become isolated by South China Sea, leading to the allopatric speciation of *C. lanceolata*.

Chapter 4 Taxonomy

Based on the results of molecular phylogenetic analyses discussed in Chapter 2, a new classification for categorising species of *Camellia* in Indochina is elaborated here. Each taxon is described with the taxonomic literature cited, specimens (especially type materials) examined and its synonyms (if there are any), distribution map, conservation status and nomenclatural notes provided. A key to Indochinese species of *Camellia* is also presented.

The data of macro-morphology are mainly used here (see Section 1.5.1, Table 4.1). Data from other sources, such as leaf anatomy (Section 1.5.2), pollen morphology (Section 1.5.3), chemistry (Section 1.5.4) and species compatibility (Section 1.5.5), are not generated here because of a budget and time limitation of this Ph.D. project.

4.1 Material and methods

4.1.1 Specimens and literature examination

Specimens kept in the following public herbaria were examined: **ABD, BK, BKF, BM, C, CMUB, DLU, E, FU, GXFI, GXMI, HITBC, HN, HNL, HNNU, HNU, IBK, IBSC, K, KKKU, KUN, L, MBK, P, PE, PHH, QBG, SGN, SING, SYS, TCD, VFM, VNF, VNM, VNMN** and **NUOL**. The digital images of specimens from **A, G, L, LINN, MICH, MO, NY, P, TAI, US, WU** were examined on their websites (see the links below). I also examined specimen photos from **CDBI, HIB, HNWP, IFP, LBG, NAS, WUK** and **XJBI** on the website of Chinese Virtual Herbarium (CVH, <http://www.cvh.ac.cn/>) and studied type specimen images from **GZU, M, PH** and **S** on the website of JSTOR (<https://plants.jstor.org/>). **NSW** sent high quality images of specimens in a USB key to us for the research.

Specimens cited are mainly indicated by collector's family name and relevant collection number which are printed in italic type with the exception for Vietnamese names. The Vietnamese collectors are cited with the last part of their given names based on their own practice (Chapter 16.86 of CMS) or the available name(s) on the specimen sheet. The localities of collections cited are presented in a 'zoom in' order: country (in capital and bold type in Additional specimens examined), province (or state, in bold type in Additional specimens examined), district and detailed location. Up-to-date English names of country, province (state) and district are used and generally verified by Google Maps (<https://www.google.ie/maps>) and Wikipedia (<https://en.wikipedia.org>). Obscure localities are cited with quotation marks. Exclamation mark (!) means that I examined the physical specimen whereas a dagger (†) indicates that only an image or photo of that specimen was available to me. Underlining is used to indicate the herbarium barcode: solid underlining means that the image of the specimen is available online and dotted underlining indicates that it is unavailable. Digital specimens may be available on the following websites:

A: http://kiki.huh.harvard.edu/databases/specimen_index.html

BM: <http://data.nhm.ac.uk/>

E: <http://elmer.rbge.org.uk/bgbase/vherb/bgbasevherb.php>

G: <http://www.ville-ge.ch/musinfo/bd/cjb/chg/index.php?lang=en>

GZU & WU: <http://herbarium.univie.ac.at/database/search.php>

IBK, PE & SYS: <http://www.cvh.ac.cn/> or <http://pe.ibcas.ac.cn/sptest/syninvok.aspx>

JSTOR Global Plants (some types): <https://plants.jstor.org/>

K: <http://apps.kew.org/herbcat/gotoSearchPage.do>

KUN: <http://db.kun.ac.cn/>

L: <http://bioportal.naturalis.nl/?language=en&back>

LINN: <http://linnean-online.org/>

MICH: <http://lsa.umich.edu/herbarium/databases.html>

MO: <http://www.tropicos.org/ImageSearch.aspx>

NY: <http://sweetgum.nybg.org/science/vh/>

P: <https://science.mnhn.fr/institution/mnhn/collection/p/item/search/form>

TAI: <http://tai2.ntu.edu.tw/specimeninfo.php>

US: <http://collections.nmnh.si.edu/search/botany/?ti=3>

The protologue of each name has been read and the nomenclatural status of the name was judged based on the ICN (McNeill et al. 2012). Information on taxonomic literature was searched using Taxonomic Literature II online (<http://www.sil.si.edu/DigitalCollections/tl-2/index.cfm>) and BPHOnline (http://fmhibd.library.cmu.edu/fmi/iwp/cgi?-db=BPH_Online&-loadframes). Some critical literature was found on the website of the Biodiversity Heritage Library (<http://www.biodiversitylibrary.org>), the Bibliothèque Nationale de France (<http://gallica.bnf.fr/>) and Google Books (<https://books.google.ie/>). Literature that was not written in Chinese or English was generally read with the help from Google Translate (<https://translate.google.com/>). Author's information was verified on IPNI (<http://www.ipni.org/ipni/authorsearchpage.do>).

4.1.2 Names and typification

The single correct name for each living taxon of *Camellia* was recognised based on the ICN (McNeill et al. 2012). Accepted names of taxa were printed in bold italics. Accepted specific and infraspecific names were numbered with square brackets ([]). Homotypic synonyms were indicated by the identity sign ($\equiv$) whereas heterotypic ones by the equality sign ($=$). Names that need typification were identified and their types were selected according to Art. 9.3. The type of a name in a rank higher than species (e.g., name of section, subgenus or genus) was cited as the species name (Art. 10.1). The type (holotype, lectotype or neotype) of a name of a species or infraspecific taxon was cited as a single specimen or an illustration (Art. 8.1).

Following each accepted name and synonym, I cited the examined protologue and other relevant taxonomic literature where available. The standard form of author names cited here followed IPNI

but the person's family name was cited in full (see Styles).

4.1.3 Description

The description of each taxon was based on my examination of the corresponding dry specimens, my records of fresh characters in the field (notes and photos), and other's published data and online photos where available. A series of morphological characters that usually varied between different species of *Camellia* (see Table 4.1) were measured/judged and recorded using Microsoft Excel Worksheet if time permitted (e.g., when I worked at **TCD**). If time did not allow for the detailed measuring work (e.g., when I visited other herbaria), photos of detailed characters accompanied by rulers were taken using two Nikon D90 digital cameras: one with an AF-S Nikkor 18–55 mm 1:3.5–5.6G lens and the other with a Tamron SP 90 mm F/2.8 1:1 Macro lens. Photos of specimens that were loaned to **TCD** were also taken using such two cameras. Those photos of specimens were catalogued by the scientific name of corresponding collection, the collector(s), collection number, herbarium and barcode (if available), and stored in my laptop (Lenovo Z51 with Intel Core i7-5500U, 16 GB RAM, 1 TB + 8 GB SSHD) to facilitate subsequent search and examination.

Table 4.1. Morphological characters used in the description of *Camellia* taxa.

Organ	Character (states)
Branchlet	Indumentum (glabrous/hairy).
Leaf	Petiole: length, indumentum (glabrous/hairy). Leaf blade: shape, size, texture (coriaceous/papery), colour, indumentum (glabrous/hairy), number of secondary veins, shape of base, margin and apex.
Flower	Size. Pedicel: length, indumentum (glabrous/hairy). Bracteole: number, shape, size, indumentum (glabrous/hairy). Sepal: number, shape, size, indumentum (glabrous/hairy). Petal: number, colour (red/white/yellow), shape, size, indumentum (glabrous/hairy). Androecium: length, indumentum (glabrous/hairy) and architecture of filaments (e.g., forming a tube). Gynoecium: shape and indumentum (glabrous/hairy) of ovary, number, length and indumentum (glabrous/hairy) of style(s).
Fruit	Shape, size, indumentum (glabrous/hairy). Pericarp: thickness.
Seed	Colour, shape, size, indumentum (glabrous/hairy).

In the description of each taxon, the two-dimensional size was recorded as length $\times$ width. The colour of each character where indicated is that on living plants except those of punctate and hair—they were described from dry specimens. Though there may be a significant difference on the size of characters between living plants and dry specimens (Parnell et al. 2013), data from dry collections was mainly used here because of the unavailability of that from living plants. The

morphological glossary followed Min & Bartholomew (2007) and Beentje (2012). Different types of hair are illustrated in Figure 4.1 following Beentje (2012). Other morphological characters, such as the habit, two-dimensional and three-dimensional shapes and the gradual transition from bracteoles, sepals to petals, are illustrated using photos in Figures 4.2 below.

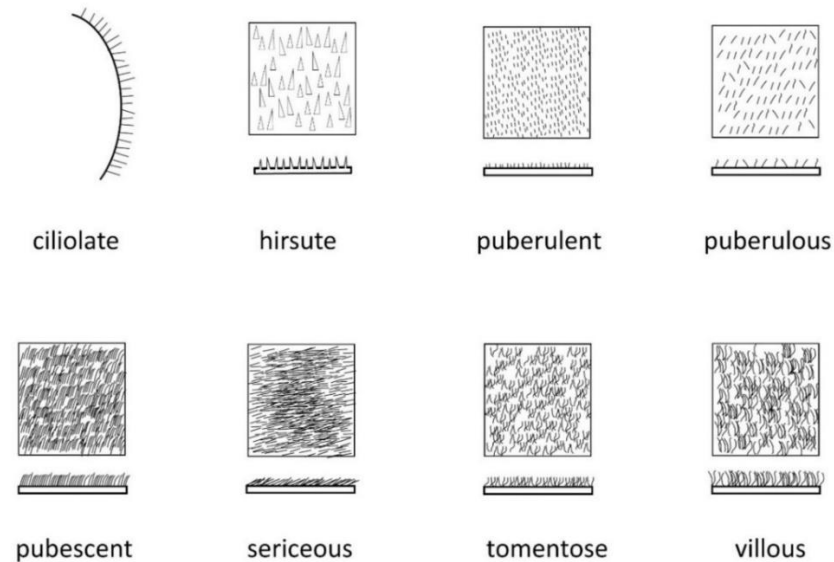


Figure 4.1. Indumenta of margin (ciliolate) and surfaces (others), redrawn from Beentje (2012).

4.1.4 Distribution mapping

Distribution data were retrieved from the record on each specimen sheet. Collections from natural forest with detailed localities but without geographic coordinate data were re-located on Google Maps (<https://www.google.ie/maps/>) from which the rough data of latitude and longitude was retrieved. The distribution data was mapped using ArcMap 10.4.1 (ArcGIS) on an Asia map with Robinson (1974) projection. The layout of each map was optimised in Adobe Illustrator.

4.1.5 Conservation assessments

A preliminary conservation assessment for each accepted species and infraspecific taxon was undertaken by following the categories and criteria of the International Union for Conservation of Nature (IUCN 2012) and its guidelines

(<http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf>). One of the nine categories was assigned to each taxon: extinct (EX), extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD) and not evaluated (NE), and the relevant criteria/categories of IUCN that were used to assess the conservation status were also reported.

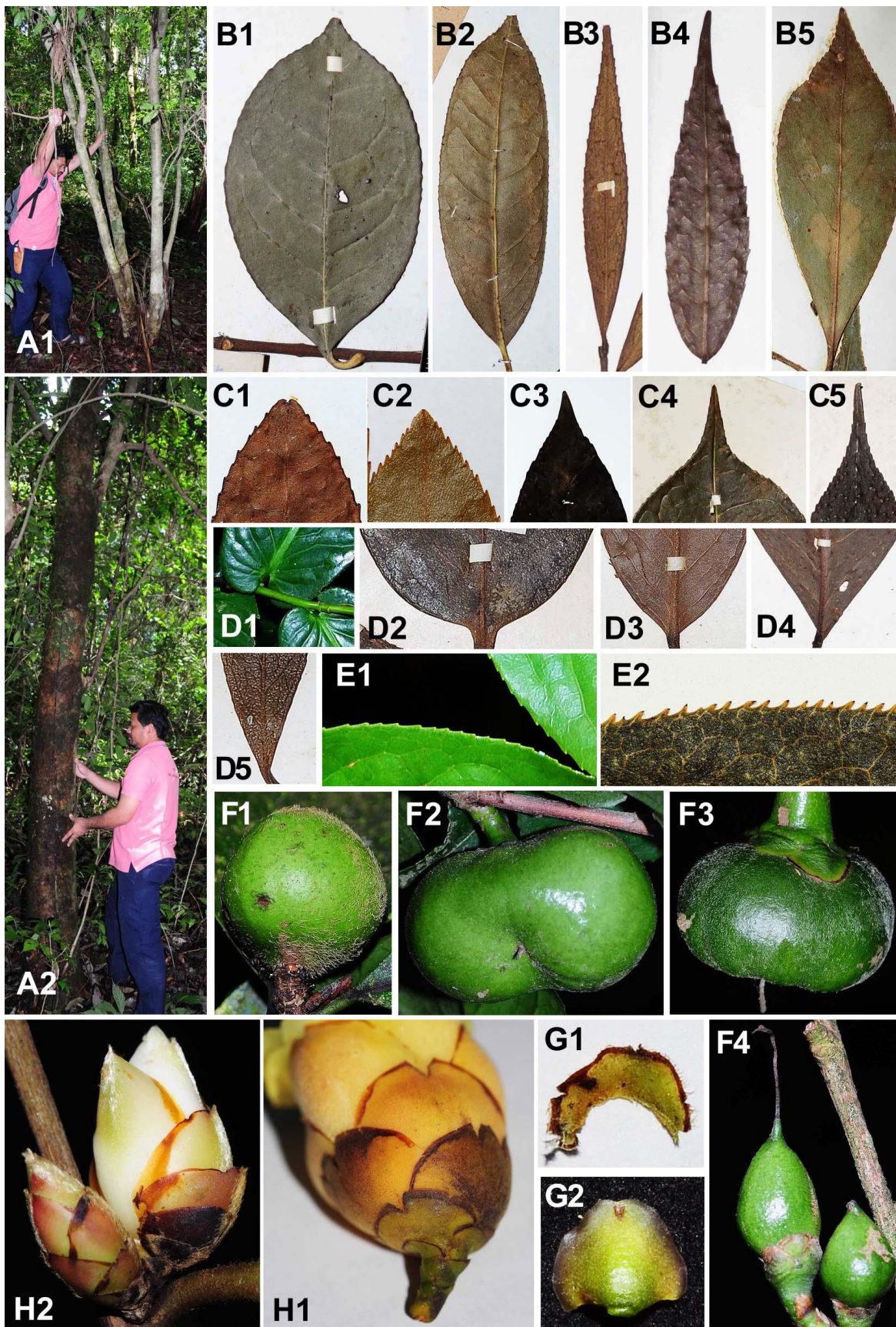


Figure 4.2. Illustration of some morphological glossary used here. Habit (A1: shrub; A2: tree), two-dimensional shapes (B1: elliptic; B2: oblong; B3: linear; B4: lanceolate; B5: obovate; G1: crescent; G2: broadly ovate), apex (C1: obtuse; C2: acute; C3: attenuate; C4: acuminate; C5: caudate), base (D1: cordate; D2: rounded; D3: obtuse; D4: cuneate; D5: attenuate), margin (E1: serrulate; E2:

sharply pointed serrulate), three-dimensional shapes (F1: globose; F2: bi-coccal; F3: oblate; F4: ovoid) and the gradual transition from bracteoles, sepals to petals (H1 & H2).

4.2 Taxonomic treatment

Camellia Linnaeus, Species Plantarum 2: 698. 1753 & Genera Plantarum 5: 311. 1754; Aiton, Hortus Kewensis 2: 460. 1789; Loureiro, Flora Cochinchinensis 2: 411. 1790 & 2nd ed. 2: 499–500. 1793; Salisbury, Prodromus Stirpium in Horto ad Chapel Allerton Vigentium 370. 1796; Miller & Martyn, The Gardener's and Botanist's Dictionary 1(1). 1807; Sweet, Hortus Suburbanus Londinensis 157. 1818; Link, Enumeratio Plantarum Horti Regii Botanici Berolinensis Altera 2: 73. 1822; de Candolle, Prodromus Systematis Naturalis Regni Vegetabilis 1: 529–530. 1824; D. Don, Prodromus Florae Nepalensis 224. 1825; G. Don, A General History of the Dichlamydeous Plants, 1: 574–578. 1831; Loudon, Arboretum et Fruticetum Britannicum 1: 381–392. 1838; Sweet & G. Don, Sweet's Hortus Britannicus 3rd ed. 89–91. 1839; Endlicher, Genera Plantarum Secundum Ordines Naturales Disposita 1022. 1840; K. Koch, Hortus Dendrologicus 68–69. 1853; Griffith, Notulae ad Plantas Asiaticas 4: 553–560. 1854; Choisy in Mémoires de la Société de Physique et d'histoire Naturelle de Genève 14(1): 146–149. 1855; Seemann in Transactions of the Linnean Society of London 22: 341–346. 1859; Bentham & Hooker f., Genera Plantarum 1(1): 187. 1862, excl. *Cordyloblaste*; Miquel, Annales Musei Botanici Lugduno-Batavi 3: 16–17. 1867; Dyer in Hooker f., Flora of British India 1(2): 292–293. 1874; Kurz, Forest Flora of British Burma 1: 108–109. 1877; Brandis, Indian Trees 56, 60–61. 1906; Cohen-Stuart in Mededeelingen van het Proefstation voor Thee 40: 57–73. 1916 & in Bulletin du Jardin Botanique, 3rd series 1(4): 232–247. 1919; Craib, Florae Siamensis Enumeratio 1(1): 131–132. 1925; Melchior in Engler, Die Natürlichen Pflanzenfamilien, 2nd ed. 21: 126, 128–133. 1925; Kanjilal et al., Flora of Assam 1(1): 121–124. 1934; Nakai in The Journal of Japanese Botany 16(11): 666–667. 1940 & 16(12): 691–699. 1940; H. Keng in Taiwania 1: 224, 230–241. 1950; Sealy in American Camellia Yearbook 1–9. 1956 & A Revision of the Genus Camellia 1–239. 1958; Hu & Hung T. Chang in Chun et al., Flora Hainanica 1: 495, 498–501. 1964; H. Keng in Flora of Thailand 2(2): 142–143, 145–149. 1972; Hung T. Chang, A Taxonomy of the Genus Camellia 1–180. 1981, in F.H. Chen, Flora of Guangdong 2: 123–144. 1991, in Flora of Guangxi 1: 758–799. 1991 & in Flora Reipublicae Popularis Sinicae 49(3):1, 3–195. 1998; B.M. Bartholomew in American Camellia Yearbook 41–52. 1981; Grierson & D. G. Long, Flora of Bhutan 1(2): 362, 366. 1984; Hung T. Chang & B.M. Bartholomew, Camellias 1–211. 1984; K.M. Feng in The International Camellia Journal 16: 13–18. 1984; C.X. Ye in Acta Botanica Yunnanica 10(1): 61–67. 1988; P.H. Hồ, Cây cỏ Việt Nam 1(1): 511, 527–537. 1991; C.E. Jarvis et al. in Regnum Vegetabile 127: 29. 1993; T.L. Ming & W.J. Zhang in Acta Botanica Yunnanica 18(1): 1–13. 1996; T.L. Ming in Flora Yunnanica 8: 264–308. 1997, in Acta Botanica Yunnanica 21(2): 149–159. 1999 & Monograph of the Genus Camellia 1–352. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 344–350. 2003; Kubitzki, The Family and Genera of Vascular Plant 6: 467–468. 2004; J.Y. Gao et al., Collected Species of

the Genus *Camellia*: An Illustrated Outline 1–302. 2005; C.E. Jarvis, Order out of Chaos: Linnaean Plant Names and their Types 376. 2007; T.L. Ming & B.M. Bartholomew in Flora of China 12: 366–412. 2007; B.G. Li & L.H. Liu, Flora of Hunan 3: 29, 46–75. 2010; Orel & Curry, In Pursuit of Hidden Camellias 1–339. 2015, excl. *C. luuana*. —**Type:** *C. japonica* Linnaeus

= *Thea* Linnaeus, Species Plantarum 1: 515. 1753, 2nd ed. 1: 734–735. 1762 & Genera Plantarum 5: 232. 1754; Aiton, Hortus Kewensis 2: 230–231. 1789; Loureiro, Flora Cochinchinensis 1: 338–340. 1790 & 2nd ed. 1: 413–415. 1793; Salisbury, Prodromus Stirpium in Horto ad Chapel Allerton Vigentium 370. 1796; Hayne, Getreue Darstellung und Beschreibung der in der arzneykunde Gebräuchlichen Gewächse t. 27–29. 1821; de Candolle, Prodromus Systematis Naturalis Regni Vegetabilis 1: 530. 1824; Loudon, Arboretum et Fruticetum Britannicum 1: 392–395. 1838; Sweet & G. Don, Sweet's Hortus Britannicus 3rd ed. 91. 1839; Endlicher, Genera Plantarum Secundum Ordines Naturales Disposita 1023. 1840; K. Koch, Hortus Dendrologicus 69. 1853; Choisy in Mémoires de la Société de Physique et d'histoire Naturelle de Genève 14(1): 149–157. 1855; Seemann in Transactions of the Linnean Society of London 22: 346–350. 1859; Miquel, Annales Musei Botanici Lugduno-Batavi 3: 17. 1867; Baillon, Histoire des Plantes 4: 227–229, 252. 1873; Pierre, Flore Forestière de la Cochinchine 2(8): supra t. 119. 1887; Szyszyłowicz in Engler & Prantl, Die Natürlichen Pflanzenfamilien 3(6): 181–184. 1895; Kochs in Engler, Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 27(5): 578–597. 1900; Pitard in Lecomte, Flore Générale de l'Indo-Chine 1(4): 331, 340–347. 1910; Hayata, Icones Plantarum Formosananarum 1: 89–93. 1911; Rehder & E.H. Wilson in E. H. Wilson & Sargent, Plantae Wilsonianae 2(2): 390–394. 1915; Rehder in Journal of the Arnold Arboretum 5(4): 238–239. 1924; Nakai in The Journal of Japanese Botany 16(11): 666–667. 1940 & 16(12): 701–704. 1940; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 303–321. 1943; Hu & Hung T. Chang in Chun et al., Flora Hainanica 1: 495–497. 1964; Biswas, Plants of Darjeeling and the Sikkim Himalayas 1: 171–173. 1966; C.E. Jarvis et al. in Regnum Vegetabile 127: 93. 1993; C.E. Jarvis, Order out of Chaos: Linnaean Plant Names and their Types 884. 2007. —**Type:** *T. sinensis* Linnaeus

= *Tsia* Kaempfer ex Adanson, Familles des Plantes 2: 450, 613. 1763. ≡ *Thea*.

≡ *Tsubaki* Kaempfer ex Adanson, Familles des Plantes 2: 399, 614. 1763.

= *Sasanqua* Nees von Esenbeck in Siebold, Nippon, Archiv Zur Beschreibung von Japan 2(4): 13. 1832; Miquel in Literaturberichte zur Flora 4(9): 144. 1834; Rafinesque, Sylva Telluriana 140. 1838. —**Type:** *S. vulgaris* Nees von Esenbeck

= *Calpandria* Blume, Bijdragen tot de Flora van Nederlandsch Indië 178. 1825. —**Type:** *C. lanceolata* Blume

= *Desmitus* Rafinesque, Sylva Telluriana 139. 1838. —**Type:** *D. reticulata* (Lindley) Rafinesque

= *Drupifera* Rafinesque, Sylva Telluriana 140. 1838. —**Type:** *D. oleosa* Rafinesque

≡ *Kemelia* Rafinesque, *Sylva Telluriana* 139. 1838.

= *Theaphyla* Rafinesque, *Medical Flora* 267. 1830 & *Sylva Telluriana* 138. 1838. —**Lectotype (designated here):** *T. laxa* Rafinesque

= *Piquetia* (Pierre) Hallier f. in *Beihefte zum Botanischen Centralblatt*, 2nd Abteilung 39(1): 162. 1921; Melchior in Engler, *Die Natürlichen Pflanzenfamilien*, 2nd ed. 21: 126–127. 1925. —**Type:** *P. piquetiana* (Pierre) Hallier f.

= *Stereocarpus* (Pierre) Hallier f. in *Beihefte zum Botanischen Centralblatt*, 2nd Abteilung 39(1): 162. 1921; Melchior in Engler, *Die Natürlichen Pflanzenfamilien*, 2nd ed. 21: 126, 128. 1925. —**Type:** *S. dormoyanus* (Pierre) Hallier f.

= *Dankia* Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(2): 198. 1939. —**Type:** *D. langbianensis* Gagnepain

= *Bembiciopsis* H. Perrier in *Mémoires du Muséum National d'histoire Naturelle*, Nouvelle Série 13(3): 300. 1940. **Syn. nov.** —**Type:** *B. uniflora* H. Perrier

= *Camelliastrum* Nakai in *The Journal of Japanese Botany* 16(12): 699. 1940. —**Lectotype (designated here):** *C. caudatum* (Wallich) Nakai

= *Theopsis* (Cohen-Stuart) Nakai in *The Journal of Japanese Botany* 16(12): 704. 1940. —**Lectotype (designated here):** *T. euryoides* (Lindley) Nakai

= *Yunnanea* Hu in *Acta Phytotaxonomica Sinica* 5(4): 282. 1956. —**Type:** *Y. xylocarpa* Hu

= *Glyptocarpa* Hu in *Acta Phytotaxonomica Sinica* 10(1): 25. 1965. —**Type:** *G. camellioides* (Hu) Hu

Shrubs or trees, evergreen, 1–20 m tall. *Bark* smooth. *Hairs* present, simple. *Leaves* simple, alternate, porrect, flat, stipules absent; *leaf blades* usually coriaceous, margin dentate, teeth with a deciduous glandular apex (theoid), venation brochidodromous. *Flowers* axillary, bisexual, radial, 1–14 cm in diam., pedicellate or subsessile. *Sepals* 3–6. *Petals* 5–15 in 1–3 whorls, white, yellow or red. *Stamens* numerous, seldom fewer than 30, in 2–6 whorls, anthers dorsifixed, 2-loculed. *Ovary* superior, (2–)3–5(–7)-loculed; ovules 1–8 per carpel, placentation axile. *Capsule* globose, oblate or bi-coccal, 1–5(–7)-loculed with 1–6 seeds per locule, loculicidal into 1–5(–7) valves. *Seeds* globose, hemispherical or polyhedral, wingless; hilum umbilicate; cotyledons full and fleshy; endosperm absent.

Notes—The lectotype of *C. japonica* was designated as an illustration ‘Tsubaki’ on page 851 of *Amoenitatum Exoticarum Politico-physico-mediciarum Fasciculi V* (Kaempfer 1712) by Bartholomew (Jarvis et al. 1993: 29). The voucher specimen on which the illustration may be based is conserved in the Historical Collection of **BM**.

Thea was treated as a synonym of *Camellia* by Sweet (1818: 157). *Theaphyla* (Rafinesque 1830:

267) and *Tsia* (Adanson 1763: 613) are illegitimate replacement names for *Thea* because the latter was cited as a synonym of them, this makes *Tsia* and *Theaphyla* nomenclaturally superfluous (Arts. 6.11, 52.1 & 52.2[e]). Similarly, *Kemelia* (Rafinesque 1838: 139) and *Tsubaki* (Adanson 1763: 399) are illegitimate replacement names for *Camellia* because the latter was cited in the synonymies of them (Arts. 6.11, 52.1 & 52.2[e]).

The monotypic *Bembiciopsis* (Perrier 1940: 300) was established based on a single collection (**P00389083!**), which is *C. japonica*. Therefore, *Bembiciopsis* is treated as a new synonym of *Camellia*.

‘*Kailosocarpus*’ (Hu 1957: 170) was cited by Min (2000: 73) as a synonym of *Camellia*; however, ‘*Kailosocarpus*’ was not validly published since neither a Latin description or diagnosis was provided in the protologue, nor was a previously and effectively published Latin description or diagnosis cited (Art. 39.1).

Camellia morphologically differs from its phylogenetically closely-related genera in the Theaceae, such as *Pyrenaria* and *Polyspora* (see Section 1.4), mainly by its wingless globose, hemispherical or polyhedral seeds—seeds of *Pyrenaria* are longitudinally compressed whereas those of *Polyspora* have an apical wing (Sealy 1958, Min & Bartholomew 2007).

A key to the accepted specific and infraspecific taxa of *Camellia* in Indochina is shown below.

1. Sepals persistent after flowering, coriaceous.....2
1. Sepals caducous after flowering, crustaceous.....41
2. Style 1, apically (2)3–5-lobed.....3
2. Styles (2)3–5(7), distinct.....11
3. Leaf blade abaxially punctate; petals yellow.....4
3. Leaf blade abaxially non-punctate; petals white.....5
4. Ovary glabrous.....[38] *C. dormoyana*
4. Ovary hairy.....[39] *C. thuongiana*
5. Bracteoles caducous.....6
5. Bracteoles persistent.....8
6. Sepals 3–4.....[43] *C. laotica*
6. Sepals 5.....7
7. Terminal buds glabrous or sparsely puberulous, style usually 5-lobed.....[41] *C. taliensis*
7. Terminal buds pubescent or puberulous, style usually 3-lobed.....[40] *C. sinensis* var. *assamica*
8. Ovary and style pubescent.....[10] *C. caudata*
8. Ovary and style glabrous.....9
9. Filaments glabrous.....[11] *C. tsaii*
9. Filaments villous.....10
10. Bracteoles, sepals and petals glabrous outside.....[12] *C. tsingpiensis*
10. Bracteoles, sepals and petals pubescent outside.....[13] *C. tsingpiensis* var. *pubisepala*

11. Leaf blade abaxially punctate.....	12
11. Leaf blade abaxially non-punctate.....	30
12. Petals red or white.....	13
12. Petals yellow.....	21
13. Leaf blade usually small, 3.5–11(–12) cm long, 1.5–4(–4.5) cm wide; styles 1–9 mm long.....	14
13. Leaf blade usually large, 11.5–33 cm long, 4.5–11.5 cm wide; styles 1–3.5 cm long.....	17
14. Secondary veins of leaf 5–7(–8); ovary glabrous.....	[46] <i>C. sealyana</i>
14. Secondary veins of leaf 8–13; ovary pubescent.....	15
15. Outer filaments completely united into a tube.....	[24] <i>C. connata</i>
15. Outer filaments basally connate for ca. 1/2 of length or less.....	16
16. Leaf margin serrulate; styles ca. 1 mm long.....	[25] <i>C. lutescens</i>
16. Leaf margin sharply pointed serrulate; styles 7–9 mm long.....	[26] <i>C. wardii</i>
17. Leaf blade abaxially pubescent or puberulent.....	18
17. Leaf blade abaxially glabrous.....	19
18. Sepals 5, 6–15 × 7–10 mm; petals red.....	[42] <i>C. calcicola</i>
18. Sepals 7–8, 25–37 × 23–31 mm; petals white.....	[44] <i>C. megasepala</i>
19. Pedicel 8–24 mm long.....	[19] <i>C. amplexicaulis</i>
19. Pedicel less than 5 mm long.....	20
20. Leaf blade 11.5–15 cm long; bracteoles and sepals 9–10; petals ca. 12.....	[45] <i>C. rubriflora</i>
20. Leaf blade 15–20 cm long; bracteoles and sepals 6–8; petals 7–10.....	[47] <i>C. yokdonensis</i>
21. Styles basally swollen; dorsal suture and apex of carpel thickened in fruit.....	[9] <i>C. pleurocarpa</i>
21. Styles basally slender; dorsal suture and apex of carpel not thickened in fruit.....	22
22. Petiole and abaxial leaf blade glabrous.....	23
22. Petiole and abaxial leaf blade hairy.....	28
23. Ovary and styles pubescent.....	[37] <i>C. dilinhensis</i>
23. Ovary glabrous or sparsely puberulous; styles glabrous.....	24
24. Flowers 3–6 cm in diam.; sepals 6–10 mm long.....	25
24. Flowers 1–2.5 cm in diam.; sepals less than 5 mm long.....	26
25. Secondary veins of leaf 8–12; pedicel 3–7 mm long; sepals inside sericeous.....	[1] <i>C. euphlebia</i>
25. Secondary veins of leaf 5–7; pedicel 8–15 mm long; sepals inside glabrous.....	[8] <i>C. petelotii</i>
26. Secondary veins of leaf 13–15, adaxially channelled.....	[4] <i>C. hulungensis</i>
26. Secondary veins of leaf 5–10, adaxially flat, slightly impressed or obscure.....	27
27. Leaf blade 6–11.5(–12.5) cm long; seeds glabrous.....	[5] <i>C. indochinensis</i>
27. Leaf blade 12–17.5 cm long; seeds tomentose.....	[6] <i>C. micrantha</i>
28. New branchlets, petiole and abaxial leaf blade hairy, hairs spreading villous.....	[3] <i>C. hirsuta</i>
28. New branchlets puberulous or glabrous; petiole and abaxial leaf blade pubescent, sparsely puberulous or glabrous.....	29
29. Leaf blade 2.5–7.5 cm wide; ovary and styles pubescent.....	[2] <i>C. flava</i>

29. Leaf blade 8–12 cm wide; ovary and styles glabrous.....[7] *C. murauchii*
30. Ovary sat on a cylindrical lobulate disc; seeds villous.....[23] *C. gilbertii*
30. Ovary sat on the apex of pedicel; seeds glabrous.....31
31. Leaf blade 4–13(–16) cm long; petals white; capsule globose or ovoid.....32
31. Leaf blade 14–52 cm long; petals yellow or red; capsule oblate.....36
32. Bracteoles absent or 1.....33
32. Bracteoles 2–3.....34
33. Secondary veins of leaf 11–15; pedicel 5–10 mm long; petals 9–11.....[14] *C. corallina*
33. Secondary veins of leaf 6–8; pedicel 1.5–3.5 mm long; petals 5–6.....[16] *C. nematodea*
34. Pedicel 8–37 mm long; ovary pubescent.....35
34. Pedicel ca. 2 mm long; ovary glabrous.....[17] *C. nervosa*
35. Petals outside puberulous; seeds 1–1.5(–2) cm in diam.....[15] *C. gracilipes*
35. Petals outside glabrous; seeds 2–2.5 cm in diam.....[18] *C. pubicosta*
36. Terminal buds and abaxial leaf blade glabrous.....37
36. Terminal buds and abaxial leaf blade hairy.....38
37. Petiole 1–4 mm long; secondary veins of leaf 20–26.....[32] *C. inusitata*
37. Petiole 7–17 mm long; secondary veins of leaf 13–16.....[36] *C. sonthaiensis*
38. Petiole and abaxial leaf blade glabrous.....[33] *C. krempfii*
38. Petiole hairy or glabrous, leaf blade abaxially hairy.....39
39. Pedicel 20–55 mm long; filaments glabrous.....[34] *C. langbianensis*
39. Pedicel 5–15 mm long; filaments puberulous.....40
40. Leaf margin nearly entire or sparsely serrulate; petals red.....[35] *C. piquetiana*
40. Leaf margin serrulate; petals yellow.....[31] *C. dalatensis*
41. New branchlets glabrous; pericarp furfuraceous.....42
41. New branchlets hairy; pericarp usually smooth.....44
42. Leaf blade small, 4.5–6.5 × 1.5–3 cm; Capsule 2–2.5 cm in diam.....[22] *C. gaudichaudii*
42. Leaf blade large, 7.5–17 × 2.5–7 cm; Capsule 3–5 cm in diam.....43
43. Flowers ca. 3 cm in diam.; petals yellow; ovary glabrous.....[20] *C. fleuryi*
43. Flowers 4–6 cm in diam.; petals white; ovary pubescent.....[21] *C. furfuracea*
44. New branchlets, petiole and abaxial leaf blade hairy, hairs spreading villous.....[30] *C. kirinoi*
44. New branchlets, petiole puberulous; leaf blade abaxially glabrous.....45
45. Flowers 4.5–10 cm in diam.; styles 8–12 mm long; pericarp 2–8 mm thick.....[27] *C. drupifera*
45. Flowers 1–4(–4.5) cm in diam.; styles 1.5–7 mm long; pericarp 0.5–1.5 mm thick.....46
46. Leaf blade (1.5–)2–5 cm wide; flowers 2–4.5 cm in diam.....[28] *C. drupifera* var. *kissii*
46. Leaf blade 0.5–1.6 cm wide; flowers 1–1.5 cm in diam.....[29] *C. drupifera* var. *stenophylla*

4.2.1 Section *Archecamellia*

Section *Archecamellia* Sealy, A Revision of the Genus *Camellia* 36. 1958, excl. *C. amplexicaulis*

(Pitard) Cohen-Stuart & *C. krempfii* (Gagnepain) Sealy; T.L. Ming & W.J. Zhang in Acta Botanica Yunnanica 15(1): 3–15. 1993, excl. *C. amplexicaulis* & *C. krempfii*; Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 35(1): 79. 1996, excl. *C. amplexicaulis* & *C. krempfii*; T.L. Ming in Acta Botanica Yunnanica 21(2): 151–152. 1999, excl. *C. amplexicaulis*, *C. krempfii* & *C. megasepala* Hung T. Chang & Ninh, & Monograph of the Genus Camellia 78–108. 2000, excl. *C. amplexicaulis*, *C. calcicola* T.L. Ming, *C. krempfii* & *C. megasepala*. —**Type:** *C. petelotii* (Merrill) Sealy

= *Camellia* sect. *Chrysanth* Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 18(3): 69. 1979, A Taxonomy of the Genus Camellia 101–107. 1981 & in Flora Reipublicae Popularis Sinicae 49(3):101–112. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 128–136. 1984; J.Y. Gao et al., Collected Species of the Genus Camellia: An Illustrated Outline 88–126. 2005. —**Type:** *C. chrysanth* (Hu) Tuyama

= *Camellia* sect. *Luteoflora* Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 21(3): 72. 1982; Hung T. Chang & B.M. Bartholomew, Camellias 73. 1984. **Syn. nov.** — **Type:** *C. luteoflora* Y.K. Li

= *Camellia* sect. *Pleurocarpus* Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 35(1): 79. 1996, excl. *C. megasepala*. —**Type:** *C. pleurocarpa* (Gagnepain) Sealy

Leaf blade abaxially punctate; bracteoles and sepals persistent; petals yellow; stamens numerous.

Notes—Sealy (1958: 27) considered sect. *Archecamellia* as the ‘base-group’ of *Camellia* with seven species in it. Zhang’s (1981a, 1996a, Zhang & Bartholomew 1984) views on this section were elaborated in Section 1.3.1. Min (2000) maintained Sealy’s (1958) concept on this section and enlarged it to contain 18 species. The emendation of sect. *Archecamellia* is discussed in Section 2.4.4(a). In addition, *C. hirsuta*, *C. hulungensis* and *C. murauchii* are included here. This section morphologically differs from sect. *Cylindria* by its yellow flowers whereas the latter usually has red flowers.

I have not seen the type of *C. crassiphylla* Ninh & Hakoda. However, this species may resemble *C. petelotii* or *C. euphlebia* based on its protologue (Tran & Hakoda 1998b) and other collections at HNU. It was indicated that *C. hakodae* Ninh and *C. tamdaoensis* Hakoda & Ninh were published in a Vietnamese Journal ‘VNU Joun. Science’ in 2007 (Tran & Hakoda, Các Loài Trà Của Vườn Quốc Gia Tam Đảo. 64 & 104, respectively. 2010—this Vietnamese booklet was not effectively published) but I have not found the protologues. These three names are not treated here because of a lack of essential information.

Species of this section are generally horticultural plants and valued by the camellias enthusiasts for their golden/yellow flowers.

[1] *Camellia euphlebia* Merrill ex Sealy in Kew Bulletin 4(2): 216. 1949 & A Revision of the

Genus *Camellia* 41–42, fig. 11. 1958; Hung T. Chang in *Acta Scientiarum Naturalium Universitatis Sunyatseni* 18(3): 70, 73. 1979, 30(2): 80–81. 1991, A Taxonomy of the Genus *Camellia* 101, 105. 1981, in *International Camellia Journal* 24: 61. 1992 & in *Flora Reipublicae Popularis Sinicae* 49(3): 103, t. 28, fig. 1. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 128, 132, t. 44, fig. 1. 1984; C.X. Ye & Z.R. Xu in *Acta Scientiarum Naturalium Universitatis Sunyatseni* 31(4): 71, 73. 1992; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 152. 1999 & Monograph of the Genus *Camellia* 79, 97, 99, t. 9. fig. 1–3. 2000. H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 345. 2003; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 95–96. 2005. —**Holotype**: VIETNAM, Quang Ninh, Tien Yen, ‘Kau Nga Shan and Vicinity’, 13–22 December 1936, *Tsang* 27346 (**A00024748**[†]). Isotypes: **E00284419**!, **IBSC0003491**!, **K000704299**!, **K000704300**!, **K000704301**!, **P04511418**!, **SYS00081433**!, **SYS00081434**!, **SYS00094922**!, **SYS00094923**!.

= *Camellia chrysantha* (Hu) Tuyama var. *macrophylla* S.L. Mo & S.Z. Huang in *Acta Phytotaxonomica Sinica* 17(2): 88, fig. 1. 1979. —**Lectotype (designated here)**: CHINA, Guangxi, Dongxing, Malu, 11 December 1970, *Wan* 76506 (**GXMI050187**!). Isolectotype: **GXMI050186**!, **PE01432101**!.

= *Camellia euphlebia* Merrill ex Sealy var. *macrophylla* (S.L. Mo & S.Z. Huang) C.X. Ye & J.Y. Liang in *Acta Scientiarum Naturalium Universitatis Sunyatseni* 31(4): 74.

= *Camellia rosmannii* Ninh in *International Camellia Journal* 30: 74. 1998. **Syn. nov.** —**Holotype**: VIETNAM, Quang Ninh, Uong Bi, Yen Tu, Nam Mau, 23 October 1995, *Ninh* 9512 (**HNU**!).

= *Camellia insularis* Orel & Curry, In Pursuit of Hidden Camellias 187. 2015. **Syn. nov.** —**Holotype**: VIETNAM, Quang Ninh, estuarine islands, 5 November 1999, *Orel et al.* 7219 (**NSW901919**[†]).

= *Camellia tienyenensis* Orel & Curry, In Pursuit of Hidden Camellias 234. 2015. **Syn. nov.** —**Holotype**: VIETNAM, Quang Ninh, ‘unnamed coastal region’, 2 December 1999, *Orel et al.* 991202 (**NSW901896**[†]).

= *Camellia phanii* Hakoda & Ninh ex Le, Hakoda & Ninh in *International Camellia Journal* 48: 119. 2016. **Syn. nov.** —**Holotype**: VIETNAM, Thai Nguyen, Dai Tu, Tan Thai, 200 m, February 2004, *Hakoda & Ninh* TN 04-02-05 (**HNU**!).

Shrubs 2–5 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 8–14 mm long, glabrous; *leaf blades* elliptic, oblong or ovate, 11.5–16 × 4–8.5 cm, coriaceous, abaxially yellowish green and brown punctate, adaxially dark green, both surfaces glabrous, midrib and secondary veins abaxially elevated and adaxially impressed, secondary veins 8–12 on each side of midrib, base cuneate, obtuse or rounded, margin serrulate, apex attenuate to acuminate. *Flowers* solitary, 3–5 cm in diam. *Pedicels* 3–7 mm long. *Bracteoles* 6–8, alternate, 2-ranked, crescent to semi-orbicular, 1–5 × 3–7 mm, outside glabrous, inside glabrous or sparsely sericeous, margin ciliolate. *Sepals* 5,

broadly ovate or sub-orbicular, 4–7 × 6–10 mm, outside glabrous, inside sericeous, margin ciliate. *Petals* 8–11 in 2–3 whorls, yellow, sub-orbicular, elliptic or obovate, 1–3 × 1–2 cm, outside glabrous, inside puberulent at apex or glabrous. *Stamens* 1.5–3 cm long; *filaments* glabrous, outer filaments basally connate for 1–1.5 cm. *Ovary* ovoid, glabrous. *Styles* 3, distinct, 2.5–3.5 cm long, glabrous. *Capsule* oblate, globose or bi-coccal, 3.5–5 cm in diam., 2–3 cm in height; *pericarp* 2–4 mm thick. *Seeds* fuscous, hemispherical or globose, 1–2 cm in diam., glabrous.

Phenology: flowering October–December, fruiting April–December.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.1).

Habitat: evergreen forest, 200–1000 m.

Conservation status: critically endangered (CR, A1/A2, see Section 1.7 and Notes below, IUCN 2012).

Additional specimens examined

VIETNAM. Quang Ninh: 22 December 1969, *Tiep 1200 (HN)*; ‘Mong Bi’, 20 December 1979, *Cong 277 (HN)*; Ba Che, 27 October 2015, *Van SH76 (VNMN)*; Ha Long, Vung Tau, 26 December 1979, *Phong 301 (HN)*; Hoanh Bo, Thong Nhat, 22 December 1979, *Luong 260 (HN)*.

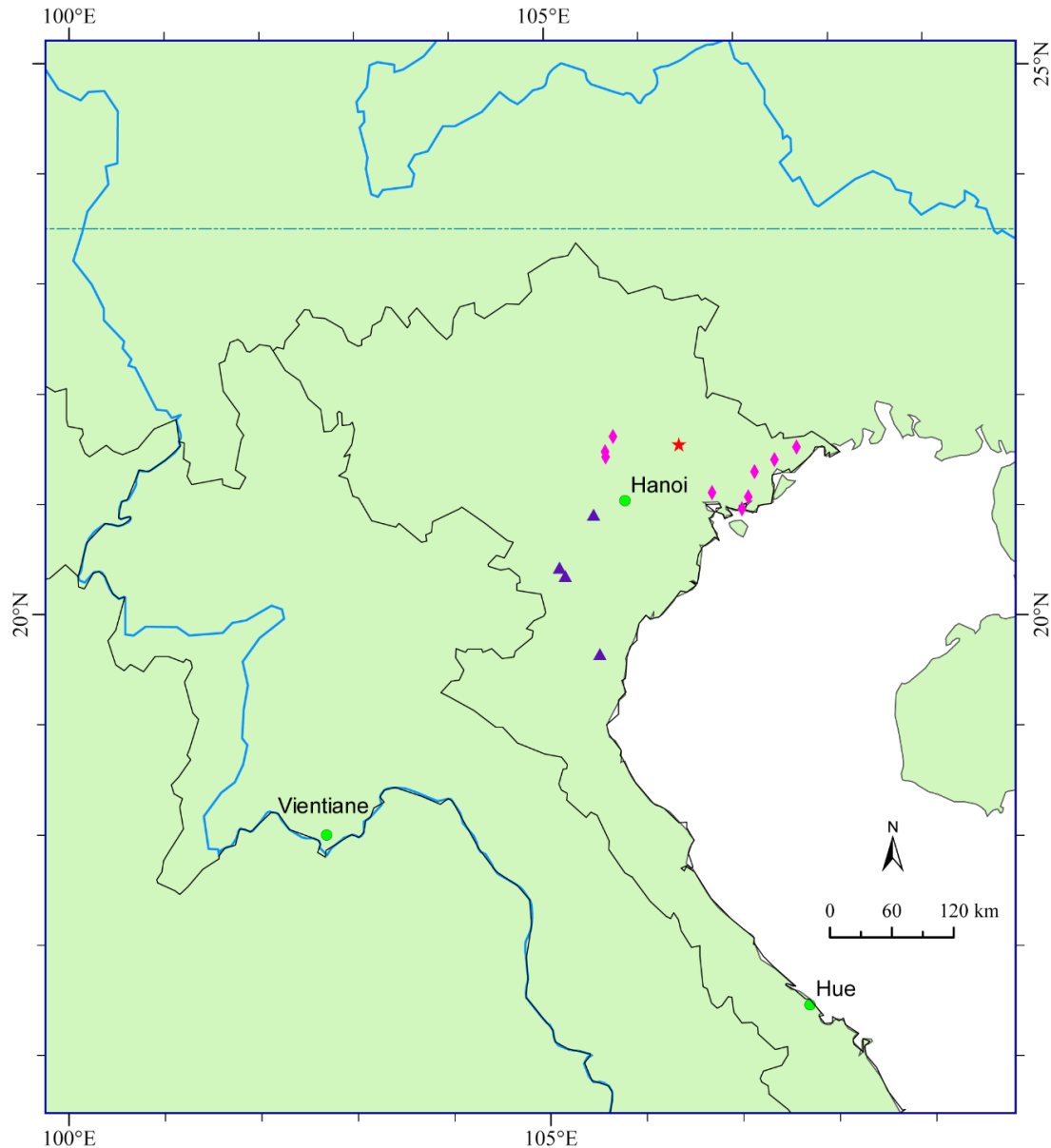
Vinh Phuc: ‘Me Linh’, 26 April 2004, *Phuong 7522 (HN)*, 28 April 2004, *Phuong 7750 (HN)*; Tam Dao, 1000 m, 14 October 1995, *TN 951053 (HNU)*, 6 November 2015, *Binh SH78 (VNMN)*.

Notes—Collection *Wan 76506* at **GXMI** was cited as the type of *C. chrysantha* var. *macrophylla* (Mo & Huang 1979) but two specimens of this gathering were found there: **GXMI050186** and **GXMI050187**. They were labelled as isoelectotype and lectotype, respectively, on the specimen sheets. However, I have not found any publication about this lectotypification (Art. 7.9) and a label on the specimen sheet cannot be treated as an effective publication (Art. 30.1). Therefore, the lectotype of *C. chrysantha* var. *macrophylla* (**GXMI050187**) is treated as being designated here.

Tran (1996: 14) described *C. rosmannii* in a Vietnamese journal. Though there was a Latin description (Art. 39.1), the species was not validly published there because he (Tran 1996) failed to indicate a herbarium or institution in which the type was conserved (Art. 40.7). *Camellia rosmannii* was subsequently validly published two years later by the same author (Tran 1998b)—‘as a mark of our co-operation’, commented by the French nurse Jean-Claude Rosmann (1997: 76) before the name being validly published.

Hakoda et al. (2007) described *C. phanii* without supplying or citing a Latin description or diagnosis so this species was not validly published there (Art. 39.1). Le et al. (2016: 119) thought that the species names in the publication of Hakoda et al. (2007), including *C. phanii*, were ‘not effective’ because of a ‘lacking description in Latin’. Therefore, they gave the ‘required’ Latin description to ‘make these scientific names effective’. However, *C. phanii* was effectively (but not validly) published by Hakoda et al. (2007, Art. 29.1). Moreover, a Latin description is not a

requirement anymore for a name being validly published on or after 1 January 2012—it can be replaced by an English one (Art. 39.2).



Map 4.1. Distribution of *Camellia euphlebia* (pink diamond), *C. hulungensis* (red star) and *C. pleurocarpa* (purple triangle) in Indochina.

Camellia euphlebia is morphologically like *C. petelotii* but differs from the latter mainly by its shorter pedicel and that the sepals are sericeous on the inner surface—*C. petelotii* has longer pedicel and glabrous sepals. As with other yellow camellias occurring in northern Vietnam, *C. euphlebia* has been exposed to a critical over-exploitation for medicinal purposes in its natural habitats (Map 4.1, Tran & Le 2013). Every day, local Vietnamese searched and collected its flower buds during the flowering season to meet the demands in the market (Tran & Le 2013).

Exploitation was so severe that it was ‘not easy to see a yellow *Camellia* flower in the natural forests of Vietnam’ (Tran & Le 2013: 127).

[2] *Camellia flava* (Pitard) Sealy in Kew Bulletin 4(2): 217. 1949 & A Revision of the Genus *Camellia* 36, 39–40, fig. 9. 1958; Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 18(3): 70–71. 1979, 30(2): 79, 81. 1991, 35(1): 80. 1996, A Taxonomy of the Genus *Camellia* 101–102. 1981 & in International *Camellia* Journal 24: 60–61. 1992; Hung T. Chang & B.M. Bartholomew, *Camellias* 128. 1984; P.H. Hô, *Cây cỏ Việt Nam* 533, fig. 1469. 1991; T.L. Ming & W.J. Zhang in Acta Botanica Yunnanica 15(1): 4, 6. 1993; T.L. Ming in Acta Botanica Yunnanica 21(2): 151. 1999 & Monograph of the Genus *Camellia* 78, 80–82, t. 2, fig. 4–6. 2000; Hakoda & Ninh in Curtis's Botanical Magazine 18(4): 190–193, t. 426. 2001; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 345. 2003; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 98. 2005.

≡ *Thea flava* Pitard in Lecomte, Flore Générale de l'Indo-Chine 1(4): 346. 1910; Cohen-Stuart in Bulletin du Jardin Botanique, 3rd series 1(4): 240. 1919; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 304, 319. 1943. —**Lectotype** (designated by Sealy 1958: 40): VIETNAM, 'Tonkin, Vó Xà, in monte Chùa Hạc', 23 December 1884, *Bon* 2831 (**P04511548**!). Syntypes: VIETNAM, 'Tonkin, in monte Bút Sơn', 7 December 1883, *Bon* 2353 (**P01903401**!); 'Tonkin, Lạt Sơn', 17 December 1885, *Bon* 3101 (**P01903400**!).

= *Thea tonkinensis* Pitard in Lecomte, Flore Générale de l'Indo-Chine 1(4): 343. 1910; A. Chevalier in Bulletin Économique de l'Indochine 22(137): 531. 1919; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 303, 308. 1943. D. Wei Zhao et al. in Phytotaxa 292(2): 177. 2017. **Syn. nov.** —**Lectotype** (designated by Zhao et al. 2017a: 177): VIETNAM, Hanoi, 'vallée de Lankok (Mont. Bavi)', 24 November 1887, *Balansa* 3860 (**P01903514**!). Isolectotype: **P01903515**!.

= *Camellia tonkinensis* (Pitard) Cohen-Stuart in Mededeelingen van het Proefstation voor Thee 40: 67. 1916 & in Bulletin du Jardin Botanique, 3rd series 1(4): 243. 1919; Melchior in Engler, Die Natürlichen Pflanzenfamilien 2(21): 129. 1925; Sealy, A Revision of the Genus *Camellia* 40, fig. 10. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 87–88. 1981 & in Acta Scientiarum Naturalium Universitatis Sunyatseni 35(1): 82. 1996; Hung T. Chang & B.M. Bartholomew, *Camellias* 112. 1984; T.L. Ming & W.J. Zhang in Acta Botanica Yunnanica 15(1): 4, 8. 1993; T.L. Ming in Acta Botanica Yunnanica 21(2): 151. 1999 & Monograph of the Genus *Camellia* 79, 87, t. 5, fig. 1. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 350. 2003. **Sny. nov.**

= *Camellia cordatula* Merrill in Journal of the Arnold Arboretum 20(3): 348. 1939. —**Holotype**: VIETNAM, Hoa Binh, 'between Hoa Binh and Vu Ban', 5 May 1938, *Pételot* 6387 (**A00024747**†).

= *Camellia cucphuongensis* Ninh & Rosmann ex Ninh in International *Camellia* Journal 30: 71. 1998; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 94. 2005; Utteridge & Bramley, The Kew Tropical Plant Families Identification Handbook 145, fig. 2, 5, 9. 2014. **Syn. nov.** —**Holotype**: VIETNAM, Ninh Binh, Cuc Phuong National Park, 11 January 1995, *Anh PA* 95109 (**HNU**!). Isotype: **HNU**!.

Shrubs or trees up to 8 m tall. *New branchlets* and *terminal buds* puberulous. *Petioles* 2–5 mm long, sparsely puberulous; *leaf blades* elliptic to oblong, 7–21 × 2.5–7.5 cm, thinly coriaceous to coriaceous, abaxially yellowish green and brown punctate, glabrous or sparsely puberulous along midrib, adaxially dark green and shiny, midrib abaxially elevated and adaxially slightly raised, secondary veins 6–9 on each side of midrib, abaxially slightly raised and adaxially slightly impressed, base subcordate, rounded or obtuse, margin sparsely serrulate, apex attenuate to caudate. *Flowers* solitary, 2–6 cm in diam. *Pedicels* 5–10 mm long. *Bracteoles* 5–7, alternate, 2-ranked, gradually transitioning to sepals, deltate, semi-orbicular or crescent, 1.5–4 × 2–11 mm, sparsely puberulent to puberulent on both surfaces, margin ciliolate. *Sepals* 4–6, gradually transitioning to petals, crescent, sub-orbicular or ovate, 6–18 × 10–16 mm, yellowish green to yellow, outside densely puberulent, inside sericeous, margin ciliolate. *Petals* 14–15 in 3 whorls, yellow, circular, elliptic to obovate, 1.5–3.5 × 1.5–2 cm, basally connate for 5–10 mm, outside densely puberulent, inside sericeous at apex and gradually becoming glabrous basally. *Stamens* 1–2.5 cm long; *filaments* pale yellow, outer filaments basally adnate to petals for 5–15 mm, basally puberulous and gradually becoming glabrous apically. *Ovary* oblate, densely pubescent. *Styles* (3–)5, distinct, 2–2.5 cm long, pubescent. *Capsule* oblate, 2.5–5.5 cm in diam., 2–3 cm in height, (3–)5-loculed; *pericarp* 1–3 mm thick. *Seeds* fuscous, hemispherical or polyhedral, 1.5–2 cm in diam., tomentose. Figure 4.3.

Phenology: flowering October–April, fruiting July–August.

Distribution: endemic to northern Vietnam (Map 4.2).

Habitat: evergreen forests on slopes of limestone mountains, 100–650 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² (B1, Map 4.2) and it may have undergone an over-exploitation during the hyping of golden camellias (see Section 1.7, IUCN 2012).

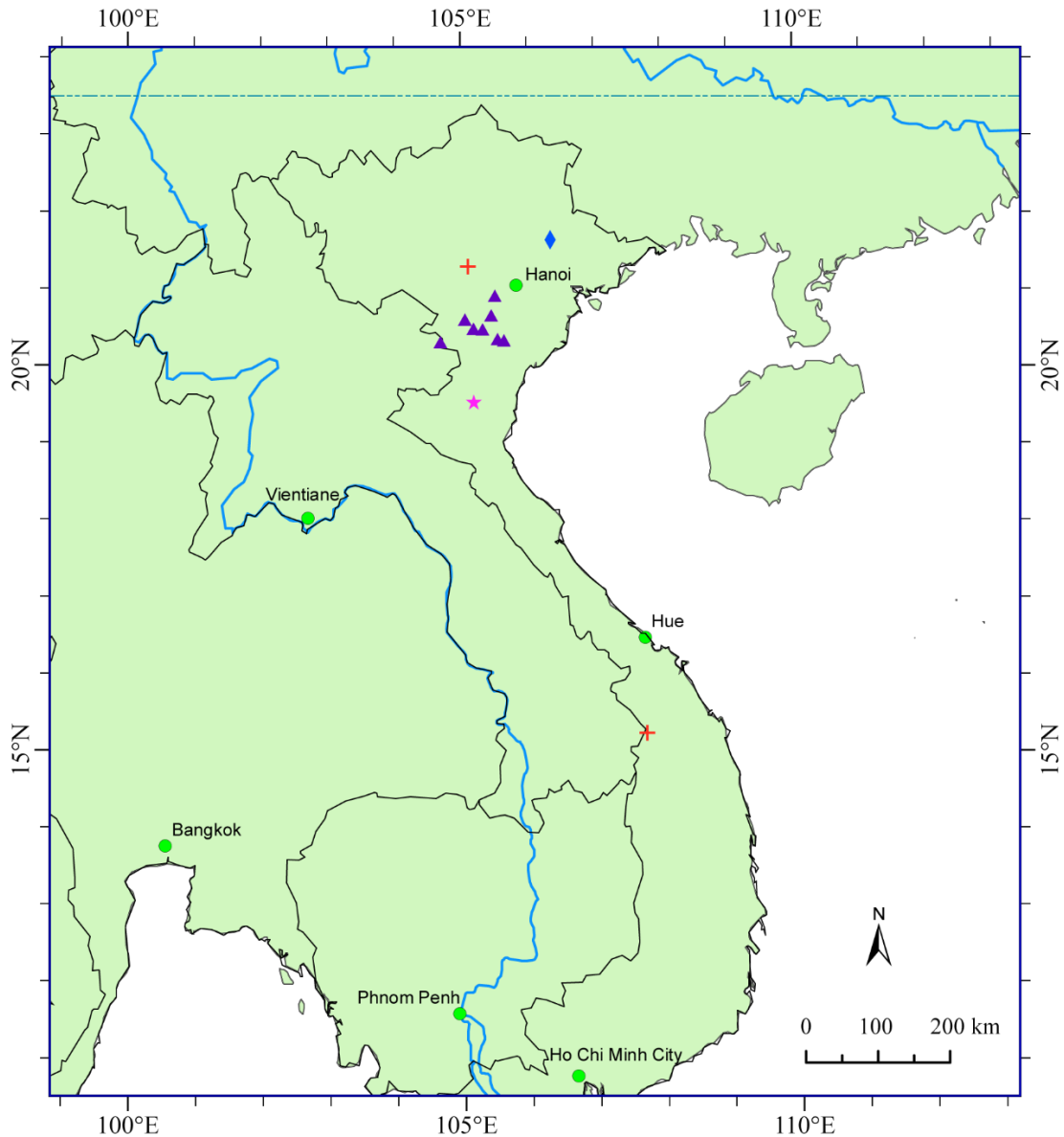
Additional specimens examined

VIETNAM. Hoa Binh: ‘Entre Hoa Binh et Vu Bin’, 27 December 1940, *Pételot* 2303 (HNU, YNM00003789); Kim Boi, Thuong Tien, 24 December 1999, *Phuong* 2542 (HN); Lac Son, Ngoc Son, Khu, 20°27'42"N, 105°18'34"E, 611m, 28 July 2006, *Loc et al.* HAL 9025 (HN, P05247464, P05247465, P05247467, PE 2341344); Luong Son, Ha Son Binh, 5 March 1984, *Binh B.907* (HNU); Mai Chau, Van Mai, 21 December 1999, *Phuong* 2461 (HN).

Ninh Binh: Nho Quan, Cuc Phuong, 200–400 m, 1995, *Ninh PA 95104, PA 95106, PA 95108, PA 95112, PA 95115 & PA 95116* (HNU); 13 January 1963, *Sino-Vietnam Exp.* 2159 (HN), 16 February 1965, *Sino-Vietnam Exp.* 2137 (HN, IBK00118472, IBSC0238703, KUN0694266, PE01679136, VFM), December 1992, *Ninh NT 92131* (HNU), 100 m, October 1995, *Rosmann 95680* (P05247458), 300 m, 3 April 1997, *Werff et al.* 14244 (HN), 20°19'48"N, 105°36'55"E, 270 m, 30 November 1998, *Soejarto et al.* 10527 (P00226766), 10 March 2007, *Nguyen et al.* HNK-

1312 (HN, K, PE02022257), 20 October 2010, *Phe BC-TV 1445* (VNF).

Thanh Hoa: Pu Luong, April 2013, *Ly BC-TV 1445* (VNF); Quan Son, Na Meo, Ban Son, 20°17'28"N, 104°40'43"E, 300 m, 24 August 2007, *Loc et al. HAL 11204* (HNU 019012).



Map 4.2. Distribution of *Camellia calcicola* (pink star), *C. flava* (purple triangle), *C. micrantha* (red cross) and *C. murauchii* (blue diamond) in Indochina.

Notes—Pitard (1910) cited ‘Tonkin: forêt de la vallée de Lankok (Balansa)’ in the protologue of *T. tonkinensis*. Only *Balansa 3860*, consisting of P01903514 and P01903515, was found that accorded with the protologue. P01903514 bears a drawing and Pitard’s slip ‘*Thea tonkinensis* sp. n.’ so it is designated here as the lectotype (Zhao et al. 2017a). *Camellia tonkinensis* differs from *C. flava* only by the three styles in its flower whereas the latter usually has five styles. This single difference is not sufficient to warrant separation of *C. tonkinensis* from *C. flava* at either species or infraspecific (e.g., varietal) level—here it is recognised as a morphological variation in the

populations of *C. flava* because there are some collections of this species that have four styles (e.g., *Ly BC-TV 1445* at **VNF**). *Thea flava* and *T. tonkinensis* (Pitard 1910) were suggested as the earliest yellow camellias ever described (Savign 1994, Yang et al. 2014b). However, before they were published, Lanessan (1886) and Pierre (1887) described *T. dormoyana* which also had yellow flowers (see Section 4.2.10, species [38]).

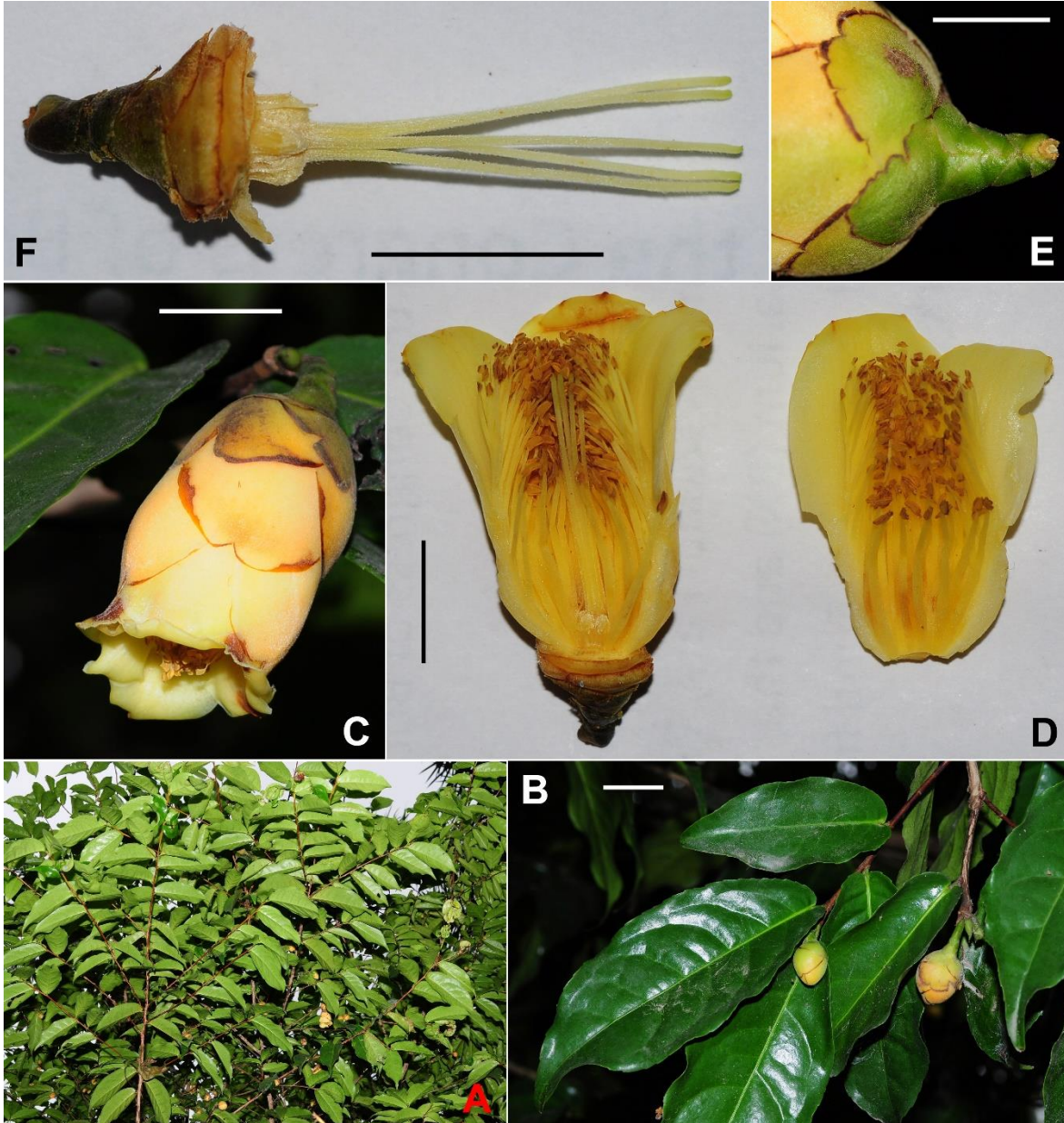


Figure 4.3. *Camellia flava*. A & B: branches; C: flower; D: a dissected flower; E: pedicel, bracteoles and sepals; F: gynoecium and pedicel. The bars represent 2 cm in B but indicate 1 cm in C, D, E & F, respectively.

Tran & Nguyen (1995) described *C. cucphuongensis* without giving or citing a Latin description or diagnosis so it was not validly published there (Art. 39.1). This name was validly published three years later by Tran (1998a). Hakoda & Tran (2001) suggested that *C. cucphuongensis* had 6–8 seeds per locus in the fruit by which it differed from *C. flava* (that had only one seed per locus,

according to Hakoda & Tran 2001: 191). Orel (2007: 7) considered that '*C. cucphuongensis* is morphologically, but not genetically, similar to *C. flava*' but did not supply any genetic data. Parks (2007: 15) pointed out that *C. cucphuongensis* and *C. flava* appeared 'identical in all major morphological characteristics'. However, the *RPB2* gene tree (Figure 2.9) supported a very close relationship between *C. cucphuongensis* and *C. flava*. The number of seeds per loculus in the fruit usually varies and may not be merited as a diagnostic character at specific level in sect. *Archecamellia*. Therefore, *C. cucphuongensis* is here recognised as a synonym of *C. flava*.

[3] *Camellia hirsuta* Hakoda & Ninh ex Le, Hakoda & Ninh in International Camellia Journal 48: 119, fig. 1. 2016. —**Holotype:** VIETNAM, Thai Nguyen, Dai Tu, Tan Thai, 200 m, February 2004, *Hakoda & Ninh TN 04-02-07 (HNU!)*. Paratypes: VIETNAM, Thai Nguyen, Dai Tu, Tan Thai, 10 December 2004, *Ninh TN 120204, TN 120304, TN 120404 & TN 120504 (HNU!)*, 7 October 2006, *TN 2.1006 (HNU!)*.

Shrubs 5–6 m tall. *New branchlets* with spreading villous hairs, hairs 1.5–3 mm long, *terminal buds* pubescent. *Petioles* 2–4 mm long, with spreading villous hairs; *leaf blades* elliptic, oblong, or ovate-oblong, 14–22 × 5–8 cm, coriaceous, abaxially yellowish green, with spreading villous hairs and brown punctate, adaxially dark or yellowish green, glabrous, or hirsute along midrib, midrib abaxially elevated and adaxially channelled, secondary veins 12–15 on each side of midrib, abaxially raised and adaxially impressed, base rounded or subcordate, margin serrulate, apex attenuate or acuminate. *Flowers* solitary or paired, 4–5 cm in diam. *Pedicels* ca. 2 mm long. *Bracteoles* 7–9, alternate, ovate, 1.5–5 × 2–6 mm, outside glabrous, or puberulous along midrib, inside sericeous, margin ciliolate. *Sepals* 5, broadly ovate, 4–7 × 6–9 mm, outside glabrous, inside sericeous, margin ciliolate. *Petals* ca. 9 in 2 whorls, yellow, elliptic or obovate, 1.3–2.5 × 1–1.5 cm, outside glabrous, inside sericeous. *Stamens* not seen. *Ovary* globose or ovoid, pubescent. *Styles* 3, distinct, ca. 2 cm long, glabrous. *Capsule* oblate, oblate or bi-coccal, 3–4.5 cm in diam., 2–3 cm in height; *pericarp* 2–3 mm thick. *Seeds* fuscous, hemispherical, polyhedral or globose, 2–2.5 cm in diam., villous.

Phenology: flowering October–February, fruiting November–December.

Distribution: endemic to northern Vietnam (Map 4.3).

Habitat: evergreen forest, ca. 200 m.

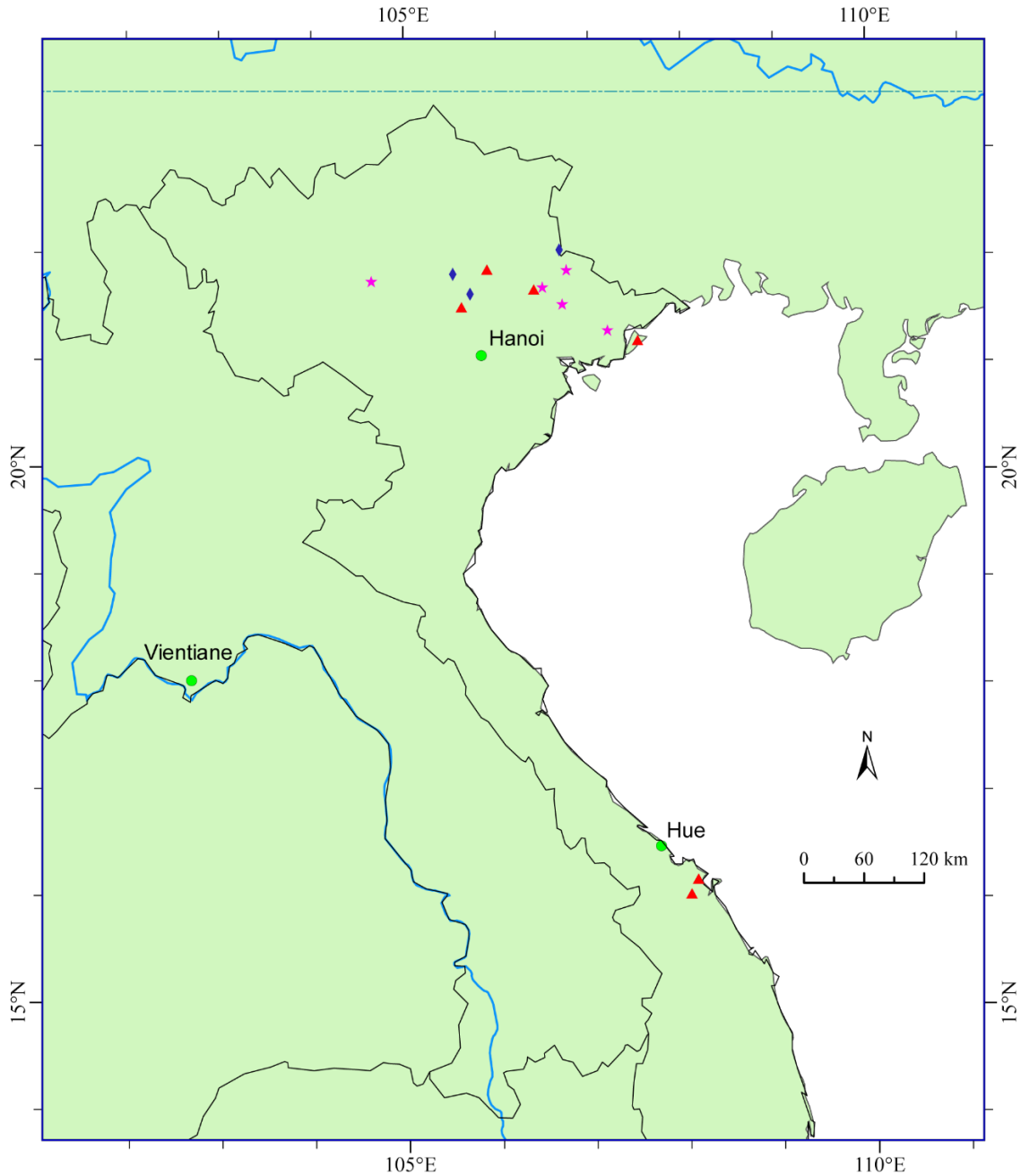
Conservation status: endangered (EN). The area of occupancy of this species is estimated to be less than 500 km² (B2). It is known to exist at only three locations (Map 4.3) and may be influenced by deforestation for economic reasons in the low-elevation areas (IUCN 2012).

Additional specimens examined

VIETNAM. Lang Son: Van Lang, Tan Thanh, 27 November 1971, *Bien 8076 (HN)*.

Thai Nguyen: Dinh Hoa, Phu Dinh, 1 April 2005, *Phuong 9740 (HN)*.

Notes—*Camellia hirsuta* was described without supplying or citing a Latin description or diagnosis (Hakoda et al. 2007) so this species was not validly published there (Art. 39.1). It was subsequently validly published by Le et al. (2016). This species can be easily identified by the spreading villous hairs on its new branchlet, petiole and abaxial surface of leaf blade.



Map 4.3. Distribution of *Camellia hirsuta* (purple diamond), *C. indochinensis* (pink star) and *C. petelotii* (red triangle) in Indochina.

[4] *Camellia hulungensis* Rosmann & Ninh in *Jardins de France* 10: 4. 1997. —**Holotype:** VIETNAM, Lang Son, Huu Lung, 10 January 1997, Rosmann 97160 (P01903391!).

Shrubs 2.5–3 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 4–9 mm long, glabrous;

leaf blades elliptic or obovate, 16–22 × 7–11 cm, coriaceous, abaxially yellowish green and pale brown punctate, adaxially dark green, both surfaces glabrous, midrib and secondary veins abaxially elevated and adaxially channelled, secondary veins 13–15 on each side of midrib, base rounded or subcordate, margin serrulate, apex acuminate. *Flowers* solitary or paired, ca. 2.5 cm in diam. *Pedicels* 4–5 mm long. *Bracteoles* 4–5, glabrous. *Sepals* 5, broadly ovate, glabrous. *Petals* 6–10 in 1–2 whorls, yellow, elliptic or obovate, glabrous. *Stamens* not seen. *Ovary* glabrous. *Styles* 3, distinct, glabrous. *Capsule* globose, 2–2.5 cm in diam.; *pericarp* ca. 1 mm thick. *Seeds* not seen.

Phenology: flowering and fruiting in January.

Distribution: endemic to northern Vietnam (Map 4.1).

Habitat: evergreen forest.

Conservation status: critically endangered (CR). This species is known to exist at only a single location (B1, Map 4.1, IUCN 2012).

Additional specimens examined

VIETNAM. Lang Son: Huu Lung, Tan Thanh, 10 January 1998, *Ninh TN 9804* (**HNU**).

Notes—No flower collection of this species is available to me. Therefore, the description of flower characters is based on the protologue and a coloured photo attached on *Ninh TN 9804* at **HNU**.

Camellia hulungensis could be differentiated from other species of sect. *Archecamellia* by its large, glabrous leaves and small, glabrous flowers.

[5] *Camellia indochinensis* Merrill in Journal of the Arnold Arboretum 22(3): 347. 1939; Sealy, A Revision of the Genus *Camellia* 50, 87–88, fig. 39. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 99–100, fig. 16. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 125–127, fig. 42. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 534, fig. 1473. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 152. 1999 & Monograph of the Genus *Camellia* 80, 104–105, t. 11, fig. 1–5. 2000, excl. syn. *Camellia parvipetala* J.Y. Liang & Z.M. Su; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 346. 2003; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 106. 2005, excl. photo. —**Lectotype** (designated by Zhao et al. 2017a: 172): VIETNAM. Lang Son: near Van Linh, 17 November 1938, *Pételot 6459* (**A00024750**[†]). Isolectotypes: **A00024721**[†], **NY00385754**[†], **P04511510**!, **US00113901**[†]).

≡ *Thea indochinensis* (Merrill) Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 307. 1943.

= *Camellia limonia* C.F. Liang & S.L. Mo in *Guihaia* 2(2): 63, fig. 2. 1982. —**Holotype**: CHINA, Guangxi, Chongzuo, Longzhou, Nonggang, 140 m, 3 November 1979, *Nonggang Exp. 11527* (**IBK00190498**!). Isotype: **IBK00190483**!. Paratypes: CHINA, Guangxi, Chongzuo, Longzhou, Nonggang, 1 November 1979, *Nonggang Exp. 11481* (**HITBC 57629**!, **IBK00118616**!).

SYS00092107!) & 11528 (IBK00190480!, IBK00190482!, IBK00200005!, SYS00092112!, SYS00092108!), 4 November 1979, *Nonggang Exp. 11549* (IBK00190481!, SYS00081503!).

= *Camellia limonia* C.F. Liang & S.L. Mo f. *obvata* S.L. Mo & Y.C. Zhong in *Guihaia* 5(4): 355, fig. 5. 1985. —**Holotype**: CHINA, Guangxi, Fusui, 1981, *Wei 81086* (IBK00190499!).

Shrubs, 1–5 m tall. *New branchlets* glabrous; *terminal buds* glabrous. *Petioles* 4–10 mm long, glabrous; *leaf blades* oblong to elliptic, 6–12.5 × 3–6.5 cm, thinly coriaceous, abaxially yellowish green and brown punctate, adaxially dark green and shiny, both surfaces glabrous, midrib abaxially elevated and adaxially flat, secondary veins 5–8 on each side of midrib, abaxially slightly elevated and adaxially slightly impressed or obscure, base cuneate, margin sparsely serrulate, apex attenuate to acuminate. *Flowers* solitary, 1–2 cm in diam. *Pedicels* 2–4 mm long. *Bracteoles* 4–5, alternate, 2-ranked, crescent to semi-orbicular, 0.5–1.5 × 1–1.5 mm, both surfaces glabrous. *Sepals* 5, broadly ovate or sub-orbicular, 1.5–2 × 1.5–2.5 mm, both surfaces glabrous, margin ciliate. *Petals* 8–10 in 2 whorls, pale yellow, sub-orbicular, elliptic to obovate-elliptic, 6–15 × 4–7 mm, both surfaces glabrous. *Stamens* 4–8 mm long; *filaments* white, outer filaments basally adnate to petals for 1–2 mm, glabrous. *Ovary* globose, glabrous. *Styles* 3, distinct, 8–13 mm long, glabrous. *Capsule* oblate, globose or bi-coccal, 1.5–2.5 cm in diam., 1–1.5 cm in height; *pericarp* ca. 1 mm thick. *Seeds* fuscous, hemispherical, polyhedral or globose, 8–12 mm in diam., glabrous.

Phenology: flowering November–February, fruiting November.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.3).

Habitat: evergreen forest, ca. 140 m.

Conservation status: vulnerable (VU). The area of occupancy of this species is estimated to be less than 2000 km² (B2). It is known to exist at less than 10 locations (Map 4.3) and may be influenced by the deforestation for economic reasons in the low-elevation areas (IUCN 2012).

Additional specimens examined

VIETNAM. Bac Giang: ‘Entre Lang Met et Thanh Mai’, 9 December 1940, *Pételot 6671* (VNM00003793, VNM00003794, VNM00003795, VNM00003796).

Lang Son: Chi Lang, ‘Lang Ngua’, 17 January 1965, *Sino-Vietnam Exp. 1506* (**HN**, PE01679140, **VFM**); ‘at km 10 on road from Met to Dong Mo’, 18 January 1965, *Sino-Vietnam Exp. 1573* (**HN**, PE01679139, **VFM**).

Quang Ninh: Ba Che, 27 October 2015, *Van BC3* (**TCD**, **VNMN**).

Yen Bai: ‘Bao Ha’, 21 February 1936, *Poilane 25289* (P06614710).

Notes—Merrill (1939: 347) cited a single gathering *Pételot 6459* in the protologue. Five specimens of this gathering were found at **A**, **NY**, **P** and **US** so they are syntypes (Art. 40 Note 1). Only **A00024750** bears manuscript notes ‘*Camellia (Thea) indochinensis* Merr. n. sp.’ and ‘Type’ on the

label and the sheet, respectively, so it is selected as the lectotype. The isoelectotype **P04511510** bears the wrong collector's number '5459', it should be 6459 because this specimen was collected by Pételot at the same place and on the same day as the duplicates of *Pételot 6459* that are so labelled in **A**, **NY** and **US**. Both Sealy (1958: 87) and Ming (2000: 105) cited the wrong number '*Pételot 5459*' in their monographs (Zhao et al. 2017a).

'*Camellia fusuiensis*' was cited by Min (2000: 104) as a synonym of *C. indochinensis*; however, it was not validly published because no Latin description was cited or accompanied it (Liang 1990: 24, 1993: 23). *Camellia indochinensis* is morphologically like *C. micrantha* but differs from the latter by its smaller leaf blade (6–12.5 × 3–6.5 cm) and glabrous seeds—*C. micrantha* has larger leaf blade (12–17.5 × 5–12 cm) and tomentose seeds.

[6] *Camellia micrantha* S.Y. Liang & Y.C. Zhong ex S.Y. Liang, Y.Q. Xie, C.Z. Jiang & P.L. Lei in Acta Scientiarum Naturalium Universitatis Sunyatseni 4: 110. 1988; Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 30(2): 80, 84. 1991, 35(1): 82. 1996 & in Flora Reipublicae Popularis Sinicae 49(3): 102, 112. 1998; C.X. Ye & Z.R. Xu in Acta Scientiarum Naturalium Universitatis Sunyatseni 31(4): 70, 76–77. 1992; T.L. Ming in Acta Botanica Yunnanica 21(2): 151. 1999 & Monograph of the Genus *Camellia* 79, 89, 91, t. 6, fig. 6–8. 2000; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 110. 2005. — **Holotype:** CHINA, Guangxi, Ningming, Xiashi, Banjiao, 190–350 m, 26 December 1984, *Liang 8409430 (GXFI!)*. Paratypes: CHINA, Guangxi, Ningming, Xiashi, Banjiao, 17 February 1984, *Liang 840217 (GXFI!)*, 7 October 1983, *Liang 8309394 (GXFI!)*; Guangxi, Nanning, 17 December 1979, *Liang 7909224 (GXFI!)*, 12 December 1981, *Zhong 81012012 (GXFI!)*.

= *Camellia minima* Orel & Curry, In Pursuit of Hidden Camellias 227. 2015. **Syn. nov.** —

Holotype: VIETNAM, Phu Tho, unnamed mountainous region, 13 December 2011, *Orel & Curry 1245b (NSW901891†* [sheet 1 of 2], *NSW849514†* [sheet 2 of 2]).

Shrubs, 3–6 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 6–15 mm long, glabrous; *leaf blades* elliptic to broadly elliptic, 12–17.5 × 5–12 cm, coriaceous, abaxially yellowish green and brown punctate, adaxially dark green, both surfaces glabrous, midrib and secondary veins abaxially elevated and adaxially flat or slightly impressed, secondary veins 7–10 on each side of midrib, base obtuse, rounded or cuneate, margin sparsely serrulate, apex acute, attenuate or acuminate. *Flowers* solitary, 1–2 cm in diam. *Pedicels* 3–6 mm long. Bracteoles 4–5, alternate, 2-ranked, crescent, deltate or broadly ovate, 1–1.5 × 1.5–2 mm, both surfaces glabrous, margin ciliolate. *Sepals* 5, ovate to broadly ovate, 1.5–3 × 2–4 mm, outside glabrous or sparsely puberulent, inside glabrous, margin ciliolate. *Petals* 6–9 in 2 whorls, pale yellow, sub-orbicular, elliptic or obovate, 5–12 × 4–6 mm, both surfaces glabrous, basally connate for 2–3 mm. *Stamens* 5–12 mm long; *filaments* glabrous, outer filaments basally connate for 2–4 mm. *Ovary* ovoid or oblate, glabrous or sparsely puberulous. *Styles* 3, distinct, ca. 1 cm long, glabrous. *Capsule* oblate,

globose or bi-coccal, 3–4 cm in diam., 2–2.5 cm in height; *pericarp* 1–2 mm thick. *Seeds* fuscous, hemispherical or globose, 1–2 cm in diam., tomentose.

Phenology: flowering November–December, fruiting October–November.

Distribution: China and Vietnam (Map 4.2).

Habitat: evergreen forest, 150–1200 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

VIETNAM. Kon Tum, Dak Glei, ‘about 12 km to N of Dak Gley town (24 km by road), near Mang Khen village’, 1100–1200 m, 17 November 1995, *Averyanov et al.* VH 1770 (**P04500295**).

Notes—*Camellia micrantha* morphologically differs from *C. euphlebia* and *C. petelotii* by its small flower (1–2 cm in diam.) whereas the latter two have large flowers (3–6 cm in diam.).

[7] *Camellia murauchii* Ninh & Hakoda in International Camellia Journal 30: 77. 1998. —

Holotype: VIETNAM, Lang Son, Huu Lung, Huu Lien, Yen Thinh, 300–400 m, 17 January 1998, *Ninh & Hakoda* TN98906 (**HNU!**).

Shrubs 4–5 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 3–5 mm long, pubescent; *leaf blades* elliptic or obovate, 17–23 × 8–12 cm, coriaceous, abaxially yellowish green, pubescent and brown punctate, adaxially dark green and glabrous, midrib and secondary veins abaxially elevated and adaxially channelled, secondary veins 16–19 on each side of midrib, base cordate, margin serrulate, apex acuminate. *Flowers* solitary, ca. 5 cm in diam. *Pedice*l 3–5 mm long. *Bracteoles* ca. 6, broadly ovate, 1–2 × 2–3 mm, outside puberulous and inside glabrous. *Sepals* 5, broadly ovate, 4–5 × 4–6 mm, outside puberulous. *Petals* 8–13 in 2–3 whorls, yellow or pale yellow, elliptic or obovate, outside glabrous. *Stamens* not seen. *Ovary* glabrous. *Styles* 3, distinct, 2.3–2.5 cm long, glabrous. *Fruit* and seeds not seen.

Phenology: flowering in January.

Distribution: endemic to northern Vietnam (Map 4.2).

Habitat: evergreen forest, 300–400 m.

Conservation status: critically endangered (CR). This species is known to exist at only a single location (B1, Map 4.2, IUCN 2012).

Notes—Only the type collection was available to me. Some characters of the flower are described based on photos taken by camellias enthusiasts (<https://murauchi.muragon.com/entry/162.html>). The cordate leaf base of *C. murauchii* resembles that of *C. amplexicaulis* but *C. murauchii* differs from the latter by its yellow flower and its leaf blade is abaxially pubescent—*C. amplexicaulis* usually has red flowers and glabrous leaf blades.

[8] *Camellia petelotii* (Merrill) Sealy in Kew Bulletin 4(2): 219. 1949 & A Revision of the Genus *Camellia* 36, 42–43, fig. 12. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 99. 1981 & in Acta Scientiarum Naturalium Universitatis Sunyatseni 35(1): 79. 1996; Hung T. Chang & B.M. Bartholomew, Camellias 125. 1984; P.H. Hô, Cây cỏ Việt Nam 1(1): 534, fig. 1472. 1991; T.L. Ming & W.J. Zhang in Acta Botanica Yunnanica 15(1): 5, 9–10. 1993; Hung T. Chang & C.X. Ye in Acta Scientiarum Naturalium Universitatis Sunyatseni 32(3): 119, fig. 1. 1993; C.X. Ye in Guihaia 15(1): 3. 1995; Ninh & Hakoda in International Camellia Journal 30: 81–83. 1998; T.L. Ming in Acta Botanica Yunnanica 21(2): 152. 1999 & Monograph of the Genus *Camellia* 79, 94–95, t. 8, fig. 1–4. 2000, quoad type; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 348. 2003; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 117. 2005.

≡ *Thea petelotii* Merrill in University of California Publications in Botany 10: 427. 1924. —

Holotype: VIETNAM, Vinh Phuc, ‘Massif du Tam Dao’, 900 m, February 1923, *Pételot 848* (UC, photo at P†).

= *Camellia aurea* Hung. T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 18(3): 71. 1979; C.X. Ye & Z.R. Xu in Acta Scientiarum Naturalium Universitatis Sunyatseni 31(4): 70–71, fig. 2. 1992; T.L. Ming, Monograph of the Genus *Camellia* 79, 83, t. 3, fig. 1–3. 2000. **Syn. nov.** — **Holotype:** VIETNAM, Lang Son, Huu Lung, ‘Bou Lac’, 18 January 1965, *Sino-Vietnam Exp. 1599* (IBSC). Isotypes: **HN!**, **KUN1205974!**, **PE01679144!**, **VFM!**.

= *Camellia thanxaensa* Hakoda & Ninh ex Le, Hakoda & Ninh in International Camellia Journal 48: 120, fig. 2. 2016. **Syn. nov.** — **Holotype:** VIETNAM, Thai Nguyen, Vo Nhai, Than Xa, 300 m, January 2005, *Hakoda et al. TN 05-1-25* (HNU!). Paratypes: VIETNAM, Thai Nguyen, Vo Nhai, Than Sa, *Ninh 1.0514* (HNU!), 10 December 2004, *Ninh 120904*, *121004* & *121104* (HNU!).

= *Camellia elizabethae* Orel & Curry, In Pursuit of Hidden Camellias 195. 2015. **Syn. nov.** — **Holotype:** VIETNAM, Vinh Phuc, Tam Dao National Park, 12 December 1999, *Orel et al. 1999-11* (NSW901752†).

= *Camellia erubescens* Orel & Curry, In Pursuit of Hidden Camellias 245. 2015. **Syn. nov.** — **Holotype:** VIETNAM, Quang Ninh, unnamed coastal region, 2 December 1999, *Orel et al. 991202 Is* (NSW901735†).

Shrubs, 2–7 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 6–15 mm long, glabrous; *leaf blades* elliptic or oblong, 7–19 × 3–8.5 cm, coriaceous, abaxially yellowish green and brown punctate, adaxially dark green, both surfaces glabrous, midrib abaxially elevated and adaxially flat, secondary veins 5–7 on each side of midrib, abaxially slightly elevated and adaxially slightly impressed or obscure, base cuneate to obtuse, margin sparsely serrulate to nearly entire, apex acute, attenuate to acuminate. *Flowers* solitary, 4–6 cm in diam. *Pedicel* 8–15 mm long. *Bracteoles* 5–7, alternate, 2-ranked, crescent to semi-orbicular, 1–3 × 2–4 mm, both surfaces glabrous, margin

ciliolate. *Sepals* 5, broadly ovate or sub-orbicular, 4–8 × 5–9 mm, both surfaces glabrous, margin ciliolate. *Petals* 8–12 in 2–3 whorls, yellow, sub-orbicular, elliptic to obovate-elliptic, 1.5–4 × 1–3 cm, both surfaces glabrous. *Stamens* 1.5–2.5 cm long; *filaments* glabrous, outer filaments basally connate for 5–15 mm. *Ovary* ovoid, glabrous. *Styles* 3, distinct, 1.5–2 cm long, glabrous. *Capsule* oblate or bi-coccal, 2–5 cm in diam., 1.5–3.5 cm in height; *pericarp* 0.5–2.5 mm thick. *Seeds* fuscous, hemispherical, polyhedral or globose, 1.5–2.5 cm in diam., puberulent or glabrous.

Phenology: flowering December–January, fruiting July–August.

Distribution: China and Vietnam (Map 4.3).

Habitat: evergreen forest, 300–900 m.

Conservation status: critically endangered (CR, A1/A2, see Section 1.7, IUCN 2012).

Additional specimens examined

VIETNAM. Da Nang: ‘Mount Bani’, July 1927, *Clemens* 3845 (**P06615013**, **K**) & 4101 (**P06615014**); Lien Chieu, 650 m, 15 August 1923, *Poilane* 7496 (**P05312442**, **K**).

Notes—There were great debates on the circumscription of *C. petelotii* (Min & Zhang 1993, Ye 1993, 1995, 1996b, 1997, Zhang & Ye 1993, 1994, Zhang 1996a, Tran & Hakoda 1998a, Min 2000, Gao et al. 2005)—generally about whether *C. nitidissima* and *C. chrysantha*, which were described based on collections from China, should be treated as synonyms of *C. petelotii* (see Section 1.2.1). I examined only a black and white photo of the type of *C. petelotii* at **P**. So, I provisionally abstain from these debates because of a lack of data.

[9] *Camellia pleurocarpa* (Gagnepain) Sealy, A Revision of the Genus *Camellia* 38, fig. 8. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 16. 1981 & in *Acta Scientiarum Naturalium Universitatis Sunyatseni* 35(1): 79. 1996; Hung T. Chang & B.M. Bartholomew, *Camellias* 31–32. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 527, fig. 1452. 1991; T.L. Ming & W.J. Zhang in *Acta Botanica Yunnanica* 15(1): 4, 6. 1993; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 151. 1999 & *Monograph of the Genus Camellia* 78, 82–83, t. 1, fig. 3–4. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 349. 2003.

≡ *Thea pleurocarpa* Gagnepain in *Notulae Systematicae* 10(3): 130. 1942 & in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 304, 320–321, t. 30, fig. 13–15. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 177. 2017. —**Lectotype** (designated by Zhao et al. 2017a: 177): VIETNAM, Thanh Hoa, La Han, 500 m, 5 August 1920, *Poilane* 1731 (**P01903367**!).
Isolectotypes: **A00025100**†, **K000704302**!, **P01903368**!, **P04500229**!.

Shrubs or trees up to 14 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 4–7 mm long, glabrous; *leaf blades* elliptic to oblong, 12–26 × 6–13 cm, coriaceous, abaxially brown punctate and adaxially shiny, both surfaces glabrous, midrib abaxially elevated and adaxially slightly raised,

secondary veins 8–11 on each side of midrib, abaxially raised and adaxially slightly impressed, base obtuse or rounded, margin sparsely serrulate, apex attenuate to acuminate. *Flowers* solitary or paired, 3–5 cm in diam. *Pedicels* 6–13 mm long. *Bracteoles* 5–8, alternate, 2-ranked, gradually transitioning to sepals, deltate, broadly ovate or crescent, $1.5\text{--}8 \times 2\text{--}13$ mm, outside glabrous to sericeous, inside glabrous, margin ciliolate. *Sepals* 6–8, broadly ovate, $1\text{--}2 \times 1\text{--}3$ cm, outside sericeous, inside glabrous, margin ciliolate. *Petals* ca. 14 in 3 whorls, light yellow, elliptic or obovate, $2\text{--}3 \times 1.5\text{--}2.5$ cm, inner petals basally connate for 1–1.5 cm, outside sericeous, inside glabrous. *Stamens* 1–1.5 cm long; *filaments* glabrous. *Ovary* globose or oblate, glabrous. *Styles* 5, distinct, ca. 2 cm long, basally swollen, puberulous and gradually becoming glabrous apically. *Capsule* oblate or globose, 3.5–4.5 cm in diam., 2.5–3 cm in height, 5-loculed; *pericarp* 0.5–1.5 mm thick, dorsal suture and apex of carpel thickened when mature. *Seeds* brown, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous.

Phenology: flowering August–March, fruiting August.

Distribution: endemic to Vietnam (Map 4.1).

Habitat: evergreen forests on limestone mountains, 500–850 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² (B1). It is known to exist at five locations (see type and additional specimens cited) and may have undergone an over-exploitation during the haying of golden camellias (see Section 1.7) because it has large yellow flowers (IUCN 2012).

Additional specimens examined

VIETNAM. Hoa Binh: Luong Son, Lam Son, 5 March 1984, *Binh B.907* (HN).

Thanh Hoa: Ba Thuoc, Co Lung, Eo Dieu, 20°25'56"N, 105°14'12"E, 500–850 m, 23 September 2003, *Averyanov HAL 3264* (HN), Pu Luong, 20 November 2002, *Phuong 5744* (HN); Hai Xuan, 25 August 1920, *Poillane 1783* (P04511417, K, VNM00003770).

Notes—A single gathering *Poillane 1731* was cited in the protologue of *T. pleurocarpa* (Gagnepain 1942). Only P01903367 and P04500229 have fruits but the former also has seeds so it is designated here as the lectotype (Zhao et al. 2017a). *Camellia pleurocarpa* differs from others of sect. *Archecamellia* by its basally swollen styles and its fruit with thickened dorsal suture and apex of carpel.

Keng (1972: 146) recorded the occurrence of *C. pleurocarpa* in Thailand based on a single gathering *Smitinand 4331-A* at **BKF**, which is *C. taliensis* (see species [41] in Section 4.2.11).

4.2.2 Section *Camelliopsis*

Section *Camelliopsis* (Pierre) Sealy, A Revision of the Genus *Camellia* 97. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 169–180. 1981. —**Lectotype** (designated by Zhang 1981a:

169): *C. caudata* Wallich

≡ *Thea* sect. *Camelliopsis* Pierre, Flore Forestière de la Cochinchine 2(8): supra t. 119. 1887.

≡ *Thea* sect. *Euthea* Szyszylowicz in Engler & Prantl, Die Natürlichen Pflanzenfamilien 3(6): 183. 1895, excl. *T. lanceolata* (Blume) Pierre, *T. quiscosaura* (Korthals) Pierre & *T. sinensis* Linnaeus; Kochs in Engler, Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 27(5): 579, 581–590. 1900, excl. *T. dormoyana* Pierre, *T. lanceolata*, *T. lasiostyla* Warburg, *T. lutescens* (Dyer) Pierre, *T. piquetiana* Pierre, *T. quiscosaura* & *T. sinensis*.
—**Lectotype (designated here)**: *T. caudata* (Wallich) Seemann

≡ *Camellia* sect. *Eriandria* Cohen-Stuart in Mededeelingen van het Proefstation voor Thee 40: 69. 1916 & in Bulletin du Jardin Botanique, 3rd series 1(4): 241. 1919; Hung T. Chang & B.M. Bartholomew, Camellias 199–207. 1984; Hung T. Chang in Flora Reipublicae Popularis Sinicae 49(3): 181–195. 1998; T.L. Ming in Acta Botanica Yunnanica 21(2): 154–155. 1999 & Monograph of the Genus *Camellia* 192–209. 2000; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 130–141. 2005; T.L. Ming & B.M. Bartholomew in Flora of China 12: 389–392. 2007. —**Lectotype** (designated by Zhang & Bartholomew 1984: 199): *C. caudata*

= *Camellia* sect. *Theopsis* Cohen-Stuart in Mededeelingen van het Proefstation voor Thee 40: 70. 1916, excl. *C. henryana* Cohen-Stuart, & in Bulletin du Jardin Botanique, 3rd series 1(4): 241. 1919, excl. *C. henryana*; Sealy, A Revision of the Genus *Camellia* 48–96. 1958, excl. *C. indochinensis* Merrill; Hung T. Chang, A Taxonomy of the Genus *Camellia* 128–169. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 141–181. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 157–199. 1984; T.L. Ming in Acta Botanica Yunnanica 21(2): 153–154. 1999 & Monograph of the Genus *Camellia* 152–192. 2000; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 229–270. 2005; T.L. Ming & B.M. Bartholomew in Flora of China 12: 380–389. 2007. —**Lectotype** (designated by Zhang 1981a: 128): *C. cuspidata* hortulanorum

≡ *Camelliastrum* Nakai in The Journal of Japanese Botany 16(12): 699. 1940, excl. *C. mairei* (H. Léveillé) Nakai. —**Lectotype** (see the synonymy of *Camellia* above): *C. caudatum* (Wallich) Nakai

= *Theopsis* (Cohen-Stuart) Nakai in The Journal of Japanese Botany 16(12): 704. 1940. —**Lectotype** (see the synonymy of *Camellia* above): *T. euryoides* (Lindley) Nakai

= *Camellia* subg. *Metacamellia* Hung T. Chang, A Taxonomy of the Genus *Camellia* 128. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 141–195. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 157–207. 1984. —**Type**: *C. cuspidata*

Leaf usually thinly coriaceous; flower small, generally less than 4 cm in diam.; bracteoles and sepals persistent; style 1, apically 3–5-lobed; capsule ovoid or globose, usually 1-loculed with a single globose seed.

Notes—The emendation of sect. *Camelliopsis* is discussed in Section 2.4.4(b) and its nomenclature is partly introduced in Sections 1.3.1 & 1.3.2. Compared with other *Camellia*, species of this section generally have relatively small leaves, flowers and fruits. The capsule is usually 1-loculed with the columella being compressed into the pericarp by a single globose seed.

In horticulture, species of this section are usually used as a robust stock for grafting other camellias, such as cultivars of *C. japonica*.

[10] *Camellia caudata* Wallich, *Plantae Asiaticae Rariores* 3: 36. 1832; Griffith in *Transactions of the Agricultural and Horticultural Society of India* 4: t. A. 1838, *Itinerary Notes of Plants Collected in the Khasyah and Bootan Mountains 1837–38, in Affghanistan and Neighbouring Countries 1839–1841* 40. 1848, *Notulae ad Plantas Asiaticas* 4: 559. 1854 & *Icones Plantarum Asiaticarum* 4: t. 601, fig. 2. 1854; Choisy in *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève* 14(1): 148. 1855; Dyer in Hooker f., *Flora of British India* 1: 293. 1874; Kurz in *Journal of the Asiatic Society of Bengal* 43(2): 94. 1874 & *Forest Flora of British Burma* 1: 108. 1877; Hance in *Journal of Botany, British and Foreign* 21(250): 296. 1883; Brandis, *Indian Trees* 61. 1906; Dunn & Tutchter, *Flora of Kwangtung and Hongkong (China)* (in *Bulletin of Miscellaneous Information, Additional Series* 10) 45–46. 1912; Cohen-Stuart in *Mededeelingen van het Proefstation voor Thee* 40: 70. 1916 & in *Bulletin du Jardin Botanique*, 3rd series 1(4): 242. 1919; Kanjilal et al., *Flora of Assam* 1(1): 122. 1934; Kanehira, *Formosan Trees Indigenous to the Island* (revised) 467, fig. 414. 1936; H. Keng in *Taiwania* 1: 224, 233–234. 1950; Sealy, A *Revision of the Genus Camellia* 98, 103–106, fig. 49 & 50. 1958, excl. syn. *Camellia buisanensis* Sasaki, *Thea buisanensis* (Sasaki) F.P. Metcalf & *Camelliastrum buisanense* (Sasaki) Nakai; Banerji, *Contributions to the Flora of East Nepal* (in *Records of the Botanical Survey of India* 19[2]) 27. 1965; Hung T. Chang, A *Taxonomy of the Genus Camellia* 177–178, t. 31, fig. 4–6. 1981, excl. syn. *Camellia buisanensis* Sasaki, in F.H. Chen, *Flora of Guangdong* 2: 143. 1991, excl. syn. *Camellia buisanensis* Sasaki & in *Flora Reipublicae Popularis Sinicae* 49(3): 192–193, t. 53, fig. 4–6. 1998, excl. syn. *Camellia buisanensis* Sasaki & *Camelliastrum buisanense* (Sasaki) Nakai; Hung T. Chang & B.M. Bartholomew, *Camellias* 200, 204. 1984, excl. syn. *Camellia buisanensis* Sasaki, *Thea buisanensis* (Sasaki) F.P. Metcalf & *Camelliastrum buisanense* (Sasaki) Nakai; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 536, fig. 1479. 1991; T.L. Ming in *Flora Yunnanica* 8: 265, 278–279. 1997, in *Acta Botanica Yunnanica* 21(2): 154. 1999 & *Monograph of the Genus Camellia* 193, 200–203. 2000, excl. syn. *Camellia buisanensis* Sasaki, *Camelliastrum buisanense* (Sasaki) Nakai, *Camellia membranacea* Hung T. Chang, *Camellia parvilapidea* Hung T. Chang & *Camellia percuspidata* Hung T. Chang; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 344. 2003; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 133. 2005, excl. photo; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 389, 391. 2007, excl. syn. *Camellia membranacea* Hung T. Chang, *Camellia parvilapidea* Hung T. Chang & *Camellia percuspidata* Hung T. Chang; D. Wei Zhao et al. in *Phytotaxa* 292(2): 172. 2017. —**Lectotype**

(designated by Zhao et al. 2017a: 172): INDIA, Meghalaya, Khasia Hills, ‘the district of Sylhet’, November 1827, *H. Bruce s.n.* in *Wallich 978* (right-hand specimen of **K001110475!**). Syntypes: INDIA, *Wallich 978* (**A00024746†**, **G00354806†**, **P04500104!**, **P04500138!**); Meghalaya, Khasia Hills, ‘Pundua’, *Wallich 978* (**BM!**, **E00273841!**, left-hand specimen of **E00273843!**, **G00354841†**, **G00354852†**, **GZU000280824†**, **K000380533!**, **K000380534!**, left-hand specimen of **K001110475!**, **L.2399754†**, **P04500117!**, **S 09-47084†**, **TCD!**); ‘Sylhet mountain’, *Wallich 978* (left-hand specimen of **K001110474!**).

= *Camellia assimilis* Champion in Hooker’s *Journal of Botany and Kew Garden Miscellany* 3: 309. 1851 & in *Transactions of the Linnean Society of London* 21(2): 112. 1853; Choisy in *Mémoires de la Société de Physique et d’Histoire Naturelle de Genève* 14(1): 148. 1855; Seemann, *The Botany of the Voyage of H.M.S. Herald* 367, t. 77. 1857; Benthams, *Flora Hongkongensis* 30. 1861; Dunn & Tutchers, *Flora of Kwangtung and Hongkong (China)* (in *Bulletin of Miscellaneous Information, Additional Series* 10) 45, 46. 1912; Cohen-Stuart, *Mededeelingen van het Proefstation voor Thee* 40: 66, 69, 70. 1916 & in *Bulletin du Jardin Botanique*, 3rd series 1(4): 242. 1919; Sealy, *A Revision of the Genus Camellia* 98, 106–107, fig. 51. 1958; Hung T. Chang, *A Taxonomy of the Genus Camellia* 170, 178. 1981 & in *Flora Reipublicae Popularis Sinicae* 49(3): 183, 193–194. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 200, 204. 1984. P.H. Hô, *Cây cỏ Việt Nam* 1(1): 536, fig. 1478. 1991; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 344. 2003. —**Lectotype** (designated by Zhang & Bartholomew 1984: 205): CHINA, Hong Kong, *Champion 65* (**K000380537!**). Syntype: CHINA, Hong Kong, *Champion s.n.* (**K000380536!**).

≡ *Thea caudata* (Wallich) Seemann in *Transactions of the Linnean Society of London* 22: 348. 1859; Pierre, *Flore Forestière de la Cochinchine* 2(8): supra t. 119. 1887; Szyszylowicz in Engler & Prantl, *Die Natürlichen Pflanzenfamilien* 3(6): 183. 1895; Kochs in Engler, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 27(5): 583. 1900; Hayata, *Flora Montana Formosae* 63–64. 1908 & *Icones Plantarum Formosanarum* 1: 89–90. 1911; Gagnepain in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 304, 313–314. 1943.

= *Thea assimilis* (Champion) Seemann in *Transactions of the Linnean Society of London* 22: 349. 1859; Pierre, *Flore Forestière de la Cochinchine* 2(8): supra t. 119. 1887; Szyszylowicz in Engler, *Die Natürlichen Pflanzenfamilien* 3(6): 183. 1895; Kochs in Engler, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 27(5): 584. 1900; Gagnepain in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 303, 307. 1943.

= *Camellia gracilis* Hemsley in *Annals of Botany* 9(33): 146. 1895; A. Henry, *A List of Plants from Formosa* (in *Transactions of the Asiatic Society of Japan* 24: supplement) 20. 1896; Matsumura & Hayata, *Enumeratio Plantarum in Insula Formosa...* 50. 1896; Cohen-Stuart, *Mededeelingen van het Proefstation voor Thee* 40: 70. 1916 & in *Bulletin du Jardin Botanique*, 3rd series 1(4): 242. 1919, Kanehira, *Formosan Trees Indigenous to the Island* (revised) 456–457. 1936. —**Holotype**: CHINA, Taiwan, ‘Bankinsing mountains’, *Henry 1612* (**K000380535!**).

Isotype: NY00353776[†].

= *Thea gracilis* (Hemsley) Hayata, Materials for a Flora of Formosa 45. 1911 & Icones Plantarum Formosanarum 1: 90. 1911.

= *Camelliastrum assimile* (Champion) Nakai in The Journal of Japanese Botany 16(12): 700. 1940.

≡ *Camelliastum caudatum* (Wallich) Nakai in The Journal of Japanese Botany 16(12): 701. 1940.

= *Camelliastrum gracile* (Hemsley) Nakai in The Journal of Japanese Botany 16(12): 701. 1940.

= *Camellia caudata* Wallich var. *gracilis* (Hemsley) Yamamoto ex H. Keng Taiwania 1: 234.

1950; T.L. Ming in Acta Botanica Yunnanica 21(2): 155. 1999 & Monograph of the Genus *Camellia* 203–204. 2000, excl. syn. *Camellia subglabra* Hung T. Chang & *Camellia edentata* Hung T. Chang.

= *Theopsis caudata* (Wallich) Hu in Acta Phytotaxonomica Sinica 8(3): 266. 1963.

= *Camellia triantha* Hung T. Chang, A Taxonomy of the Genus *Camellia* 144. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 159. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 172. 1984. —**Holotype**: CHINA, Guangxi, Yongning, 20 October 1963, *Huang* 17625

(SYS00094835!). Isotype: IBSC0003575!, GXMI050183!, GXMI050184! & GXMI050185!.

= *Camellia tubiformis* Hung T. Chang & S.X. Ren in Acta Scientiarum Naturalium Universitatis Sunyatseni 31(1): 75. 1992. —**Holotype**: CHINA, Guangdong, Fengkai, Heishiding, 580 m, 1 January 1991, *Jiang s.n.* (SYS00094839!)

Trees or shrubs up to 15 m tall. *New branchlets* and *terminal buds* pubescent. *Petioles* 1–5 mm long, pubescent; *leaf blades* elliptic, oblong or lanceolate, 3.5–11.5 × 1.5–3 cm, thinly coriaceous or papery, abaxially pale green, sparsely appressed pubescent or villous, adaxially yellowish or dark green, shiny, hirsute along midrib, midrib abaxially elevated and adaxially slightly impressed, secondary veins 8–12 on each side of midrib, abaxially slightly elevated and adaxially obscure, base attenuate to obtuse, margin serrulate, apex caudate. *Flowers* solitary or up to 3 in a cluster, 2–4 cm in diam. *Pedicel* 2.5–7 mm long. *Bracteoles* 3–6, alternate, deltate to semi-orbicular, 1–2.5 × 1–3 mm, outside sparsely pubescent to pubescent, inside glabrous, margin ciliolate. *Sepals* 5, sub-orbicular, 2–3 × 2–4 mm, outside pubescent, inside glabrous. *Petals* 5–7 in 1–2 whorls, white, elliptic to obovate, 11–20 × 8–14 mm, outside pubescent, inside glabrous, apex rounded to emarginate, inner 4–5 petals basally adnate to filament whorl for 2–4 mm. *Stamens* 1–1.5 cm long; *filaments* white, outer filaments basally connate for 6–10 mm, distinct part villous. *Ovary* globose to ovoid, densely pubescent. *Style* 8–18 mm long, basally densely pubescent and gradually becoming sparsely pubescent apically, apically 3-lobed for 1–3 mm. *Capsule* globose to ovoid, 11–15 mm in diam., 1-loculed with 1 seed; *pericarp* 0.4–1 mm thick. *Seeds* fuscous, globose, 1–1.5 cm in diam., glabrous. Figure 4.4.

Phenology: flowering October–December, fruiting March–December.

Distribution: China, India, Laos, Myanmar, Nepal, Thailand and Vietnam (Map 4.4).

Habitat: semi-evergreen, evergreen and deciduous montane forests, 500–2000 m.

Conservation status: least concern (LC). This species is widespread and abundant in subtropical and tropical Asia (IUCN 2012).

Additional specimens examined

LAOS. Khammouan: Kaeng Maew landing on Nakai Nam Theun, 17°45'47"N, 105°20'22"E, 538 m, 4 November 2005, *Newman et al. LAO 842* (**BKFSN180005**, **CMUB**, **E00226006**), *LAO 843* (**BKFSN183122**, **NUOL0003017**, **P05286336**); Northeastern slopes of Phou Yang, 17°48'29"N, 105°32'59"E, 1118 m, 24 October 2005, *Newman et al. LAO 1013* (**BKFSN181079**, **NUOL0003019**, **P05233079**).

MYANMAR. Kachin: Putao, Naungmung, 27°41'14"N, 97°53'25"E, 1363 m, 7 November 2015, *Armstrong et al. 1302* (**NY02649038**).

THAILAND. Chiang Rai: Wiang Pa Pao, Doi Luang, Doi Mok Mountain, close to source of Man Mae Nga Stream, 19°15'36"N, 99°20'24"E, 950 m, 23 July 1998, *Morci 1365.0* (**CMUB**).

Nan: ‘Doi Tiu’, 1100 m, 8 March 1921, *Kerr 5041* (**BK203924**, **BM**, **K**, **L.2399739**); Tha Wang Pha, Pa Kha, Doi Wao, 1400–1700 m, 10 September 1995, *Larsen et al. 46319* (**BKF SN147973**) & 46292 (**IBSC0256482**).

Uttaradit: Phu Soi Dao, 1531 m, 17 November 2009, *Norsaengsri & Intamusik 6104* (**QBG 42621**), 1570 m, 18 November 2009, *Norsaengsri & Intamusik 6202* (**QBG 42737**).

VIETNAM. Bac Kan: Na Ri, Liem Thuy, Na Po, 21°57'54"N, 106°5'24"E, ca. 520 m, 20 November 2004, *Wu et al. WP 514* (**HN**).

Cao Bang: ‘Massif du Pia-ouac’, 18 February 1931, *Poilane 19109* (**IBSC0238134**, **P04500123**, **YNM00003728**); Nguyen Binh, Thanh Cong, Col de Lea, 13 December 1961, *Xuan 4917* (**VFM**); Tra Linh, 19 December 1998, *Franck 474* (**HN**).

Da Nang: ‘Col des nuages près Tourane’, 900 m, 17 September 1923, *Poilane 8056* (**P04511538**, **P04511542**).

Gia Lai: K’Bang, 18 May 1981, *LX-VN 677* (**HN**).

Hai Phong: Cat Hai, Cat Ba, 23 December 1986, *LX-VN 3365* (**HN**).

Hanoi: Ba Vi, 800–1300 m, 8 January 1965, *Sino-Vietnam Exp. 1198* (**HN**, **IBK00118049**, **IBSC0256475**, **KUN0693671**, **PE01679137**), January 1994, *Ninh 9417* (**HN**).

Hoa Binh: ‘Massif de Núi Biêu près Chobo’, 900–1000 m, 2 September 1926, *Poilane 13112* (**P04500125**, **SING0204884**); Mai Chau, Pa Co, 18 December 1999, *Phuong 2359* (**HN**).

Kon Tum: ‘Massif du Ngok Pau’, 2000 m, 9 December 1946, *Poilane 35751* (**P05156312**,

P05156314), 10 December 1946, *Poilane* 35771 (**P05156326**); Dak Glei, 2 February 1947, *Poilane* 32960 (**P05156327**); ‘about 15–18 km to NW of Dak Gley town, between Mang Khen (Dak Che) and Dak Polo villages, near Laos boundary’, 1250–1450 m, 22 November 1995, *Averyanov et al.* *VH* 1893 (**HN**); Kon Plong, Mang Canh, 23 November 1978, *Dung* 356 (**HN**).

Lang Son: Huu Lung, Huu Lien, 22 October 2000, *Phuong* 3812 (**HN**).

Nghe An: Con Cuong, Pu Mat, *Ninh s.n.* (**HNU**).

Quang Ninh: ‘Taai Wong Mo Shan and vicinity Chuk-phai, Ha-coi’, 1–9 November 1936, *Tsang* 27158 (**C**, **E00681066**, **IBSC0238140**, **K**, **P04500127**); 18 November–2 December 1936, *Tsang* 27314 (**C**, **E00681067**, **IBSC0238141**, **K**).

Quang Tri: ‘Massif de Dong-tri’, 16 June 1924, *Poilane* 11016 (**IBK00118027**, **IBSC0238135**, **P04500337**, **P04500338**, **VNM00003710**), 10 March 1936, *Poilane* 25318 (**IBK00118028**, **IBSC0238133**, **PE01513909**); Vinh Linh, Dong Chau, 600 m, 4 August 1924, *Poilane* 11247 (**P04500214**, **P04500217**).

Son La: Moc Chau, Xuan Nha, November 2003, *Phuong* 7212 (**HN**).

Thanh Hoa: Ba Thuoc, Thanh Son, 20°28'37"N, 105°5'20"E, 1600–1650 m, 7 October 2003, *Averyanov HAL* 4068 (**HN**), 20°28'30"N, 105°5'16"E, 1500–1550 m, 10 October 2003, *Averyanov HAL* 4230 (**HN**).

Thua Thien Hue: ‘Nui Bach-ma, près Hué’, 8 September 1938, *Poilane* 27659 (**IBSC0238132**, **P04500150**, **VNM00003729**), 1200–1500 m, 18 September 1940, *Poilane* 31213 (**P04500144**, **PE01678925**, **SING0204885**).

Vinh Phuc: Phuc Yen, Ngoc Thanh, 14 January 2001, *Phuong* 4122 (**HN**); Tam Dao, 800–1100 m, *Ninh TN* 9815 (**HNU**), 1000 m, November 1930, *Pételot s.n.* (**P04511769**), 1100 m, 3 June 1986, *Ninh* 3110 (**HNU**), 21°27'28"N, 105°38'41"E, 1100 m, 31 October 2004, *Li et al.* 583 (**HN**, **PE01513665**), 1000m, 31 October 2004, *Li et al.* 602 (**HN**, **PE01513666**), 21°27'40"N, 105°38'59"E, 1095 m, 18 November 2015, *Zhao et al.* 106(1) (**TCD**).

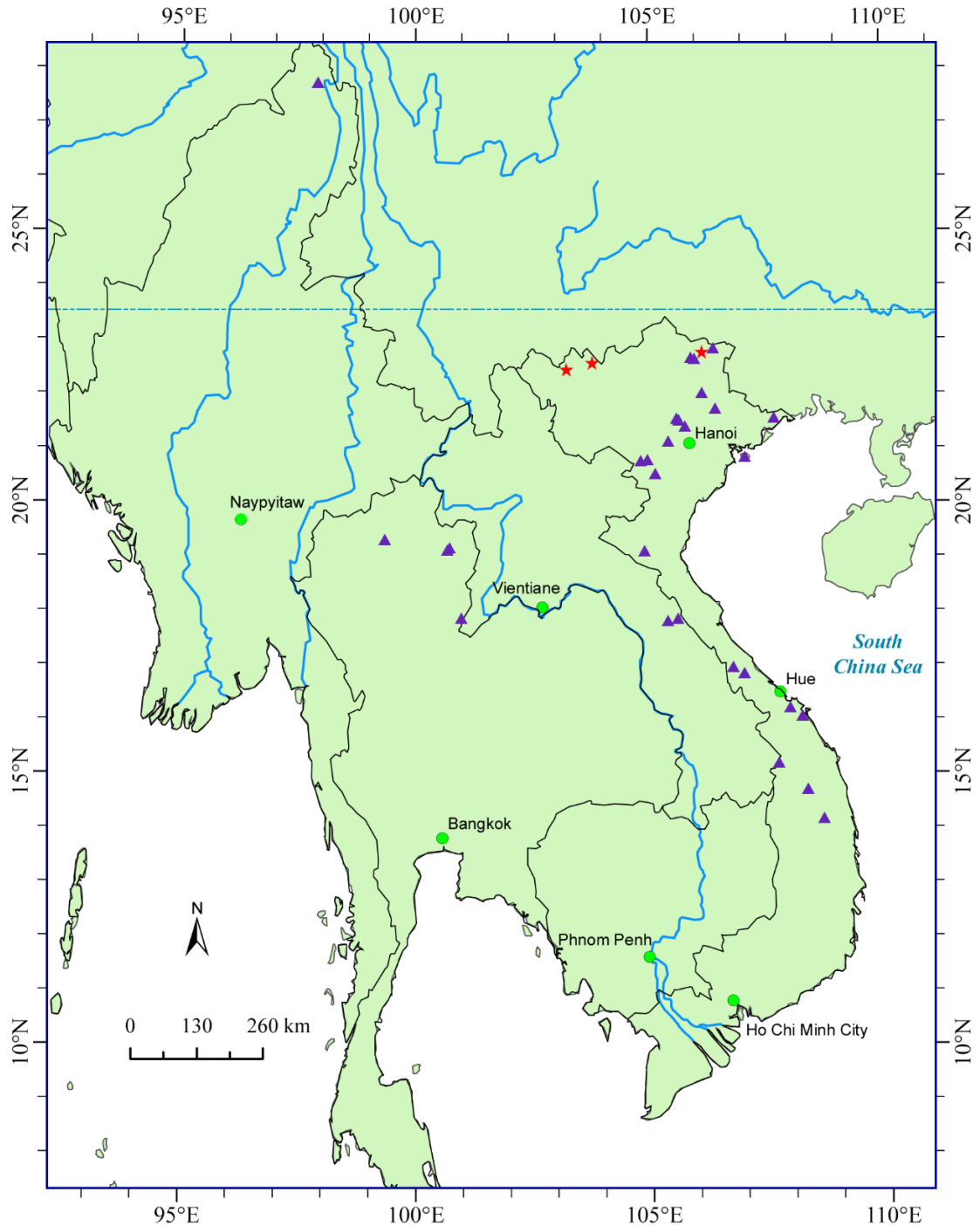
Notes—*Camellia caudata* was published by Wallich (1829) without a description or a diagnosis or a reference to a former one (and thus is a nom. nud.), and according to Art. 38.1 it was not validly published. The name was validated later by Wallich (1832) providing a Latin description (Zhang & Bartholomew 1984, Min & Bartholomew 2007, Zhao et al. 2017a).

Wallich (1832) cited in the protologue ‘Cat. Herbar. Ampl. Procur. Britan. Ind. Orient. n. 978’ and stated that *C. caudata* was native to ‘the mountains bordering on the district of Sillet’. Clark thought that the locality recorded by Wallich indicated ‘Khasia’ of India (Anonymous 1913) and Sealy (1958) followed this deduction. Another frequently recorded locality for the syntypes of *C. caudata* is Pundua, which is indicated as ‘Pundua ~ Bangladesh’ on The Wallich Catalogue website (<http://wallich.rbge.info/node/11472>). Moreover, an anonymous article on the Royal

Botanic Garden Edinburgh website (<http://stories.rbge.org.uk/archives/5029>) has a comment ‘...Pundua could be modern day Companiganj, or close to it, and not to be confused with Pandua in W Bengal’. However, the current Companiganj in Bangladesh is an alluvial plain and its elevation is generally below 50 m. *Camellia caudata* is usually distributed in the montane evergreen forest between 200 m and 2200 m (Min 2000) and it is therefore unlikely to occur in the low alluvial plain in Companiganj. Clark further commented that ‘...all the collections marked “Pundua” came (certainly to me) from Khasia—no collector at Pundua would attempt collecting southward thence in the swamps...’ (Anonymous 1913). Therefore, Clark’s deduction of the locality (Anonymous 1913) is followed here (Zhao et al. 2017a).



Figure 4.4. *Camellia caudata*. A: canopy of a tree; B: branch; C: flower; D: petals and androecia; E: a dissected flower; F: gynoecium and pedicel. The white bars represent 5 cm, 1 cm, 1 cm and 5 mm in B, C, E and F, respectively. The minimum graduation of the ruler in D indicates 1 mm.



Map 4.4. Distribution of *Camellia caudata* (purple triangle) and *C. tsaii* (red star) in Indochina.

The lectotype (specimen on the right side of K001110475) of *C. caudata* has mature flowers. Wallich 978 is a set of heterogeneous collections that were collected by different collectors at different times, so the other specimens of Wallich 978, excluding the lectotype, are not treated as isolectotypes but recognised as syntypes (Arts. 8.2, 8.3 & 9.5, Zhao et al. 2017a).

In the protologue of *C. triantha*, Zhang (1981a: 146) stated that the filaments, styles and ovaries of this species were glabrous and cited only the holotype at **SYS**. The holotype of *C. triantha* at **SYS** consists of a single leaf and two dissected flower buds upon which Zhang's (1981a: 146, 1998:

159) description was generally based. However, two isotypes of *C. triantha* (**GXMI050183** & **GXMI050184**) with mature flowers clearly show that the filaments, styles and ovaries of this species are not glabrous but hairy. Therefore, I agree with Min's (2000: 201) view and treat *C. triantha* as a synonym of *C. caudata*.

Camellia caudata differs from *C. tsingpiensis* by its sepals and petals that are pubescent on the outside and its pubescent ovary and style, whereas those of the latter are glabrous.

[11] *Camellia tsaii* Hu in Bulletin of the Fan Memorial Institute of Biology, Botany Series 8(3): 132. 1938; Sealy, A Revision of the Genus *Camellia* 51, 75–76, fig. 30. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 130, 148. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 143, 160. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 175, t. 59, fig. 1–7. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 536, fig. 1477. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 154. 1999 & Monograph of the Genus *Camellia* 154, 174–175, t. 27, fig. 5–9. 2000, excl. syn.

Camellia crassipetala Hung T. Chang, *Camellia callidonta* Hung T. Chang; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 350. 2003; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 381, 385. 2007. — **Lectotype (designated here)**: CHINA, Yunnan, Dehong, Luxi, 1750 m, 9 February 1933, *Tsai* 56865 (**PE00024349!**). Isolectotype: **A00024738†**, **IBSC0003579!**, **K000704294!**, **P01903510!**, **PE00024348!**. Paratypes: CHINA, Yunnan, Dehong, Luxi, Mengka, 1750 m, 1 March 1934, *Tsai* 56363 (**KUN1206069!**, **KUN1206093!**, **PE00716200!**).

= *Thea fusiger* Gagnepain in *Notulae Systematicae* 10(3): 126. 1942, excl. *Poilane* 12649; Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 304, 318. 1943. — **Lectotype** (first-step designated by Sealy 1958: 75): VIETNAM, Cao Bang, 'massif de Pia-ouac', 16 February 1931, *Poilane* 19040 (**P!**, two sheets, **second-step lectotype designated here: P01903512!**). Isolectotypes: **P01903511!**, **IBSC0238907!**.

≡ *Thea tsaii* (Hu) Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 316. 1943.

Trees or shrubs 1.5–8 m tall. *New branchlets* and *terminal buds* pubescent. *Petioles* 2–5 mm long, pubescent; *leaf blades* elliptic, oblong or lanceolate, 3–10 × 1.5–3 cm, thinly coriaceous or papery, abaxially pale green, sparsely appressed pubescent or glabrous, adaxially yellowish or dark green, shiny, hirsute along midrib, midrib abaxially elevated and adaxially slightly impressed, secondary veins 9–12 on each side of midrib, abaxially slightly elevated and adaxially obscure, base attenuate, cuneate or obtuse, margin serrulate, apex caudate or attenuate. *Flowers* solitary or up to 3 in a cluster, 1.5–3 cm in diam. *Pedicels* 1.5–4 mm long. *Bracteoles* 3–5, alternate, deltate to ovate, 1–2 × 1–2.5 mm, outside sparsely pubescent to pubescent, inside glabrous, margin ciliolate. *Sepals* 5, sub-orbicular or broadly ovate, 2–3 × 2–4 mm, basally connate for ca. 1 mm, outside pubescent or pubescent at apex, inside sparsely sericeous at apex or glabrous, margin ciliolate. *Petals* 5–7 in 1–2 whorls, white, obovate or elliptic, 7–20 × 6–10 mm, outside pubescent at apex, inside glabrous,

inner petals basally adnate to filaments for 2–3 mm. *Stamens* 1–1.5 cm long; outer filaments basally connate for 2–5 mm, glabrous. *Ovary* ovoid or globose, glabrous. *Style* 1–1.5 cm long, glabrous, apically 3-lobed for 1–2.5 mm. *Capsule* ovoid or globose, 10–13 mm in diam., 1-loculed with 1 seed; *pericarp* 0.5–1 mm thick. *Seeds* fuscous, globose, ca. 1 cm in diam., glabrous.

Phenology: flowering December–April, fruiting May–October.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.4).

Habitat: evergreen forest, 1600–1800 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

VIETNAM. Cao Bang: ‘massif de Pia-ouac’, 16 February 1931, *Poilane* 19031 (**K**), 18 February 1931, *Poilane* 19092 (**K**, P04511539).

Lai Chau: ‘san-lau-ngai’, 1600 m, 9 April 1936, *Poilane* 25653 (P04511355, P04511408, VNM00003822).

Lao Cai: ‘Yao san nord de Phoug Tho’, 1800 m, 10 December 1937, *Poilane* 26861 (P04511354, P04511356, VNM00003823, VNM00003824).

Notes—One syntype of *T. fusiger*, *Poilane* 12649, has no flower or fruit and may be *Eurya* sp. Therefore, it is excluded from *T. fusiger*. **P01903512** has Gagnepain’s drawing so it is designated here as the lectotype of *T. fusiger*. *Camellia tsaii* differs from *C. caudata* by its glabrous filaments, ovary and style whereas those of the latter are hairy.

[12] *Camellia tsingpienensis* Hu in Bulletin of the Fan Memorial Institute of Biology, Botany Series 8(3): 129. 1938; Sealy, A Revision of the Genus *Camellia* 50, 94–96, fig. 44. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 163. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 145, 176, t. 48, fig. 1–5. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 192. 1984; T.L. Ming in Flora Yunnanica 8: 265, 288, t. 73, fig. 7–10. 1997 & in Acta Botanica Yunnanica 21(2): 154. 1999 & Monograph of the Genus *Camellia* 186, 188, t. 36: fig. 1–3. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 350. 2003; T.L. Ming & B.M. Bartholomew in Flora of China 12: 381, 388. 2007. —**Lectotype** (first-step designated by Zhang 1981a: 163, second-step designated by Zhang & Bartholomew 1984: 192): CHINA, Yunnan, Jinping, 1800 m, 29 December 1932, *Tsai* 52519 (PE00024350!). Isolectotypes: A00024739†, IBSC0003851!. Syntypes: CHINA, Yunnan, Jinping, 1600 m, 27 December 1932, *Tsai* 52503 (PE00024351!, KUN1206074!).

Trees or shrubs 3–8 m tall. *New branchlets* with spreading villous hairs, hairs 1.5–3 mm long; *terminal buds* glabrous. *Petiole* 2–4 mm long, pubescent; *leaf blades* elliptic or oblong, 3–9 × 1.5–3 cm, thinly coriaceous or papery, abaxially yellowish green, sparsely spreading villous hairs along midrib, adaxially dark green, shiny, hirsute along midrib, midrib abaxially slightly elevated and

adaxially slightly impressed, secondary veins 9–12 on each side of midrib, obscure on both surfaces, base obtuse, rounded or cuneate, margin serrulate, apex caudate or attenuate. *Flowers* solitary or up to 3 in a cluster, 1.5–2.5 cm in diam. *Pedicel* 1.5–3 mm long. *Bracteoles* 6, alternate, deltate to broadly ovate, 1–1.5 × 1–2 mm, both surfaces glabrous, margin ciliolate. *Sepals* 5, broadly ovate, 2–3 × 2–4 mm, basally connate for ca. 1 mm, outside glabrous, inside sericeous, margin ciliolate. *Petals* 5–7 in 1–2 whorls, white, elliptic or obovate, 11–17 × 6–10 mm, outside glabrous, inside sparsely sericeous at apex or glabrous, inner petals basally adnate to filament whorl for 2–5 mm. *Stamens* 7–16 mm long; *filaments* white, basally connate for 2–10 mm, distinct part villous. *Ovary* ovoid or globose, glabrous. *Style* 1.5–2 cm long, glabrous, apically 3-lobed for 2–3 mm. *Capsule* ovoid or globose, 1–1.5 mm in diam., 1-loculed with 1 seed; *pericarp* ca. 0.5 mm thick. *Seeds* fuscous, globose, ca. 1 cm in diam., glabrous.

Phenology: flowering September–December, fruiting May–December.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.5).

Habitat: evergreen forest, 1450–1800 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

VIETNAM. ‘Tonkin, Kilo 14 route de Ta Phinh près Chapa’, 1450 m, 3 August 1926, *Poilane* 12806 (**P04511547**, **P04500202**).

Lao Cai: ‘col de Lo-qui-ho’, 3 December 1929, *Poilane* 17162 (**K**, **P04511406**, **VNM00003711**); Sa Pa, September 1931, *Pételot* 4312 (**P04500339**, **P06614750**, **P06614751**).

Notes—Hu (1938: 129) cited *Tsai* 52503 & 52519 in the protologue of *C. tsingpiensis* but failed to indicate which collection was the type so both were syntypes (Art. 9.5). Zhang (1981a: 163) designated the single gathering *Tsai* 52519 as the lectotype when he wrote ‘蔡希陶 52503, 52519 (模式)’ (it can be translated as ‘*H.T. Tsai* 52503, 52519 [Type]’). Later, Zhang & Bartholomew (1984: 192) further indicated *Tsai* 52519 as ‘lectotype in PE here designated’. There is only one sheet of *Tsai* 52519 conserved at **PE** (**PE00024350**) so the lectotypification of *C. tsingpiensis* had been completed. However, Lin et al. (2008: 1697) seemed to neglect this information and repeatedly lectotypified *C. tsingpiensis*.

[13] *Camellia tsingpiensis* var. *pubisepala* Hung T. Chang, A Taxonomy of the Genus *Camellia* 163. 1981 & in *Flora Reipublicae Popularis Sinicae* 49(3): 145, 177. 1998; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 388. 2007. —**Holotype:** CHINA, Guangxi, Baise, Napo, Delong, 25 October 1935, *Gao* 55961 (**IBSC0003582!**). Isotype: **A00024741†**, **SYS00094841!**.

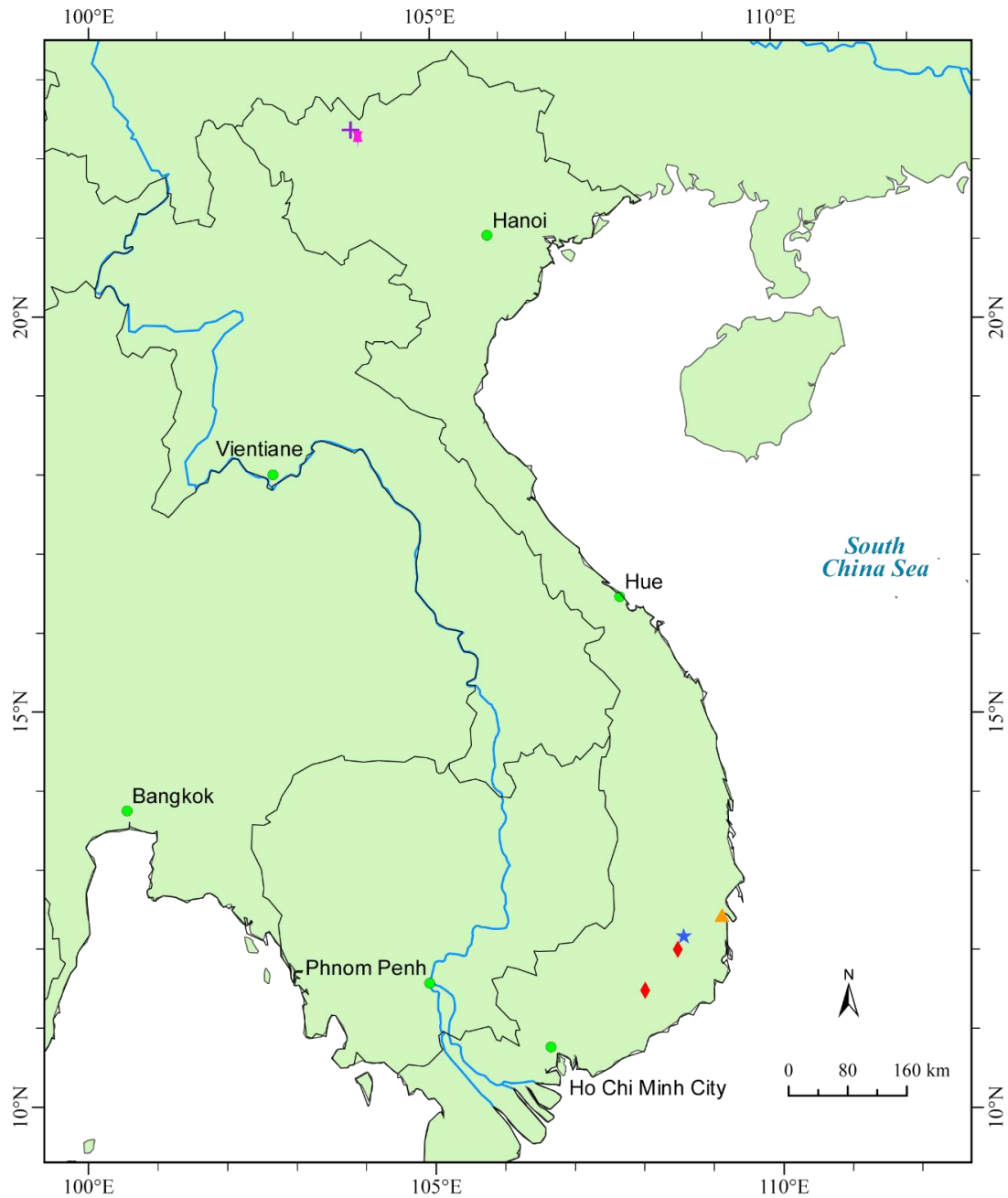
New branchlets and *terminal buds* pubescent. *Leaf blade* elliptic or ovate-oblong, 4–8.5 × 1.5–2.5 cm. *Bracteoles*, *sepals* and *petals* outside pubescent.

Phenology: flowering October–January, fruiting March.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.5).

Habitat: evergreen forest, 2000–2600 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).



Map 4.5. Distribution of *Camellia inusitata* (blue star), *C. nematodea* (orange triangle), *C. nervosa* (red diamond), *C. tsingpiensis* (purple cross) and *C. tsingpiensis* var. *pubisepala* (pink pushpin) in Indochina.

Additional specimens examined

VIETNAM. 20 March 1972, *Moi 99 (HN)*.

Lao Cai: ‘col de Loquiho’, 2000 m, 16 November 1929, *Poilane 17003* (**P04500329**); Sa Pa, 2600 m, 22 October 1976, *Nhan 20* (**HN**), 3 January 2002, *TV 270* (**HN**).

Notes—This variety differs from *C. tsingpiensis* mainly by its bracteoles, sepals and petals that are pubescent on the outer surface whereas those of the latter are glabrous.

4.2.3 Section *Corallina*

Section *Corallina* Sealy, A Revision of the Genus *Camellia* 132. 1958, excl. *C. amplexifolia* Merrill & Chun, *C. gilbertii* (A. Chevalier) Sealy, *Camellia* sp. (quoad *Poilane 13743*) & *C. parviflora* Sealy; Hung T. Chang, A Taxonomy of the Genus *Camellia* 86. 1981, quoad *C. corallina* (Gagnepain) Sealy; Hung T. Chang & B.M. Bartholomew, *Camellias* 112. 1984, quoad *C. corallina*; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 153. 1999, excl. *C. amplexifolia*, *C. pilosperma* S.Y. Liang, *C. gilbertii*, *C. parviflora* & *C. xanthochroma* K.M. Feng & L.S. Xie, & Monograph of the Genus *Camellia* 141–152. 2000, excl. *C. amplexifolia*, *C. pilosperma*, *C. gilbertii*, *C. parviflora* & *C. xanthochroma* —**Type:** *C. corallina* (Gagnepain) Sealy

= *Camellia* sect. *Yersinia* Orel ex Orel & Curry, In Pursuit of Hidden *Camellias* 166. 2015. **Syn. nov.** —**Type:** *C. harlandii* Orel & Curry

Bracteoles absent or 1–3; petals white; styles 2–4, distinct; capsule globose or ovoid, usually 1-loculed with a single seed; seed glabrous; hilum large.

Notes—This section is morphologically like sect. *Camelliopsis* because both have a 1-loculed capsule with a single glabrous globose seed but differs from the latter by its distinct styles and seed with a large hilum, whereas sect. *Camelliopsis* has a single style with a usually 3-lobed apex and a seed with a small hilum.

[14] *Camellia corallina* (Gagnepain) Sealy, A Revision of the Genus *Camellia* 132, fig. 60. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 87. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 112. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 531, fig. 1464. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 153. 1999 & Monograph of the Genus *Camellia* 141, 145–147, t. 24, fig. 1–3. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 344. 2003.

≡ *Thea corallina* Gagnepain in *Notulae Systematicae* 10(3): 126. 1942 & in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 303, 308–309, t. 29, fig. 7–9. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 174. 2017. —**Lectotype** (first-step designated by Ming 2000: 147): VIETNAM, Da Nang, Ba Na, ‘près de Tourane’, 1000–1100 m, 28 February 1939, *Poilane 29135* (**P!**, two sheets; second-step lectotype designated by Zhao et al. [2017: 174]: **P04511818!**). Isolectotypes: **K!**, **K000380544!**, **KUN1205985!**, **P01903407!**, **VNM000003765!**, **VNM000003766!**). Syntypes: VIETNAM, Da Nang, Ba Na, ‘près de Tourane’, 1200–1500 m, 1 March 1939, *Poilane 29165* (**A00025096†**, **P04511817!**, **P04511819!**); Thua Thien Hue, ‘Núi Bach Ma Station d’altitude près de Hué’, 500–1000 m, 22 April 1939, *Poilane 29920* (**A00025095†**, **K000380543!**, **P01903406!**,

P04511816!, VNM00003767!, VNM00003768!).

Shrubs or trees 6–12 m tall. *New branchlets* and *terminal buds* pubescent. *Petioles* 5–10 mm long, puberulous; *leaf blades* elliptic to oblong, 6–11 × 1.5–3 cm, coriaceous, abaxially yellowish green, puberulous, especially along midrib, adaxially yellowish or dark green, shiny, hirsute along midrib, midrib abaxially elevated and adaxially flat, secondary veins 11–15 on each side of midrib, abaxially slightly raised and adaxially slightly impressed, base attenuate or cuneate, margin sparsely serrulate, apex attenuate. *Flower buds* pendulous, silvery green with red on margins. *Flowers* solitary or up to 3 in a cluster, 1.5–2 cm in diam. *Pedicels* 5–10 mm long, puberulous. *Bracteoles* absent. *Sepals* 4–5, broadly ovate or deltate, 1–2.5 × 2–3 mm, outside puberulous, inside glabrous, margin ciliolate. *Petals* 9–11 in 2 whorls, white, obovate, ovate or broadly elliptic, 6–13 × 5–8 mm, outside pubescent, inside glabrous, basally connate for 1–2 mm, *Stamens* 5–8 mm long; *filaments* glabrous or basally puberulous, basally connate for 2–3 mm, outer filaments basally adnate to petals for 1–2 mm. *Ovary* globose or ovoid, densely pubescent. *Styles* 3–4, distinct, 5–7 mm long, basally puberulous and gradually becoming glabrous apically. *Capsule* globose, 1.5–2 cm in diam.; *pericarp* 1–4 mm thick. *Seeds* immature, glabrous.

Phenology: flowering February–March, fruiting April–May.

Distribution: endemic to central Vietnam (Map 4.6).

Habitat: evergreen forest, 400–1500 m.

Conservation status: vulnerable (VU). The extent of occurrence of this species is estimated to be less than 20000 km² (B1, Map 4.6). It is known to exist at less than 10 locations and may be influenced by deforestation (IUCN 2012).

Additional specimens examined

VIETNAM. Da Nang: Lien Chieu, Hai Van Pass, 16°11'13"N, 108°7'25"E, 663 m, 28 May 2015, *Toyama et al.* V3048 (FU).

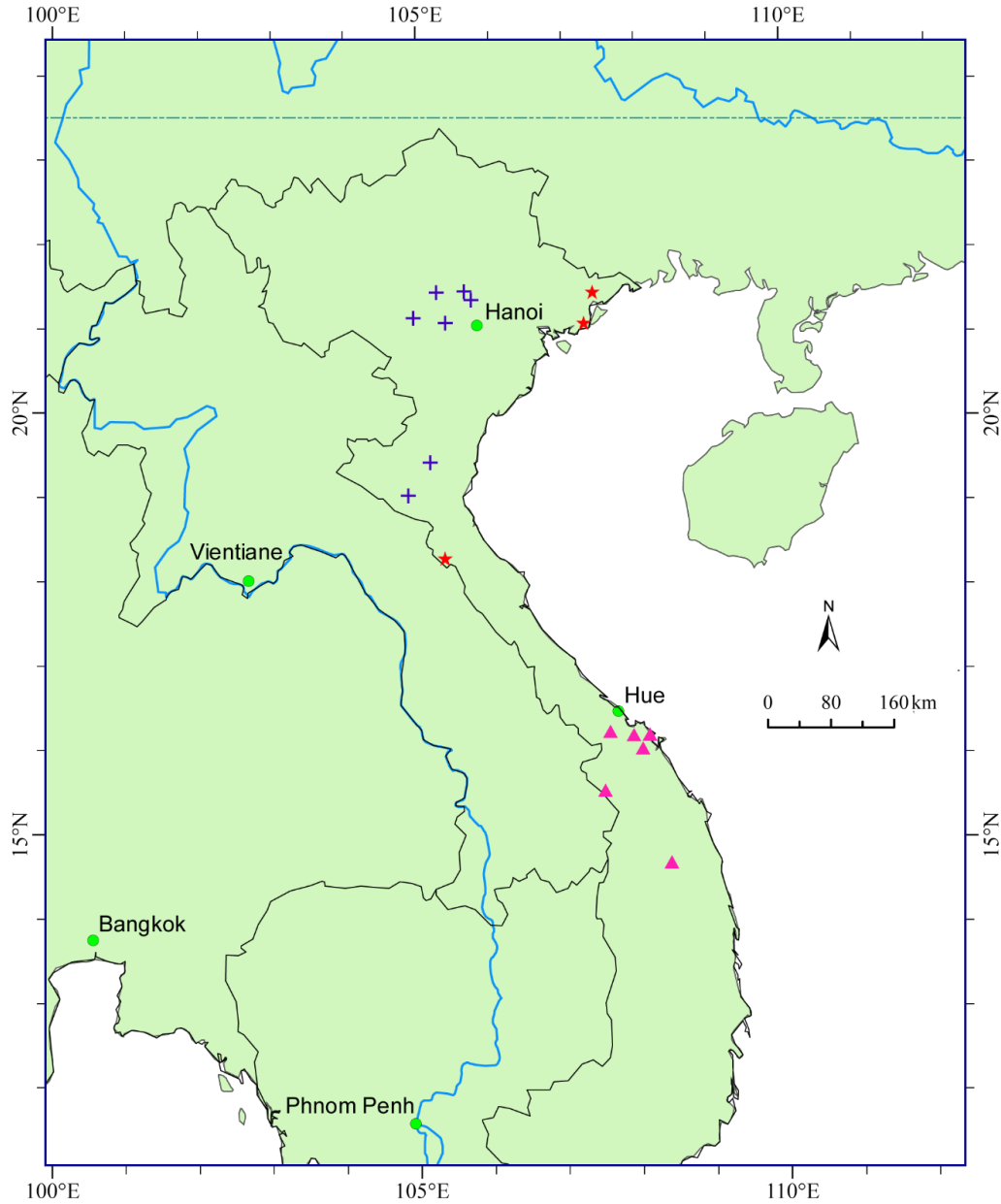
Kon Tum: Kon Plong, Hieu, Lan Trung Mang La, 14°40'17"N, 108°24'14"E, 1200–1240 m, 2 March 2000, *Harder & Loc* 4717(HN).

Quang Nam: Nam Giang, Dac Pre, 15°31'31"N, 107°31'0"E, 970 m, 13 March 2015, *Duc et al.* QN 142 (HNU, TCD).

Thua Thien Hue: Huong Thuy, Duong Hoa, 16°13'16"N, 107°35'14"E, ca. 400 m, 10 May 2005, *Averyanov et al.* HAL 8024 (HN); Phu Loc, Bach Ma, 16°13'41"N, 107°51'20"E, 502 m, 24 May 2015, *Yahara et al.* V2613 (FU).

Notes—Gagnepain (1942: 126) cited three gatherings *Poilane* 29135, 29165 & 29920 in the protologue of *T. corallina*. Min's (2000: 145) citation 'Lectotype: Vietnam, Tourane, *Poilane* 29135 (K, P)' was not an effected lectotypification because the single herbarium in which the lectotype was housed was not specified (Art. 9.22). He (Min 2000: 147) subsequently, however,

cited the specimen ‘E. Poilane...29135 (后选模式 [means lectotype], P)’ by which the lectotypification was legitimized (Art. 7.10) and, according to Art. 9.17 Ex. 12, should be treated as the first-step because there are two specimens of this gathering at **P** (**P01903407** & **P04511818**). **P04511818** bears Gagnepain’s drawing of a dissected flower and so it is designated as the second-step lectotype (Zhao et al. 2017a).



Map 4.6. Distribution of *Camellia corallina* (pink triangle), *C. gracilipes* (red star) and *C. pubicosta* (purple cross) in Indochina.

This species is characterised by its pedicellate flower with bracteoles absent on the pedicel. It differs from *C. nematodea* generally by its longer pedicel (5–10 mm long) and by having more petals (9–11) whereas the latter has a short pedicel (1.5–3.5 mm long) and fewer petals (5–6).

[15] *Camellia gracilipes* Merrill ex Sealy in Kew Bulletin 4(2): 218. 1949 & A Revision of the Genus *Camellia* 111, 130–131, fig. 59. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 124–125. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 153–154. 1984; T.L. Ming in Acta Botanica Yunnanica 21(2): 153. 1999 & Monograph of the Genus *Camellia* 136–137, 140, t. 21, fig. 1–3. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 346. 2003. —

Holotype: VIETNAM, Quang Ninh, ‘Taai Wong Mo Shan and vicinity Chuk-phai, Ha-coi’, 18 November–2 December 1936, Tsang 27275 (A00024749†). Isotypes: E00284418!,

IBSC0003497!, K000704327!, K000704328!, KUN1206011!, P04511528!, SYS00095025!.

Paratypes: VIETNAM, Quang Ninh, ‘Taai Wong Mo Shan and vicinity Chuk-phai, Ha-coi’, 23–31 October 1936, Tsang 27106 (E00681071!, IBSC0238914!, K!, SYS00095021!, SYS00095022!, SYS00095026!, SYS00095027!, SYS00095028!), 1–9 November 1936, Tsang 27151

(E00681073!, IBSC0238913!, K!, P04511530!, SYS00089824!, SYS00089826!, SYS00095023!, SYS00095024!), ‘Taai Wong Mo Shan and vicinity Tong Fa market, Ha-coi’, 11–23 September 1939, Tsang 29576 (C!, E00681072!, IBSC0238912!, K!, P04511529!, SYS00089825!).

Shrubs 2–4 m tall. *New branchlets* puberulous; *terminal buds* pubescent. *Petioles* 2–4 mm long, puberulous; *leaf blades* ligulate, oblong or lanceolate, 6–12 × 1.5–3.5 cm, coriaceous, abaxially yellowish green, puberulous, especially along midrib, adaxially dark green, shiny, glabrous, midrib abaxially elevated and adaxially slightly raised or flat, secondary veins 7–12 on each side of midrib, abaxially raised and adaxially impressed, base obtuse, margin sparsely serrulate, apex long attenuate. *Flowers* solitary or paired, borne in the axils of leaves or in the axils of bracteole, or on bracteate shoots terminated by leaf buds; bracteate shoots bearing 3–4 bracts, *bracts* caducous; flowers 1.5–2 cm in diam. *Pedicels* 15–37 mm long, puberulous. *Bracteoles* 2, alternate, ovate to ligulate, 1.5–4 × 1–1.5 mm, outside puberulous, inside glabrous, margin ciliolate. *Sepals* 5, broadly ovate, 1.5–2.5 × 2–3 mm, outside puberulous, inside glabrous, margin ciliolate. *Petals* 5–6, white, broadly ovate or elliptic, 4–12 × 5–7 mm, outside puberulous and inside glabrous, basally connate for ca. 1 mm. *Stamens* 7–11 mm long; *filaments* white, glabrous, basally adnate to petals for 0.5–1 mm. *Ovary* globose or ovoid, pubescent. *Styles* (2–)3, distinct, 5–8 mm long, basally pubescent and gradually becoming glabrous apically. *Capsule* globose, 2–2.5 cm in diam., apex apiculate; *pericarp* 1–1.5 mm thick. *Seeds* fuscous, globose, 1–2 cm in diam., glabrous and shiny.

Phenology: flowering September–February, fruiting November.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.6).

Habitat: evergreen forest, ca. 480 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

VIETNAM. Quang Ninh: ‘Khe Cham’, 29 November 1961, Ban 4767 (HN, PE01678928).

Ha Tinh: Vu Quang National Park, 18°16'21"N, 105°21'38"E, 480 m, 25 July 2015, Tagane et

al. V3721 (FU).

Notes—Sealy (1958) placed *C. gracilipes* in sect. *Thea*, a treatment with which Zhang (1981a) and Min (2000) disagreed. *Camellia gracilipes* differs from sect. *Thea* by its persistent bracteoles, distinct styles and a shiny seed with a large hilum. By contrast, species of sect. *Thea* have caducous bracteoles, a single style with a lobed apex and a smooth but not shiny seed with a small hilum (see Section 4.2.11 below). Analyses using *RPB2* data (Figures 2.3–2.9) do not support that *C. gracilipes* has a close relationship with sect. *Thea*.

Camellia gracilipes morphologically resembles *C. pubicosta* and this close relationship is supported by the *RPB2* intron 11–16 phylogenetic trees (Figures 2.3–2.5). *Camellia gracilipes* differs from the latter by its petals that are puberulous on the outside and its smaller seeds (1–2 cm in diam.) whereas *C. pubicosta* has glabrous petals and a larger seed (2–2.5 cm in diam.).

[16] *Camellia nematodea* (Gagnepain) Sealy, A Revision of the Genus *Camellia* 135, fig. 62. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 93, 96. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 117, 122. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 532, fig. 1466. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 153. 1999 & Monograph of the Genus *Camellia* 140, 147, t. 25, fig. 1–3. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 348. 2003.
 ≡ *Thea nematodea* Gagnepain in *Notulae Systematicae* 10(3): 129. 1942; Gagnepain in *Humbert, Supplément a la Flore Générale de l'Indo-Chine* 1(3): 304, 317. 1943. D. Wei Zhao et al. in *Phytotaxa* 292(2): 176. 2017. —**Lectotype** (first-step designated by Sealy 1958: 136): VIETNAM, Khanh Hoa, 'km. 25, route de Nhatrang à Ninh-hoa', 100 m, 24 October 1923, *Poilane 8371* (**P!**, three sheets; second-step lectotype designated by Zhao et al. [2017: 176]: **P01903377!**).
 Isolectotypes: **K000380545!**, **K000380546!**, **KUN1206031!**, **P01903376!**, **P05312500!**, **VNM00003802!**, **VNM00003803!**, **VNM00003804!**).

Trees, 7–8 m tall. *New branchlets* puberulous; *terminal buds* pubescent. *Petioles* 3–6 mm long, puberulous; *leaf blades* elliptic, 4–7.5 × 2–3.5 cm, thinly coriaceous, abaxially sparsely appressed puberulous and brown or black punctate, adaxially glabrous, midrib abaxially elevated and adaxially channelled, secondary veins 6–8 on each side of midrib, abaxially raised and adaxially slightly impressed, base cuneate, margin sparsely serrulate, apex attenuate or acuminate. *Flowers* solitary or paired, 2–3.5 cm in diam. *Pedicel* 1.5–3.5 mm long, puberulous or glabrous. *Bracteoles* absent or 1, ovate or deltate, 2 × 1.5 mm, outside puberulous or glabrous. *Sepals* 3–4, sub-orbicular or broadly ovate, 2–4 × 2–6 mm, outside glabrous, inside sericeous, margin membranous and ciliate. *Petals* 5–6, white, broadly ovate to obovate, 5–15 × 4–12 mm, basally connate for ca. 1 mm, glabrous on both surfaces. *Stamens* 4–7 mm long; *filaments* basally adnate to petals for 1–2 mm, glabrous. *Ovary* ovoid, glabrous. *Styles* 3, distinct, ca. 1 mm long, glabrous. *Fruit and seeds* not seen.

Phenology: flowering in October.

Distribution: endemic to southern Vietnam (Map 4.5).

Habitat: unknown, ca. 100 m.

Conservation status: critically endangered (CR). This species is known to exist at only its type location and may have influenced by deforestation in the low-elevation areas (B1, IUCN 2012).

Notes—A single gathering *Poilane 8371* was cited in the protologue of *T. nematodea* (Gagnepain 1942: 129). Sealy (1958: 136) selected a part of this single gathering conserved at **P** (**P01903376**, **P01903377** & **P05312500**) as the type, which should be considered as the first-step lectotypification (Art. 9.17 Ex. 12). It is further narrowed to **P01903377** as the second-step lectotype because this sheet bears Gagnepain's drawing (Zhao et al. 2017a).

This species differs from *C. laotica* by its shorter pedicel (1.5–3.5 mm long) and distinct styles whereas the latter has a longer pedicel (7–13 mm long) and a single style with a lobed apex.

[17] *Camellia nervosa* (Gagnepain) Hung T. Chang, A Taxonomy of the Genus *Camellia* 96. 1981; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 532, fig. 1467. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 153. 1999 & Monograph of the Genus *Camellia* 142, 149, t. 25, fig. 4–6. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 348. 2003.

≡ *Thea nervosa* Gagnepain in *Notulae Systematicae* 10(3): 129. 1942, excl. *Poilane 13576*; Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 303, 304, 306, t. 29, fig. 1–6. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 176. 2017. —**Lectotype** (first-step designated by Sealy 1958: 222): VIETNAM, Lam Dong, 'massif du Braïan, près de Djiring', 1500 m, 14 February 1935, *Poilane 24305* (**P**!, three sheets; second-step lectotype designated by Zhao et al. [2017: 176]: **P01903375**!). Isolectotypes: **A00025099**†, **IBSC0239224**!, **K000704303**!, **K000704698**!, **KUN1206034**!, **P01903374**!, **P04511810**!, **PE01432084**!, **SING0204889**!, **VNM00003807**!.

= *Camellia harlandii* Orel & Curry, In Pursuit of Hidden Camellias 166. 2015. **Syn. nov.** —

Holotype: VIETNAM, Lam Dong, Dalat Plateau, 13 January 2004, Orel et al. 218 (**NSW900405**†).

Shrubs 2–3.5 m tall. *New branchlets* glabrous; *terminal buds* puberulous. *Petioles* 4–9 mm long, glabrous; *leaf blades* elliptic to oblong, 5–11 × 1.5–3.5 cm, coriaceous, abaxially yellowish green and glabrous, adaxially dark green, glabrous and shiny, midrib and secondary veins abaxially elevated and adaxially impressed, secondary veins 6–9 on each side of midrib, base attenuate or cuneate, margin sparsely serrulate, apex attenuate or acute. *Flowers* solitary, borne in the axils of leaves or on short bracteate shoots, short shoots bearing 4–6 bracts subtending flowers, *bracts* caducous; flower ca. 1.5 cm in diam. *Pedicels* ca. 2 mm long. *Bracteoles* 2, broadly ovate or deltate, 1–2 × 2.5–3.5 mm, outside glabrous or puberulous along midrib, inside sericeous, margin ciliolate. *Sepals* 3–4, broadly ovate, 3–5 × 4–6.5 mm, outside glabrous, inside sericeous, margin

ciliolate. *Petals* 4–5, white, ovate or elliptic, 6.5–8 × 4–6 mm, outside glabrous, inside glabrous at base and sericeous at apex. *Stamens* 2–4 mm long; *filaments* glabrous, basally adnate to petals for 1–2 mm. *Ovary* globose or ovoid, glabrous. *Styles* 3–4, distinct, 3–4 mm long, glabrous. *Capsule* globose or ovoid, 1.5–3 cm in diam.; *pericarp* 1–3 mm thick, furfuraceous. *Seeds* not seen.

Phenology: flowering January–February, fruiting January–February.

Distribution: endemic to southern Vietnam (Map 4.5).

Habitat: evergreen forest, ca. 1500 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² and it is known to exist at two locations (B1, Map 4.5, IUCN 2012).

Notes—Two gatherings were cited in the protologue of *T. nervosa*: *Poilane* 24305 & 13576 (Gagnepain 1942: 130). Sealy (1958) chose *Poilane* 24305 at **P**, consisting of three sheets (**P01903374**, **P01903375** & **P04511810**), to be the type, which should be treated as the first-step lectotypification (Art. 9.17 Ex. 12). It is narrowed to **P01903375** as the second-step lectotype since this sheet bears Gagnepain's drawing. Another syntype, *Poilane* 13576, has been recognised as a different species (Sealy 1958, Zhang 1981a, Min 2000, Zhao et al. 2017a).

This species differs from *C. gracilipes* by its shorter pedicel (ca. 2 mm long) and a glabrous ovary whereas the latter has a much longer pedicel (15–37 mm long) and a pubescent ovary.

[18] *Camellia pubicosta* Merrill in Journal of the Arnold Arboretum 23: 183. 1942; Sealy, A Revision of the Genus *Camellia* 111, 129–130, fig. 58. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 110, 119. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 138, 147. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 535, fig. 1474. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 153. 1999 & Monograph of the Genus *Camellia* 142, 152, t. 24, fig. 4–7. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 349. 2003; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 223. 2005.—**Holotype:** VIETNAM, Hanoi, Mount Ba Vi, 19 November 1924, *Pételot* 1727 (**A00024753**†). **Paratype:** VIETNAM, Hanoi, Mount Ba Vi, 400–800 m, 28 August 1940, *Pételot* 2598 (**A00024752**†).

Trees or shrubs up to 10 m tall. *New branchlets* puberulous; *terminal buds* pubescent. *Petioles* 2–11 mm long, puberulous; *leaf blades* elliptic to oblong, 9–16 × 2.5–5 cm, papery or thinly coriaceous, abaxially pale green, sparsely puberulous, especially along midrib, adaxially dark green, shiny, midrib and secondary veins abaxially elevated and adaxially impressed, secondary veins 10–14 on each side of midrib, base attenuate to obtuse, margin sparsely serrulate to serrate, apex attenuate to caudate. *Flowers* solitary or up to 4 in a cluster, 2–3 cm in diam. *Pedicels* 8–20 mm long. *Bracteoles* 2–3, alternate, deltate to ovate, 1.5–4.5 × 1.5–2 mm, outside glabrous or sparsely puberulent, inside glabrous, margin ciliolate. *Sepals* 5, sub-orbicular, 2–3 × 3–4.5 mm, outside glabrous or sparsely puberulent, inside glabrous, margin ciliolate. *Petals* 6–7 in 2 whorls,

white, obovate to broadly obovate, 7–13 × 4–10 mm, both surfaces glabrous, basally connate for 1–2 mm. *Stamens* 5–10 mm long; *filaments* yellow, glabrous. *Ovary* globose to ovoid, densely pubescent. *Styles* 2–4, distinct, 5–12 mm long, basally densely pubescent and gradually becoming sparsely pubescent apically. *Capsule* globose, 2–3 cm in diam., apex apiculate, 1-loculed with 1 seed; *pericarp* 0.5–1.5 mm thick. *Seeds* fuscous or brown, globose, 2–2.5 cm in diam., glabrous. Figure 4.5.

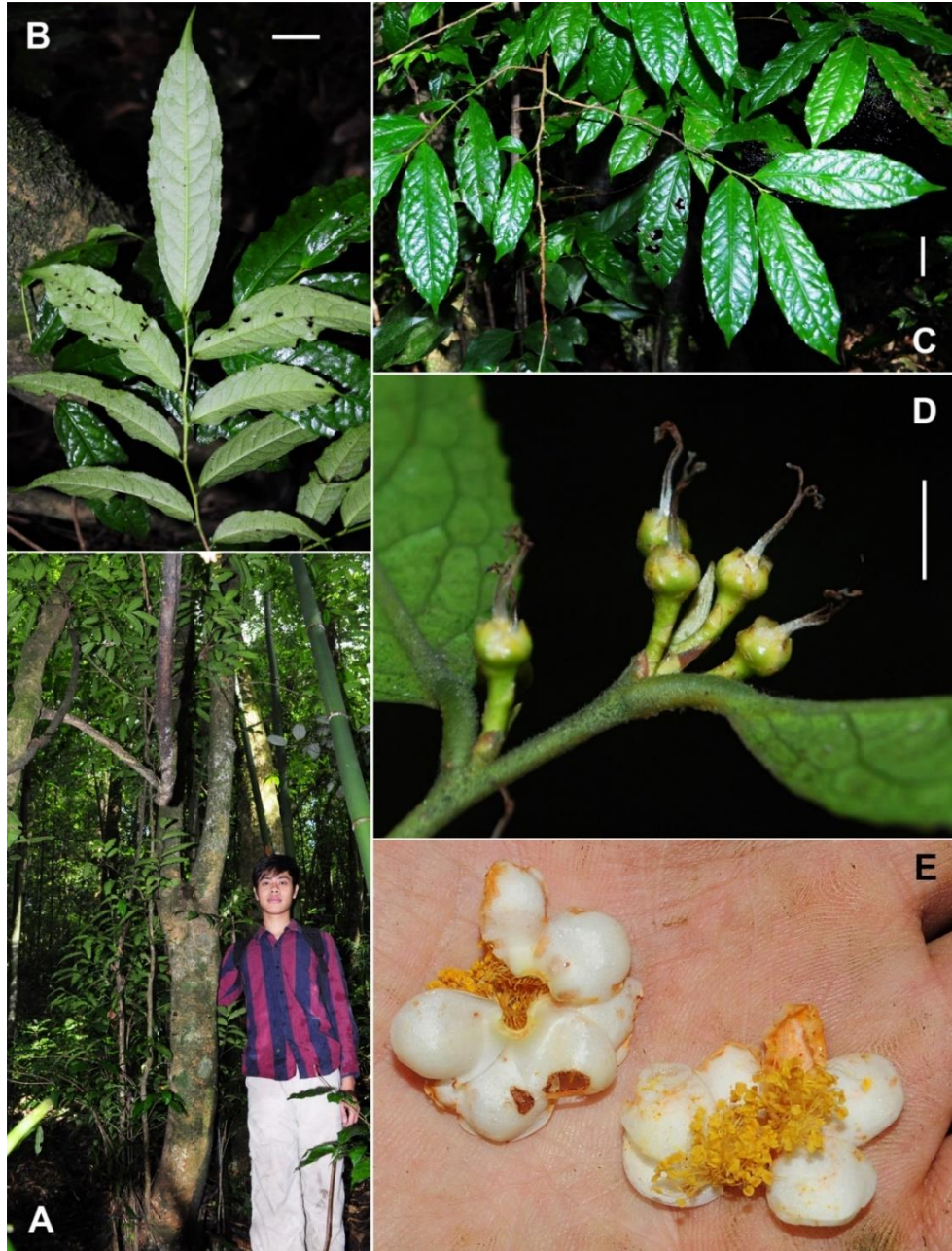


Figure 4.5. *Camellia pubicosta*. A: habit; B & C; leaf branches; D: immature fruits; E: petals & androecia. The white bars represent 2 cm, 2 cm and 1 cm in B, C and D, respectively. D was taken by Do Van Hai of HN.

Phenology: flowering October–February, fruiting June–October.

Distribution: China and Vietnam, especially northern Vietnam (Map 4.6).

Habitat: evergreen forest, 400–1200 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

VIETNAM. Hanoi: Ba Vi, 18 October 1887, *Balansa* 3183 (P04500222, P05312525), November 1887, *Balansa* 3861 (**K**, P04500222, P04511359, P04511360), June 1918, *Chevalier* 37872 (P05278755, P05278756, P05278758, VNM00003828), 600 m, 1 June 1918, *Fleury* 37816 (P05278765), 29 October 1918, *Chevalier* 37815 (P05286438, P05286439, P05286440, P05312501, P05312502, P05312504, VNM00003826), 400–800 m, 28 August 1940, *Pételot* 2285 (**HNU**), 500–800 m, 25 November 1940, *Pételot* 6655 (VNM00003813, VNM00003814).

Nghe An: Con Cuong, Pu Mat, 17 July 1998, *Ninh* C605 (**HNU**); Quy Chau, Bu Khang, 22 December 1962, *Lan* B.268 (**HN**, IBSC0256478, **VFM**).

Phu Tho: Phu Ho, November 1930, *Pasquier* s.n. (P04511793); Tan Son, Xuan San, 3 July 2003, *Phuong* 6490 (**HN**).

Vinh Phuc: Phuc Yen, Ngoc Thanh, 24 October 2001, *Phuong* 4540 (**HN**); Tam Dao, 1100 m, November 1930, *Pételot* 3837 (P04500226, VNM00003827), 7 February 1965, *Sino-Vietnam Exp.* 1943 (KUN0695860, PE01679142), 13 October 1975, *Ve* 15090 (**HN**), 31 May 1977, *Phuong* 181 (**HN**), 1100 m, 13 October 1995, *Rosmann* 95690 (P05247463), 1000 m, 19 November 1998, *Ninh* 9886 & 98117 (**HNU**), 18 October 1998, *Qin et al.* 108 (**HITBC**), 21°27'28"N, 105°38'41"E, 1000 m, 31 October 2004, *Li et al.* 604 (**HN**), 21°27'44"N, 105°38'52"E, 1170 m, 18 November 2015, *Zhao et al.* 107(1) & (2) (**TCD**).

Notes— Sealy (1958), Zhang (1981a) and Zhang & Bartholomew (1984) recognised that *C. pubicosta* was a member of sect. *Thea*, a treatment with which Min (2000) and I disagree. Phylogenetic investigations using *RPB2* data (Figures 2.3–2.9) suggest that *C. pubicosta* and sect. *Thea* do not form a clade.

Huang et al. (2014) reported the sequence of complete chloroplast genome of *C. pubicosta* and found that this species was closely related to *C. sinensis* and ‘may be classified into sect. *Thea*’. The fresh leaf material of *C. pubicosta* that they (Huang et al. 2014) used was collected in the ‘International *Camellia* Species Garden (Jinhua, Zhejiang, China)’ in May 2011 without any voucher specimen cited. Meanwhile, they stated that ‘...*C. pubicosta* [was] native to Laos’ (Huang et al. 2014: 11) and the plant materials were identified based on the taxonomic treatment in FOC (Min & Bartholomew 2007). The original reference in Huang et al. (2014) is ‘Min TL, Bruce B: *Flora of China*. Beijing, China: Science Press; 2010’ and is full of errors, see the correct one in the References below. However, the *C. pubicosta* they (Huang et al. 2014) used has several problems. Firstly, *C. pubicosta* has not been found in Laos based on my investigations of specimens (see collections cited above) and literature (Merrill 1942, Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 2000, Gao et al. 2005, Newman et al. 2007); secondly, no record of *C.*

pubicosta can be found in FOC (Min & Bartholomew 2007); and finally, the International Camellia Species Garden at Jinhua, Zhejiang, China may not have living material of *C. pubicosta* (Gao et al. 2005: 223; my correspondence with Prof. Li Jiyuan on 17 May 2017). Therefore, I doubt the credibility of the material of *C. pubicosta* used in Huang et al. (2014) and believe that this species is not a member of sect. *Thea*.

Camellia pubicosta differs from sect. *Thea* by its persistent bracteoles and distinct styles (Figure 4.5) whereas the latter have caducous bracteoles and a single style with a lobed apex (see Section 4.2.11 below).

4.2.4 Section *Cylindriea*

Section *Cylindriea* T.L. Ming, Monograph of the Genus *Camellia*, 108. 2000. —**Type:** *C. amplexicaulis* (Pitard) Cohen-Stuart

Leaf blade abaxially punctate, base cordate; bracteoles and sepals persistent; petals usually red; styles distinct.

Notes—As discussed in Section 2.4.4(d) above, this monotypic section morphologically resembles sect. *Archecamellia* but phylogenetic analyses using molecular data tell a very different story (Figures 2.3–2.12, Vijayan et al. 2009). This section formed a clade with sect. *Paracamellia* on the *RPB2* gene tree (Figure 2.9) but they are morphologically very different: the latter has leaf blades that are non-punctate on the abaxial surface, caducous bracteoles and sepals and usually white petals (see corresponding character states of sect. *Cylindriea* above).

[19] *Camellia amplexicaulis* (Pitard) Cohen-Stuart in Mededeelingen van het Proefstation voor Thee 40: 67. 1916 & in Bulletin du Jardin Botanique, 3rd series 1(4): 239, 245. 1919; Melchior in Engler, Die Natürlichen Pflanzenfamilien 2(21): 131. 1925; Sealy, A Revision of the Genus *Camellia* 36, 43, fig. 13. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 99. 1981 & in Acta Scientiarum Naturalium Universitatis Sunyatseni 35(1): 79. 1996; Hung T. Chang & B.M. Bartholomew, Camellias 125. 1984; P.H. Hô, Cây cỏ Việt Nam 534, fig. 1471. 1991; T.L. Ming & W.J. Zhang in Acta Botanica Yunnanica 15(1): 5, 9. 1993; T.L. Ming in Acta Botanica Yunnanica 21(2): 152. 1999 & Monograph of the Genus *Camellia* 79, 91, t. 7, fig. 1–4. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 344. 2003; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 23. 2005.

≡ *Thea amplexicaulis* Pitard in Lecomte, Flore Générale de l'Indo-Chine 1(4): 343. 1910; Gagnepain in Supplément a la Flore Générale de l'Indo-Chine 1(3): 303–304. 1943. —**Lectotype** (designated by Min 2000: 91): VIETNAM, Hanoi, May 1886, *Balansa* 3858 (**K!**). Isolectotype: **P!**, **P04500319!**. Syntypes: VIETNAM, Hanoi, December 1890, *Balansa* 4826 (**P04500315!**, **P04500316!**); VIETNAM, 6 February 1892, *Bon* 9113 (**P04500321!**, **P04500322!**, **P04500324!**).

= *Camellia cylindracea* T.L. Ming, Monograph of the Genus *Camellia*, 108. 2000. **Syn. nov.** —

Holotype: VIETNAM, Phu Tho, Cau Hai, 23 January 1961, s.n. (**KUN 54473!**). Isotype: **KUN1206000!**.

= *Camellia lucii* Orel & Curry, In Pursuit of Hidden Camellias 220. 2015. **Syn. nov.** — **Holotype:** VIETNAM, Hanoi, 3 April 2001, Orel & Curry 010403 (**NSW901791†**).

Shrubs, 1–4 m tall. *New branchlets* glabrous; *terminal buds* puberulous. *Petioles* 3–5 mm long, glabrous; *leaf blades* oblong to elliptic, 16–23 × 6–9 cm, coriaceous, abaxially yellowish green and brown punctate, adaxially dark green and shiny, both surfaces glabrous, midrib abaxially elevated and adaxially channelled, secondary veins 13–15 on each side of midrib, abaxially elevated and adaxially impressed, base cordate, margin serrulate, apex acute. *Flowers* solitary or up to 4 in a cluster, 4–5 cm in diam. *Pedicels* 8–24 mm long. *Bracteoles* 4–5, alternate, 2-ranked, gradually transitioning to sepals, deltate to semi-orbicular, 1.5–2.5 × 2–5 mm, outside glabrous, inside glabrous to sericeous. *Sepals* 5, sub-orbicular, outer 3 or 4 sepals 3–8 × 5–11 mm, yellowish green, inner 1 or 2 sepals 8–12 × 14–16 mm, slightly pink, outside glabrous, inside sericeous. *Petals* 11–13 in 3 whorls, red, pink or occasionally white, sub-orbicular, elliptic to obovate-elliptic, 1.8–4.5 × 2–3.5 cm, basally adnate to filament whorl for ca. 15 mm, outer 2 or 3 petals outside glabrous, inside puberulent, inner petals basally puberulent and gradually becoming glabrous apically on both surfaces. *Stamens* 2.5–4.5 cm long; *filaments* white to light yellow, outer filaments basally connate for 1.8–2.5 cm, basally puberulent and gradually becoming glabrous apically. *Ovary* globose to ovoid, glabrous. *Styles* 3(–5), distinct, 2–3.5 cm long, glabrous. *Capsule* oblate to ovoid, 1.5–2.5 cm in diam.; *pericarp* 4–8 mm thick. *Seeds* fuscous, hemispherical or polyhedral, 1–1.5 cm in diam., glabrous. Figure 4.6.

Phenology: flowering October–April, fruiting May–June.

Distribution: probably endemic to Vietnam.

Habitat: only known from cultivation.

Conservation status: extinct in the wild (EW). No natural plants of this species have been recorded or reported (IUCN 2012).

Additional specimens examined (cultivated)

VIETNAM. *DKSVT 2456* (**HN**); *Ninh s.n.* (**HNU**); 3 December 1957, *Hoc 2301* (**HNU**); **VNM00003708**.

Bac Giang: Yen The, ‘Nha Nam’, 14 December 1902, *Bois 252* (**P04500323**).

Hanoi: February 1924, *Pételot s.n.* (**P04500318**); February 1924, *Pételot s.n.* (**P04500320**); 1 February 1965, *Sino-Vietnam Exp. 2456* (**KUN1223162**); 18 November 1997, *Phe P034* (**VNF**).

Phu Tho: 16 June 1961, *Trung 3130* (**PE01678924**); Lam Thao, 10 November 2002, *Thanh s.n.* (**VNF**).

Thua Thien Hue: Hue, *Ho 260* (PHH).

Vinh Phuc: Tam Dao, 16 April 1969, *Khe 35* (HNU), 17 November 2015, *Zhao et al. 100*(1) (TCD); Vinh Yen, *Eberhabdt 3762* (K, P04500325); May 1935, *Pételot s.n.* (P04500317, VNM00003709).

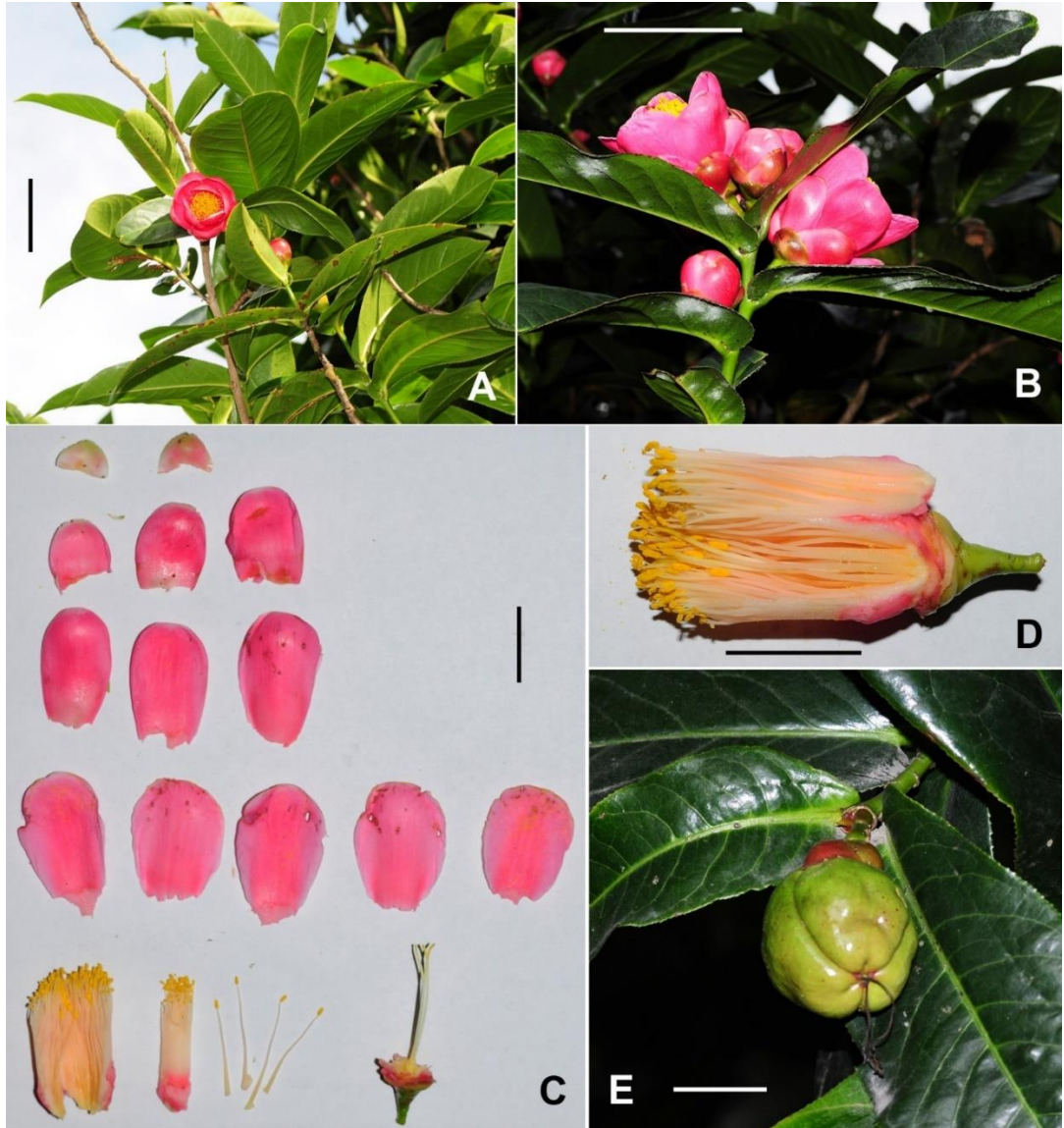


Figure 4.6. *Camellia amplexicaulis*. A & B: flower branches; C: a dissected flower; D: a flower without petals; E: an immature fruit. The bars represent 5 cm in A and B but indicate 2 cm in C, D and E, respectively.

Notes—Pitard (1910) cited ‘*Balansa, Bon*’ in the protologue of *T. amplexicaulis*. Min (2000: 91) designated ‘*B. Balansa 3858* (K)’ as the lectotype of *T. amplexicaulis* without citing any collection from **P** though many syntypes were housed at **P**. A single specimen of *Balansa 3858*, consisting of leaf and flower fragments, was found at **K**. However, a complete specimen (**P04500319** of *Balansa 3858*) with a drawing of dissected flower and Pitard’s manuscript notes ‘*Thea amplexicaulis* sp. n.’ is found at **P** and this sheet (**P04500319**) could serve as the lectotype more appropriately.

Nevertheless, Min's (2000: 91) designation must be followed under Art. 9.19.

Camellia cylindracea was not validly published by Min (1994: 343) because the author failed to use 'typus' or 'holotypus', or its abbreviation, or its equivalent in a modern language to indicate the type (Art. 40.6). It was, however, later validly published by the same author (Min 2000: 108). Min (2000) suggested that this species differed from others by its cylindrical ovary ('7 mm long and ca. 3 mm in diam.', Min 2000: 110) and a fused style with five arms at apex. Those characters were so valued by Min that he (Min 2000: 108) established sect. *Cylindria* based on *C. cylindracea*. One dissected flower is attached on the holotype of *C. cylindracea* at KUN. The length of its ovary is, however, ca. 4 mm—beneath the ovary, there is the attachment region for petals and filaments, which is ca. 3 mm long and is not a part of the ovary. Meanwhile, another flower of the holotype has four distinct styles. The fused style of the dissected flower may be an artificial effect introduced by the specimen processing.

Camellia lucii was described based on a single cultivated plant with a white flower (Orel & Curry 2015). It differs with *C. amplexicaulis* only by its flower colour. However, the flower colour of *Camellia* usually varies widely in enthusiasts' gardens and it cannot be used as a key character to support the novelty of a species of *Camellia*.

This species is a popular horticultural plant in the gardens of Vietnam and tropical China.

4.2.5 Section *Furfuracea*

Section *Furfuracea* Hung T. Chang, A Taxonomy of the Genus *Camellia* 25. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 14–22. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 40–48. 1984. —**Type:** *C. furfuracea* (Merrill) Cohen-Stuart

Flowers subsessile or pedicels very short (1–3 mm long); styles usually 3, distinct; pericarp furfuraceous.

Notes—Both the *RPB2* and ITS phylogenetic trees support the independence of this section (Figures 2.3–2.9, Vijayan et al. 2009), which morphologically differs from sect. *Heterogenea* by its furfuraceous pericarp whereas the latter has a smooth pericarp.

[20] *Camellia fleuryi* (A. Chevalier) Sealy in Kew Bulletin 4(2): 217. 1949; 1949 & A Revision of the Genus *Camellia* 152, 157–158, fig. 73. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 87, 89. 1981; Hung T. Chang & B.M. Bartholomew, Camellias 112–113. 1984; P.H. Hô, Cây cỏ Việt Nam 532, fig. 1465. 1991; T.L. Ming in Acta Botanica Yunnanica 21(2): 155. 1999 & Monograph of the Genus *Camellia* 210, 218–219, t. 46, fig. 1–4. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 345. 2003.

≡ *Thea fleuryi* A. Chevalier in Bulletin Économique de l'Indochine 22(137): 531. 1919; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 303, 306. 1943; D. Wei Zhao et

al. in *Phytotaxa* 292(2): 174. 2017. —**Lectotype:** (first-step designated by Min 2000: 218): VIETNAM, Khanh Hoa, Nha Trang, ‘massif de Hòn Bà’, 1000 m, 20–22 September 1918, *Chevalier* 38672 (**P**!, four sheets; second-step lectotype designated by Zhao et al. [2017: 175]: **P00700353**!). Isolectotypes: **P00700351**!, **P00700352**!, **P05312518**!. Syntypes: VIETNAM, Khanh Hoa, Nha Trang, ‘massif de Hòn Bà’, 800 m, September 1918, *Fleury* 38794 (**P00700357**!, **P00700358**!, **P00700359**!, **P00700360**!).

New branchlets and terminal buds glabrous. *Petioles* 6–10 mm long, glabrous; *leaf blades* elliptic or ovate, 8–11 × 2.5–3.5 cm, coriaceous, both surfaces glabrous, midrib abaxially elevated and adaxially channelled, secondary veins 5–7 on each side of midrib, abaxially raised and adaxially slightly impressed, base cuneate, margin sparsely serrulate, apex attenuate or long acuminate. *Flowers* solitary, ca. 3 cm in diam. *Pedicel* 1–2 mm long. *Bracteoles* and *sepals* ca. 7, crescent or ovate, 2.5–5 × 3–6 mm, outside glabrous, inside sericeous, margin ciliolate. *Petals* ca. 8 in 2 whorls, yellow, broadly ovate or obovate, 1–1.7 × 1–1.5 cm, outside glabrous, inside sericeous. *Stamens* ca. 1 cm long; *filaments* glabrous. *Ovary* ovoid, glabrous. *Styles* 3, distinct, ca. 7 mm long, glabrous. *Capsule* oblate, 3–4 cm in diam., ca. 2.5 cm in height; *pericarp* furfuraceous. *Seeds* not seen.

Phenology: flowering and fruiting in September.

Distribution: endemic to southern Vietnam (Map 4.7).

Habitat: montane forest, 800–1000 m.

Conservation status: endangered (EN). The extent of occurrence is estimated to be less than 5000 km² and it is known to exist at less than five locations (B1, Map 4.7, IUCN 2012).

Notes—Chevalier (1919: 531) did not cite a specific specimen in the protologue of *T. fleuryi* but wrote ‘Mss. in Herb., espèce arborescente croissant dans la forêt vierge du Hon-bà par 1000 m. d’altitude’. The elevation in the protologue matches with that of *Chevalier* 38672. The specific epithet ‘*fleuryi*’ is, however, clearly named after F. Fleury, the collector of *Fleury* 38794 (Sealy [1958] cited ‘*T. Fleury* [in herb. A. *Chevalier* 38794]’), so it might be reasonable to select *Fleury* 38794 as the lectotype though its elevation is 800 m and differs from that in the protologue. Nevertheless, Min (2000: 218) chose *Chevalier* 38672 at **P** as the lectotype and this lectotypification must be followed (Art. 9.19). However, *Chevalier* 38672 has four duplicates (**P00700351**, **P00700352**, **P00700353** & **P05312518**) at **P**. Min’s (2000) lectotypification should be considered as the first-step (Art. 9.17 Ex. 12). **P00700353** bears Gagnepain’s drawing so it is designated as the second-step lectotype (Zhao et al. 2017a).

Camellia fleuryi generally differs from *C. furfuracea* by its smaller flower (ca. 3 cm in diam.) and a glabrous ovary whereas the latter has a larger flower (4–6 cm in diam.) and a pubescent ovary.



Map 4.7. Distribution of *Camellia fleuryi* (red triangle), *C. rubriflora* (orange star) and *C. sealyana* (pink diamond) in Indochina.

[21] *Camellia furfuracea* (Merrill) Cohen-Stuart in Bulletin du Jardin Botanique, 3rd series 1(4): 240. 1919; Sealy, A Revision of the Genus *Camellia* 153, 155–157, fig. 72. 1958; Hu & Hung T. Chang in Chun et al., Flora Hainanica 1: 499–500. 1964; Hung T. Chang, A Taxonomy of the Genus *Camellia* 26, 30. 1981, in Flora of Guangxi 1: 760, 767, t. 300: 2. 1991, in F.H. Chen, Flora of Guangdong 2: 124, 130. 1991 & in Flora Reipublicae Popularis Sinicae 49(3):15, 19. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 40, 43, 45. 1984; P.H. Hô, Cây cỏ Việt Nam 1(1): 530, fig. 1459. 1991; T.L. Ming in Acta Botanica Yunnanica 21(2): 155. 1999 & Monograph of the Genus *Camellia* 211, 225, 227, t. 49, fig. 1–3. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật

Việt Nam 2: 346. 2003; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 146. 2005; T.L. Ming & B.M. Bartholomew in Flora of China 12: 393, 396. 2007; B.G. Li & L.H. Liu, Flora of Hunan 3: 46, 50, t. 3-51. 2010.

= *Thea furfuracea* Merrill in The Philippine Journal of Science, Section C. Botany 13(3): 149. 1918. —**Holotype**: CHINA, Guangdong, Huizhou, Boluo, Luofu Mountain, 9–27 August 1917, Merrill 10681. Isotype: US00113900†. Paratypes: CHINA, Guangdong, 15 August 1917, Levine 1516 (A00025083†, A00025084†, E00691269!, **MO** 825149†).

= *Thea bolovenensis* Gagnepain in Notulae Systematicae 10(3): 124. 1942; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 303, 308. 1943. —**Lectotype** (designated by Min 2000: 225): LAOS, Champasak, 'Plateau des Boloven, entre Nong Bok Kao et Phong Tham', 900 m, 6 October 1928, Poilane 15856 (K000704324!). Isolectotypes: A00025093†, IBK00118037!, P04500219!, VNM00003719!, VNM00003720!. Syntypes: LAOS, Champasak, 1100–1200 m, 21 September 1928, Poilane 15682 (P04500220!, VNM00003717!), 27 September 1928, Poilane 15745 (P04500221!, VNM00003718!); VIETNAM, Binh Dinh, Qui Nhon, 'col de Mangiang', 1000–1200 m, 15 August 1930, Poilane 18005 (P04500293!, IBK00118036!), 1000 m, 19 August 1930, Poilane 18018 (right-hand specimen of A00025094†, P04500290!, SING0204883!, VNM00003721!), 1200 m, 22 August 1930, Poilane 18098 (P04500282!, PE01678926!); Kontum, 'Moutagne Mam Ray', 1000 m, 4 September 1930, Poilane 18217 (P04500287!), 'Dak Ha', 1200–1500 m, 3 October 1930, Poilane 18440 (P04500281!), 'Ton Morang', 1000 m, 11 March 1941, Poilane 32247 (P04500294!); Lam Dong, 'Braïan près de Djiring, prov. Haut Donaï', 1200–1300 m, 18 February 1935, Poilane 24348 (P04500291!), 1300–1400 m, 23 February 1935, Poilane 24546 (A00025092†, P04500285!, VNM00003722!); Quang Tri, 'Massif de Dong Che', 500–600 m, 22 May 1924, Poilane 10527 (P04500288!, P04500289!).

= *Camellia suaveolens* C.X. Ye, Xiu J. Wang & X.G. Shi ex Xiu J. Wang, X.G. Shi, J. Xian Li, C.X. Ye in Acta Scientiarum Naturalium Universitatis Sunyatseni 43(3): 129. 2004. —**Holotype**: CHINA, Guangdong, Yingde, cultivated, introduced from Lechang, 27 October 2002, Ye 5919 (SYS00142796!). Isotypes: SYS00142792!, SYS00142793!, SYS00142794!, SYS00142795!, SYS00142797!.

= *Camellia maiana* Orel in Novon 20(2): 198. 2010; Orel & Peter G. Wilson, International Camellia Journal 42: 137. 2010; Orel & Curry, In Pursuit of Hidden Camellias 78. 2015. **Syn. nov.** —**Holotype**: VIETNAM, Lam Dong, Dalat Plateau, 19 November 2002, Orel et al. 21149 (NSW901884†). Isotype: VNM00018567!.

= *Camellia curryana* Orel & Luu ex Orel, Peter G. Wilson & Luu in Nordic Journal of Botany 32: 42. 2014; Orel & Curry, In Pursuit of Hidden Camellias 108. 2015. **Syn. nov.** —**Holotype**: VIETNAM, Lam Dong, Dalat Plateau, 27 February 2002, Orel et al. 21147 (NSW901031†).

= *Camellia duyana* Orel et al. in Novon 23(3): 308. 2014; Orel & Curry, In Pursuit of Hidden

Camellias 128. 2015. **Syn. nov.** — **Holotype:** VIETNAM, Lam Dong, Dalat Plateau, ca. 1400 m, 27 November 2010, *Orel & Duy 0719* (NSW901883†).

= *Camellia albata* Orel & Curry, In Pursuit of Hidden Camellias 239. 2015. **Syn. nov.** —

Holotype: VIETNAM, Quang Ninh, 2 December 1999, *Orel et al. 991202c* (NSW901898 [sheet 1 of 2]† NSW849513 [sheet 2 of 2]†).

= *Camellia reflexa* Orel & Curry, In Pursuit of Hidden Camellias 209. 2015. **Syn. nov.** —

Holotype: VIETNAM, Vinh Phuc, Tam Dao National Park, 2 April 2001, *Orel et al. 1240* (NSW901749†).

= *Camellia viscosa* Orel & Curry, In Pursuit of Hidden Camellias 214. 2015. **Syn. nov.** —

Holotype: VIETNAM, Lam Dong, Dalat Plateau, 19 November 2002, *Orel et al. 21148G* (NSW901821†).

Shrubs or trees up to 15 m tall. *New branchlets* glabrous; *terminal buds* glabrous or puberulous. *Petioles* 3–12 mm long, glabrous; *leaf blades* elliptic or oblong, 7.5–17 × 3–7 cm, coriaceous, abaxially yellowish or pale green, glabrous or brown punctate, adaxially dark green, glabrous and shiny, midrib abaxially elevated and adaxially channelled, secondary veins 7–11 on each side of midrib, abaxially raised and adaxially slightly impressed, base attenuate, cuneate or obtuse, margin sparsely serrulate, apex attenuate, acute or obtuse. *Flowers* solitary or paired, 4–6 cm in diam. *Pedicels* 1–3 mm long. *Bracteoles* and *sepals* 6–9, crescent or ovate, 2–13 × 3.5–20 mm, outside puberulous or pubescent, inside glabrous, margin membranous. *Petals* 6–9 in 1–2 whorls, white, elliptic or obovate, 17–25 × 9–15 mm, outside puberulous or glabrous, inside glabrous, basally connate for 1–2 mm. *Stamens* 1–1.5 cm long; *filaments* glabrous, basally adnate to petals for ca. 2 mm. *Ovary* ovoid or globose, pubescent. *Styles* 3–4, distinct, 6–10 mm long, pubescent and gradually becoming glabrous apically. *Capsule* oblate or globose, 3–5 cm in diam., 2–3 cm in height; *pericarp* 1–10 mm thick, furfuraceous. *Seeds* brown or fuscous, hemispherical or polyhedral, 1.5–2 in diam., glabrous.

Phenology: flowering October–February, fruiting December–April.

Distribution: China, Laos, Thailand and Vietnam (Map 4.8).

Habitat: evergreen forest, on slopes or along streams, 450–1800 m.

Conservation status: least concern (LC). This species is widespread and abundant in subtropical and tropical China and Indochina (Map 4.8, IUCN 2012).

Additional specimens examined

LAOS. Champasack: ‘plateau du Boloven’, October 1928, *Poilane 16260* (PE01678927); ‘Nord de Pakson plateau des Boloven’, 29 October 1928, *Poilane 16217* (P04511411, VNM00003771); Parksong, Nonglouang, 22 November 2013, *Phonesack & Sengvilai ChS.0832* (**HNL**).

THAILAND. Chanthaburi: Soi Dao, Khao Soi Dao, 1300–1400 m, 12 December 1924, *Kerr*

9638 (**BK203925**, **BM**, **C**, **K**, **P04500307**); Pong Nam Ron, Khao Soi Dao, ca. 1600 m, 23 January 1956, *Smitinand* 3242 (**BKFSN060898**), 1100 m, 5 April 1974, *Smitinand* 11994 (**BKFSN060894**), 1650 m, 9 February 1975, *Smitinand* 12023 (**BKFSN060895**, **BKFSN060896**, **P04500286**),

VIETNAM. *Phuong* 11305 (**HN**).

Bac Giang: Son Dong, Tay Yen Tu, 15 November 2012, *Cuong & Cuong* VN 2306 (**HN**).

Dak Lak: 1450–1750 m, 30 December 1997, *Phengkklai et al.* 10732 (**BKFSN150674**).

Dak Nong: Dak Glong, Dak Plao, Ta Dung, 11°52'18"N, 108°1'37"E, 1100–1250 m, 12 November 2006, *Wu et al.* WP 1568 (**HN**); Dak Mil, 9 December 1979, *Tue* 296 (**HN**), 10 December 1979, *Ly* 720 (**HN**).

Hanoi: Ba Vi, 500 m, October 1995, *Rosmann* 95685 (**P05247459**), 800 m, December 1994, *Ninh TN* 9414 (**HNU**).

Kon Tum: ‘massif du Ngok Pan’, 9 December 1946, *Poilane* 35763 (**P05156325**); Kon Plong, Mang Canh, 23 November 1978, *Phuong* 700 (**HN**).

Lam Dong: Di Linh, ‘près Djiring’, 1600–1800 m, 16 January 1935, *Poilane* 23903 (**K**, **P04511589**, **VNM00003755**), 1700–1800 m, 17 January 1935, *Poilane* 23971 (**P04511591**); Lam Ha, ‘Doi Oui’, ca. 1100 m, 30 December 1997, *Wongprasert et al.* 9712-19 (**BKFSN163432**, **BKFSN163433**).

Quang Ninh: ‘Taai Wong Mo Shan and vicinity Chuk-phai, Ha-coi’, 18 November–2 December 1936, *Tsang* 27328 (**C**, **E00681074**, **K**, **P04511543**); Tien Yen, ‘Ho Yung Shan and vicinity Tien-yen’, 13 October–22 November 1940, *Tsang* 30708 (**C**, **E00681075**, **K**, **P04500314**, **SING0204886**).

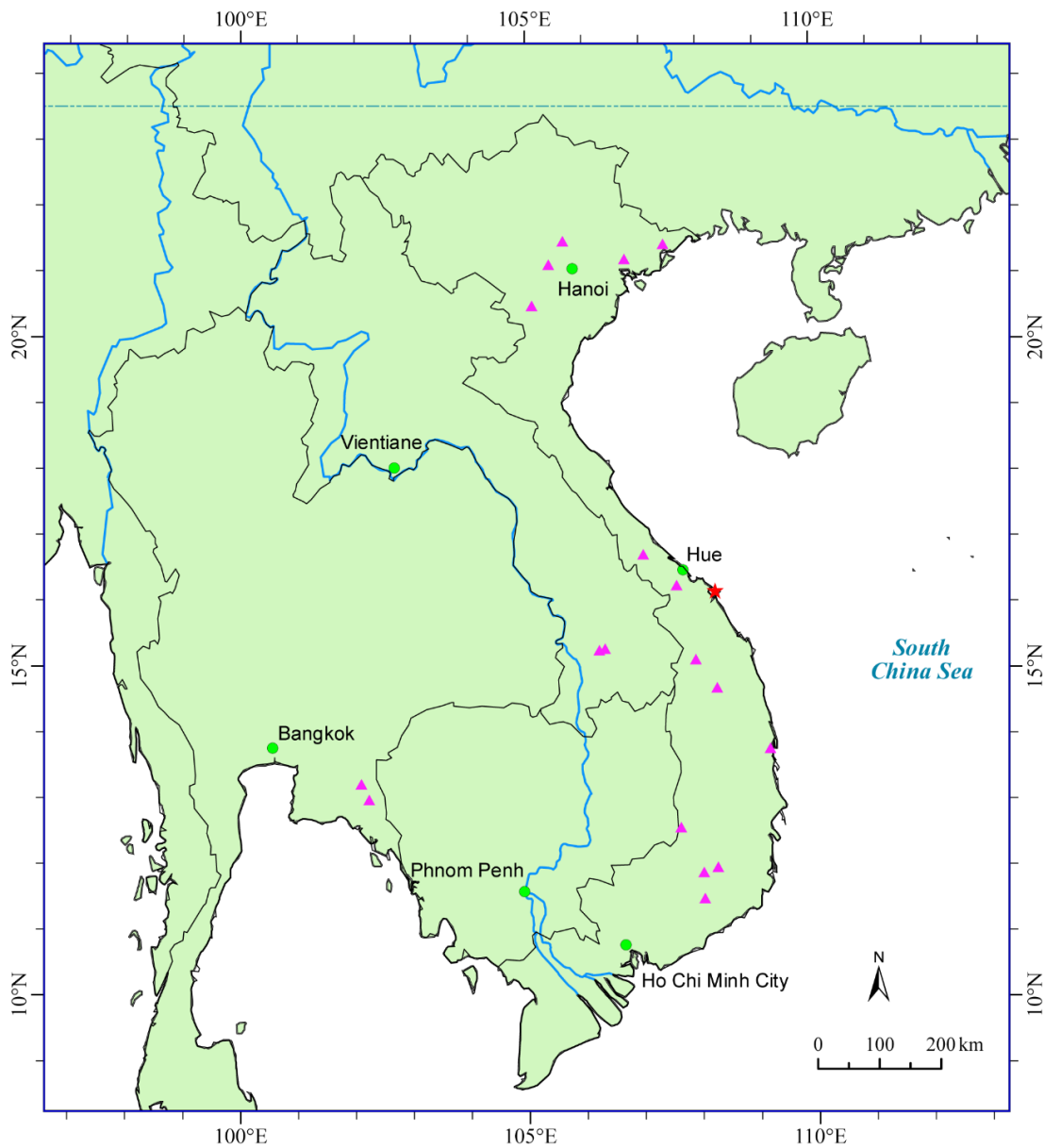
Thanh Hoa: Ba Thuoc, Thanh Son, ‘middle part of Pu Luong range’, 20°28'14"N, 105°5'34"E, 1450–1550 m, 9 October 2003, *Averyanov et al.* HAL 4184 (**HN**).

Thua Thien Hue: Huong Thuy, Duong Hoa, ‘Huong Thuy forest enterprise territory, SW slopes of Mang Chan ridge’, 16°13'36"N, 107°35'9"E, 450–500 m, 11 May 2005, *Averyanov et al.* HAL 8159 (**HN**).

Vinh Phuc: Tam Dao, 1924–1925, *Pasquier* 6 (**P06491557**, **P06491558**), 1000 m, October 1923, *Pételot* 1519 (**HNU**), 800 m, 17 November 1998, *Ninh H* 9872, *H* 9873, *H* 9874, *H* 9875 & *H* 9877 (**HNU**), 900 m, 18 November 1998, *Ninh* 9868 (**HNU**), 19 November 1998, *Ninh H* 9868 (**HNU**).

Notes—Isolectotype **P04500219** (*Poilane* 15856) of *T. bolovenensis* has Gagnepain’s drawing, which may have been neglected by Min (2000) when he designated **K000704324** as the lectotype. As a new species, *C. maiana* was validly published twice by the same authors and in the same year:

in *Novon* on 9 June 2010 (Orel & Wilson 2010d) and in the *International Camellia Journal* (with changes that the references were omitted and a coloured photo of *C. maiana* was added, Orel & Wilson 2010c). The latter journal did not state its date of issue; however, it must be later than that of *Novon* because it included an obituary that said that a lady, Ms Edith Burke Mazzei, had died on 3 September 2010 on the page 154 (Davis 2010). Therefore, the homotypic repeated name *C. maiana* published in the *International Camellia Journal* (Orel & Wilson 2010c) was illegitimate and must be rejected (Arts. 52.1 & 52.2[a]). Remarkably, Orel and Curry (2015: 78) still wrote '*Camellia maiana* Orel, sp. nov.' and cited the protologue as the 'first publication' (Orel & Curry 2015: 81). Similarly, *C. duyana* was repeatedly stated as '*Camellia duyana* Orel, Curry & Luu, sp. nov.' (Orel & Curry 2015: 128) after it being validly published (Orel et al. 2014a).



Map 4.8. Distribution of *Camellia furfuracea* (pink triangle) and *C. gaudichaudii* (red star) in Indochina.

However, Orel (2011: 12) blamed the yet to be published Art. 39.1 of the ICN (McNeill et al. 2012) which was adopted in the Eighteenth International Botanical Congress in July 2011, calling it the ‘Latin requirement’ or ‘new rule’ of the ‘International Code of Botanical Nomenclature (ICBN)’, for stopping him from publishing the new species twice in ‘European Journals’ and the *International Camellia Journal* as he had done previously because ‘...any of my writings which contain a descriptor or diagnosis of a new, named plant species, however short, if published in English, may be considered to be the first publication’ on or after 1 January 2012. And he (Orel 2011: 12) further commented: ‘...this is the downside of the new ICBN rules!’ Unfortunately, Art. 39.1 of the ICN is not relevant to Orel’s (2011) concern as it cannot apply to the case of *C. maiana* where a Latin diagnosis was provided in each of the two publications (Orel & Wilson 2010c, 2010d).

Additionally, in the protologue of *C. maiana* (Orel & Wilson 2010d), it stated that an isotype of this species was deposited at **HN**. However, I failed to find this isotype when I visited **HN** in November 2015 and the curator of **HN**, Mr Do Van Hai, said this specimen was never housed at **HN** (private correspondence with Mr Do Van Hai on 24 November 2015). Finally, this isotype was found at **VNM**.

Camellia furfuracea differs from *C. gaudichaudii* by its larger leaves (7.5–17 × 3–7 cm) and fruit (3–5 cm in diam.) whereas the latter has smaller leaves and fruit (leaf 4.5–6.5 × 1.5–3 cm, capsule 2–2.5 cm in diam.).

[22] *Camellia gaudichaudii* (Gagnepain) Sealy in Kew Bulletin 4(2): 217. 1949 & A Revision of the Genus *Camellia* 154–155, fig. 71. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 31. 1981, quoad *Gaudichaud* 271; Hung T. Chang & B.M. Bartholomew, *Camellias* 45. 1984, quoad *Gaudichaud* 271; T.L. Ming in Acta Botanica Yunnanica 21(2): 155. 1999 & Monograph of the Genus *Camellia* 211, 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 346. 2003, excl. syn. *Thea hongkongensis* (Seemann) Pierre.

≡ *Thea gaudichaudii* Gagnepain in Notulae Systematicae 10(3): 127. 1942. —**Lectotype** (designated by Zhao et al. 2017a: 175): VIETNAM, Da Nang, ‘Tourane’, *Gaudichaud* 271 (**P01903397!**). Isolectotype: **P01903398!**.

Shrubs. *New branchlets* and *terminal buds* glabrous. *Petioles* 3–5 mm long, glabrous; *leaf blades* elliptic, 4.5–6.5 × 1.5–3 cm, coriaceous, abaxially glabrous and dark brown punctate, adaxially glabrous and shiny, midrib abaxially elevated and adaxially channelled, secondary veins 6–8 on each side of midrib, abaxially slightly raised and adaxially obscure, base cuneate, margin sparsely serrulate, apex acute or obtuse. *Flowers* solitary. *Pedicels* 2–3 mm long. *Bracteoles* and *sepals* ca. 7, caducous. *Petals* elliptic or obovate, outside pubescent and inside glabrous. *Stamens* not seen. *Ovary* ovoid, pubescen. *Styles* 3, distinct, ca. 7 mm long, pubescent and gradually becoming glabrous apically. *Capsule* oblate or globose, 2–2.5 cm in diam., ca. 2 cm in height; *pericarp* 0.5–

1.5 mm thick, furfuraceous. *Seeds* brown or fuscous, hemispherical or polyhedral, 1.5–2 in diam., glabrous.

Phenology: fruiting February–August.

Distribution: endemic to central Vietnam (Map 4.8).

Habitat: evergreen forest.

Conservation status: endangered (EN). The extent of occurrence is estimated to be less than 5000 km² and it is known to exist at less than five locations (B1, Map 4.8, IUCN 2012).

Additional specimens examined

VIETNAM. Da Nang: Son Tra, February 2013, *Chinh 37* (DLU).

Notes—*Gaudichaud 271* was one of the syntypes of *C. hongkongensis* Seemann (Seemann 1859: 342) but Gagnepain (1942: 127) recognised this single gathering to represent a different species. Three sheets of this gathering were found (**P01903397**, **P01903398** & **P01903399**) and all bear Gagnepain's manuscript note '*Thea gaudichaudii* Gagnep.'. There is a red tag 'TYPE' attached on the sheet **P01903397** that is absent on the other two sheets. However, the red tag was used after 2003 (correspondence with Dr. Sovanmoly Hul of **P** on 7 March 2016, Colhelper ID: 54849), and thus was not so labelled by Gagnepain himself. So, these three sheets are syntypes (Art. 40 Note 1). **P01903398** has one gynoeceum in the attached pocket but **P01903397** has two of them with bracteole fragments, so the latter is designated as the lectotype. The plant material of **P01903399** may be mixed with *C. hongkongensis* so it is not recognised as an isoelectotype of *T. gaudichaudii* (Zhao et al. 2017a).

Camellia gaudichaudii differs from *C. drupifera* var. *kissi* by its leaf that is punctate on the abaxial surface and its furfuraceous pericarp whereas the latter has non-punctate leaves and a smooth pericarp.

4.2.6 Section *Gilbertia*

Section *Gilbertia* D. Wei Zhao, **sect. nov.** —**Type:** *C. gilbertii* (A. Chevalier) Sealy

Bracteoles and sepals persistent; ovary sat on a cylindrical lobulate disc; styles distinct; seeds villous.

Notes—This new section is supported by the ITS phylogenetic trees (Vijayan et al. 2009) and its cylindrical lobulate disc on which the ovary sits. It is like sect. *Thea* but the latter does not have such ovary discs. Moreover, species of sect. *Gilbertia* have distinct styles and villous seeds but those of sect. *Thea* have a single style with a lobed apex and glabrous seeds.

[23] *Camellia gilbertii* (A. Chevalier) Sealy, A Revision of the Genus *Camellia* 136, t. 63. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 93, 96. 1981; Hung T. Chang & B.M.

Bartholomew, Camellias 117, 122. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 533, fig. 1468. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 153. 1999 & Monograph of the Genus *Camellia* 142, 149, 151, t. 22, fig. 6–9. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 346. 2003; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 26. 2005.

≡ *Thea gilbertii* A. Chevalier in *Bulletin Économique de l'Indochine* 22(137): 531. 1919; Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 304, 317–318. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 175. 2017. (*'gilbertii'*) — **Lectotype** (first-step designated by Min 2000: 149): VIETNAM, Phu Tho, Thanh Ba, October 1917, *Gilbert* 37714 (**P!**, four sheets; second-step lectotype designated by Zhao et al. [2017: 175]: **P01903392!**). Isolectotypes: **P01903393!**, **P01903394!**, **P01903395!**). Syntypes: VIETNAM, Phu Tho, Thanh Ba, June 1918, *Gilbert* 37541 (**P05191437!**), October 1917, *Gilbert* s. n. (**VNM00003764!**), December 1917, *Gilbert* 37715 (**P01903396!**), 23 December 1918, *Chevalier* 39552 (**P05191436!**, **P05248031!**, **P05248032!**).

Shrubs. *New branchlets* puberulous or glabrous; *terminal buds* pubescent or puberulous. *Petioles* 3–7 mm long, puberulous; *leaf blades* elliptic, 5.5–17 × 2.5–6 cm, thinly coriaceous, abaxially pale green, puberulous along midrib, adaxially dark green, glabrous and shiny, midrib and secondary veins abaxially elevated and adaxially channelled, secondary veins 6–11 on each side of midrib, base cuneate, margin sparsely serrulate, apex attenuate or acuminate. *Flowers* solitary or up to 3 in a cluster, ca. 1 cm in diam. *Pedicels* 2–4 mm long. *Bracteoles* 2–3, alternate, 2-ranked, 1–1.5 × 1–2 mm, both surfaces glabrous, margin ciliolate. *Sepals* 3–5, broadly ovate, 1.5–3.5 × 2.5–4.5 mm, both surfaces glabrous, margin ciliolate. *Petals* 5–7 in 1–2 whorls, pale yellow, broadly ovate or obovate, 4–7 × 3–5 mm, both surfaces glabrous, inner petals basally adnate to filaments for ca. 1 mm. *Stamens* 2–3 mm long; *filaments* basally connate for 1–1.5 mm, glabrous. *Ovary* ovoid, glabrous, sat on a cylindrical lobulate disc; disc ca. 1 mm long, glabrous. *Styles* 3, distinct, ca. 1.5 mm long, glabrous. *Capsule* oblate, 1–1.5 cm in diam., ca. 1 cm in height; *pericarp* ca. 0.5 mm thick. *Seeds* brown, hemispherical, 5–7 mm in diam., villous.

Phenology: flowering November–April, fruiting March.

Distribution: China and Vietnam, especially northern Vietnam (Map. 4.9).

Habitat: evergreen forest.

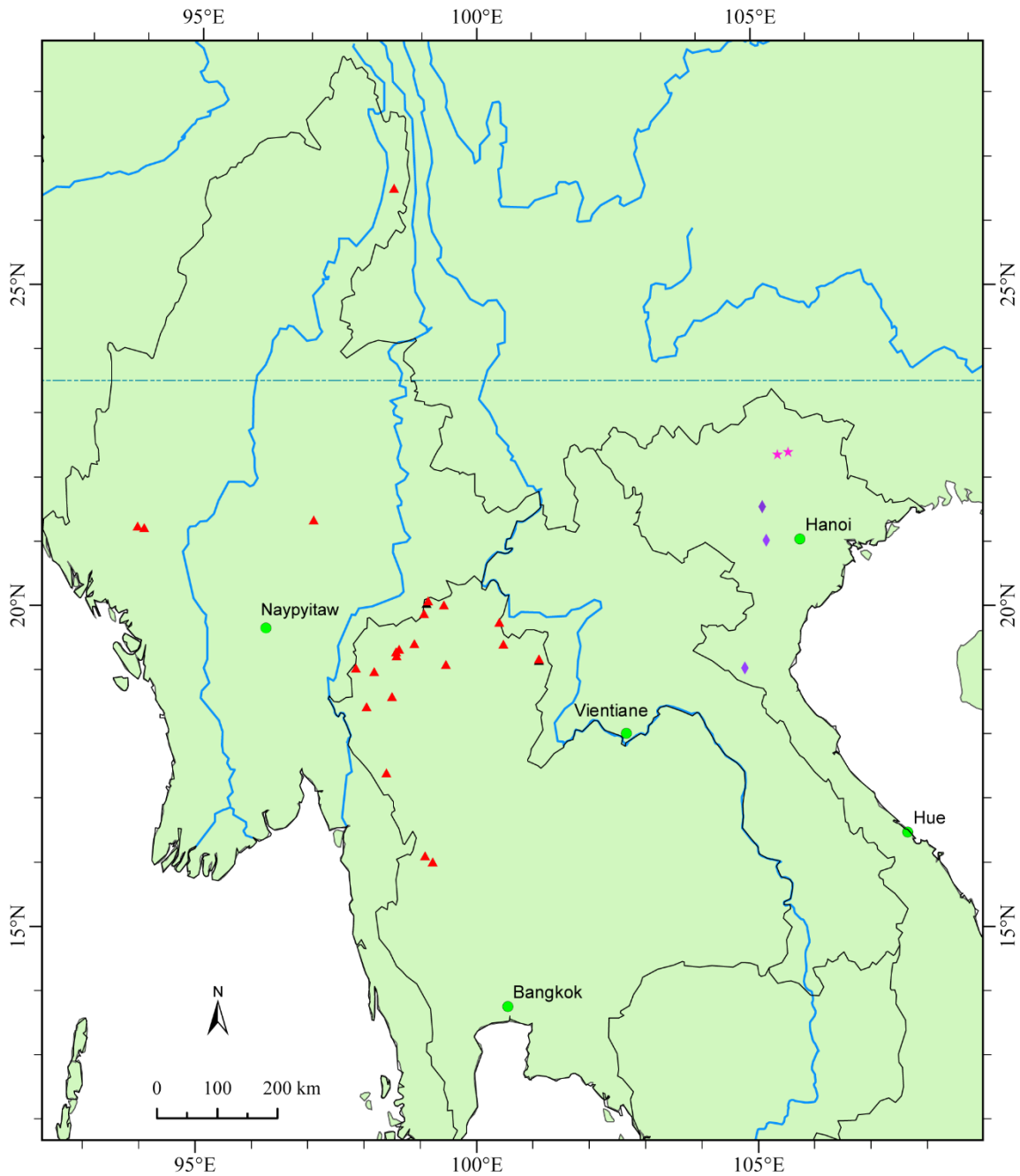
Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

VIETNAM. 1923, *Pasquier* s.n. (**P05108750**); 1924, *Pasquier* 12 (**HNL, K**); 12 April 1924, *Pasquier* s.n. (**K, P04511533**).

Nghe An: Con Cuong, Pu Mat, 'Pu Lon', 5 July 1998, *Ninh* C237 (**HNU**).

Phu Tho: November 1930, *Pasquier* 162 (**K, P04511535, P04511536**).



Map 4.9. Distribution of *Camellia gilbertii* (purple diamond), *C. megasepala* (pink star) and *C. taliensis* (red triangle) in Indochina.

Notes—No specific specimen was cited in the protologue of *Thea gilbertii* as Chevalier (1919) wrote ‘Mss. in Herb., ...assez répandu dans les forêts du Tonkin (provinces de Phu-tho, de Tuyên-quang, de Mon-cay, etc.)’. *Gilbert 37714* at **P** was selected by Min (2000: 149) as the lectotype but this collection has four duplicates at **P** (**P01903392**, **P01903393**, **P01903394** & **P01903395**). So, Min’s lectotypification should be treated as the first-step (Art. 9.17 Ex. 12). The second-step lectotype was narrowed to **P01903392** because this sheet had a dissected mature flower in its pocket which was lacking in the isotype materials (Zhao et al. 2017a).

The specific epithet of this species was ‘*gilbertii*’ in the protologue. It should be treated as an

orthographical error of ‘*gilbertii*’ under Arts. 60.12 & 60C.1 (b) (Zhang 1981a: 96, Zhang & Bartholomew 1984: 122) as it named after the collector, H. Gilbert (Zhao et al. 2017a).

4.2.7 Section *Heterogenea*

Section *Heterogenea* Sealy, A Revision of the Genus *Camellia* 152. 1958, quoad *C. henryana* Cohen-Stuart, *C. yunnanensis* (Pitard ex Diels) Cohen-Stuart & *C. wardii* Kobuski ex Merrill; T.L. Ming in Acta Botanica Yunnanica 21(2): 155–156. 1999, quoad *C. henryana*, *C. pachyandra* Hu, *C. yunnanensis* & *C. wardii*, & Monograph of the Genus *Camellia* 209–235. 2000, quoad *C. henryana*, *C. pachyandra*, *C. yunnanensis* & *C. wardii*; T.L. Ming & B.M. Bartholomew in Flora of China 12: 393–398. 2007, quoad *C. henryana*, *C. pachyandra*, *C. yunnanensis* & *C. wardii* —

Type: *C. henryana* Cohen-Stuart

Leaf blade abaxially punctate; veinlets clearly visible on both surfaces of leaf blade; ovary pubescent; styles usually 3, distinct.

Notes—As discussed in Section 2.4.4(f), sect. *Heterogenea* is amended to include *C. connata*, a species with outer filaments completely united into a tube. The filament tube was valued as a diagnostic character in the rank of section by Sealy (1958), Zhang (1981a) and Min (2000) and they placed *C. connata* in sect. *Calpandria* with *C. lanceolata*, which also has such a tube formed by the filaments. However, *RPB2* gene tree (Figure 2.9) do not support a close relationship between *C. connata* and *C. lanceolata*, suggesting that the filament tube may not be a synapomorphy (see Section 3.4.2, Figure 3.6).

[24] *Camellia connata* (Craib) Craib, Florae Siamensis Enumeratio 1(1): 131. 1925; Sealy, A Revision of the Genus *Camellia* 141, 145–146, fig. 67. 1958; H. Keng in Flora of Thailand 2(2): 146–147. 1972; Hung T. Chang, A Taxonomy of the Genus *Camellia* 108. 1981; Hung T. Chang & B.M. Bartholomew, Camellias 136–137. 1984; T.L. Ming in Acta Botanica Yunnanica 21(2): 158. 1999 & Monograph of the Genus *Camellia* 311, 313. 2000.

≡ *Thea connata* Craib in Bulletin of Miscellaneous Information 1: 6. 1914; Gagnepain in Humbert, Supplément a la Flore Générale de l’Indo-Chine 1(3): 304, 314. 1943; D. Wei Zhao et al. in Phytotaxa 292(2): 174. 2017. —**Lectotype** (first-step designated by Sealy 1958: 146):

THAILAND, Chiang Mai, Doi Suthep, 1520 m, 25 June 1911, *Kerr 1878* (K!, two sheets; second-step lectotype designated by Zhao et al. [2017: 174]: **K000704325!**). Isolectotypes:

BM000603019!, **K000704326!**, **P04511820!**, **TCD0010539!**. Syntypes: THAILAND, Chiang Mai, Doi Suthep, 1670 m, 6 October 1912, *Kerr 2732* (**BM000603029!**, **K!**, **TCD0010540!**).

Shrubs or trees up to 8 m. *New branchlets* puberulous; *terminal buds* pubescent. *Petioles* 2.5–7 mm long, sparsely puberulous; *leaf blades* elliptic to oblong, 5.5–12 × 3–5 cm, thinly coriaceous, abaxially yellowish green and brown punctate, glabrous or sparsely puberulous along midrib, adaxially yellowish or dark green, shiny, hirsute along midrib, midrib abaxially elevated and

adaxially slightly raised, secondary veins 9–12 on each side of midrib, slightly raised on both surfaces, base attenuate to rounded, margin serrulate, apex acute to attenuate. *Flowers* solitary or paired, ca. 2 cm in diam., subsessile. *Bracteoles* 3–6, alternate, 2-ranked, gradually transitioning to sepals, deltate to semi-orbicular, $1.5\text{--}3 \times 1\text{--}2.5$ mm, outside glabrous or sparsely puberulous, inside glabrous. *Sepals* 4–5, sub-orbicular or ovate, $3.5\text{--}5 \times 4\text{--}6$ mm, outside glabrous or sparsely puberulous, inside glabrous, margin ciliolate and usually lacerate. *Petals* 6–7 in 2 whorls, elliptic or ovate, glabrous, outer 2 petals $5\text{--}7 \times 7\text{--}9$ mm, greenish white, inner 4–5 petals basally adnate to filament whorl for ca. 3 mm. *Stamens* 14–20; *filaments* yellowish orange, glabrous, outer 9–14 filaments completely united into a 7–12 mm long tube, ca. 5 mm in diam., apex irregularly dentate, each tooth bearing an anther, remaining filaments 6–9 mm long, borne on the filament tube. *Ovary* globose to ovoid, pubescent. *Styles* 3, distinct, ca. 1.5 mm long, glabrous or sparsely puberulous at base. *Capsule* ovoid or globose, 10–25 mm in diam.; *pericarp* 0.5–1 mm thick. *Seeds* black to brown, globose or hemispherical, 1–1.5 cm in diam., glabrous. Figure 4.7.

Phenology: flowering April–August, fruiting July–November.

Distribution: endemic to northern Thailand (Map 4.10).

Habitat: tropical evergreen, mixed evergreen and deciduous forests, 550–2000 m.

Conservation status: near threatened (NT). This species is endemic to a small (< 20000 km², Map 4.10), protected area in northern Thailand. It may be vulnerable to environmental fluctuations, such as climate change, and is likely to qualify for a threatened category in the near future (IUCN 2012).

Additional specimens examined

THAILAND. Chiang Mai: 610 m, 16 July 1923, *Winit 1134* (**BKFSN060818**, **K**); Chiang Dao, Doi Chiang Dao, ‘east side, Sop Huay Pah Dahng-Huay Nah Lao Station’, 575 m, 18 August 1995, *Bella & Nanny 5* (**CMUB** 06549); Chom Thong, Doi Inthanon, Mae Uam Station, ca. 1700 m, 2 April 2008, *Watthana 2735* (**QBG** 37391); Fang, Doi Ang Khang, ca. 1500 m, 14 July 1922, *Kerr 6294* (**BK203711**, **BM**, **K**), 1400–1800 m, 8 June 1976, *Charoensorn s.n.* (**BK203714**); Mae Chaem, ca. 800 m, 22 October 1922, *Kerr 6428* (**BK203710**, **K**), Doi Inthanon, between 34 km and 35 km, on the road to Mae Aum Watershed Management Station, 1590–1640 m, 12 November 2015, *Zhao et al. 84* (**BKF**, **TCD**), 85–88 (**TCD**), 89–90 (**BKF**, **TCD**), 91 (**TCD**), 92 (**BKF**, **TCD**), 93 (1), (2) (**TCD**) & 94 (**BKF**, **TCD**); Mueang Chiang Mai, Doi Suthep-Pui, 18°49'42"N, 98°53'26"E, 1636 m, 13 November 2015, *Zhao et al. 97* (1) & (2) (**TCD**).

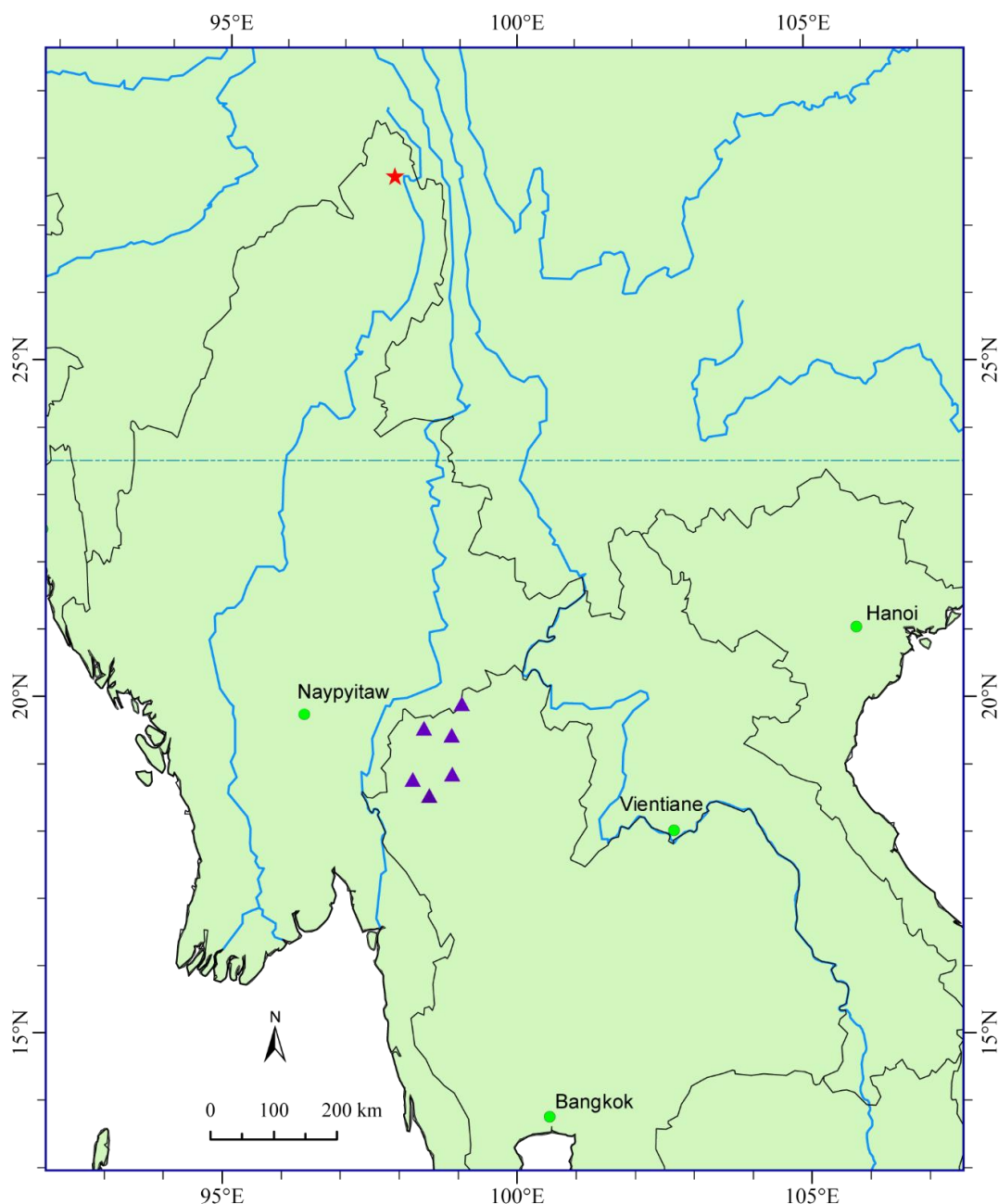
Mae Hong Son: Pai, Doi Chang, 2000 m, 31 May 1977, *Santisuk 1131* (**BKFSN178498**).

Notes—Craib (1914) cited two gatherings ‘*Kerr 1878*, 2732’ in the protologue of *T. connata*. Sealy (1958) designated the collection ‘*A.F.G. Kerr 1878*’ at **K** as the type but this collection has two duplicates at **K** (**K000704325** & **K000704326**). So, Sealy’s lectotypification should be considered as the first-step (Art. 9.17 Ex. 12). The specimen **K000704325** has more flowers and detailed collection information so it is designated here as the second-step lectotype (Zhao et al. 2017a).

Camellia connata closely resembles *C. lutescens* but differs from the latter by its filament tube (Figure 4.7) which *C. lutescens* does not have.



Figure 4.7. *Camellia connata*. A: habit; B: young branches; C: a branch with an immature fruit; D: flower, shows petals and androecium; E: flower, shows bracteoles and sepals; F: a dissected flower without petals; G: fruit and seeds. The bars represent 5 cm, 5 mm, 1 cm and 5 mm in B, D, E and F, respectively. The minimum graduation of the ruler in G indicates 1 mm.



Map 4.10. Distribution of *Camellia connata* (purple triangle) and *C. lutescens* (red star) in Indochina.

[25] *Camellia lutescens* Dyer in Hooker f., *Flora of British India* 1(2): 293. 1874; Brandis, *Indian Trees* 61. 1906; Cohen-Stuart, *Mededeelingen van het Proefstation voor Thee* 40: 66, 69, 71. 1916 & in *Bulletin du Jardin Botanique*, 3rd series 1(4): 238, 241, 243, 247. 1919; Sealy, *A Revision of the Genus Camellia* 212, fig. 96. 1958; Hung T. Chang, *A Taxonomy of the Genus Camellia* 33, 35. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 49, 51. 1984. — **Lectotype (designated here)**: CHINA, Tibet, 'Mishmi Hills, high up on Laim-planj-thaya', 15 November 1836, Griffith 777 (**K000380541!**). Isolectotype: **P01903381!** Syntypes: Griffith 779 (**K000380542!** **P04511454!**)

≡ *Thea lutescens* (Dyer) Pierre, *Flore Forestière de la Cochinchine* 2(8): supra t. 119. 1887; Kochs

in Engler, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 27(5): 589. 1900.

= *Camellia pachyandra* Hu in Bulletin of the Fan Memorial Institute of Biology, Botany Series 8(3): 131. 1938; Sealy, A Revision of the Genus *Camellia* 216, fig. 98. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 93, 95. 1981 & in *Flora Reipublicae Popularis Sinicae* 49(3): 96, 97, t. 27: 1–4. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 117, 118, t. 38, fig. 1–4. 1984; T.L. Ming in *Flora Yunnanica* 8: 266, 292. 1997, in *Acta Botanica Yunnanica* 21(2): 156. 1999 & Monograph of the Genus *Camellia* 211, 231, t. 50, fig. 4–7. 2000; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 393, 397. 2007; Q. Lin et al. in *Acta Botanica Boreali-Occidentalia Sinica* 28(8): 1696. 2008. **Syn. nov.** —**Lectotype** (designated by Lin et al. 2008: 1696): CHINA, Yunnan, Linchang, Cangyuan, 1500 m, April 1936, C. W. Wang 73288 (PE00024320!). Isolectotypes: K000704278!, P04500365!, PE00024319!. Paratypes: CHINA, Yunnan, Linchang, Cangyuan, 1450 m, April 1936, C. W. Wang 73204 (PE00024321!, PE00024322!, PE00629291!).

= *Camellia taheishanensis* F.C. Zhang in *Acta Botanica Yunnanica* 2(3): 343, t. 1, fig. 7–11. 1980. —**Holotype**: CHINA, Yunnan, Menghai, Bada, 4 April 1979, Zhang 2. Isotypes: KUN1223158!, KUN0695547!.

= *Camellia muricatula* Hung T. Chang, A Taxonomy of the Genus *Camellia* 93. 1981 & in *Flora Reipublicae Popularis Sinicae* 49(3): 96–97. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 117–118. 1984. **Syn. nov.** —**Holotype**: CHINA, Yunnan, Dehong, Xima, 1700 m, 5 September 1972, Yang 6918. Isotype: **HITBC** 57632!. Paratypes: CHINA, Yunnan, Dehong, Xima, 400 m, 3 November 1974, Tao 13131 (**HITBC**, KUN1206078!).

= *Camellia wardii* Kobuski ex Merrill var. *muricatula* (Hung T. Chang) T.L. Ming in *Flora Yunnanica* 8: 292. 1997, in *Acta Botanica Yunnanica* 21(2): 155. 1999 & Monograph of the Genus *Camellia* 230. 2000; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 397. 2007. **Syn. nov.**

Shrubs or trees 2–10 m tall. *New branchlets* glabrous or puberulous; *terminal buds* puberulous or pubescent. *Petioles* 4–7 mm long, glabrous or puberulous; *leaf blades* elliptic, oblong, oblanceolate or narrowly ovate, 5.5–10.5 × 2–4 cm, coriaceous, abaxially yellowish green, puberulous and brown punctate, adaxially dark green and glabrous, midrib abaxially elevated and adaxially slightly raised, secondary veins 8–12 on each side of midrib, abaxially slightly raised and adaxially slightly impressed, veinlets clearly visible on both surfaces, base cuneate, attenuate or obtuse, margin serrulate, apex attenuate, acute or caudate. *Flowers* solitary, 1.5–3.5 cm in diam., subsessile. *Bracteoles* and *sepals* 5–6, crescent or ovate, 2.5–8 × 3–7 mm, outside glabrous or puberulous along midrib, inside glabrous or sparsely sericeous, margin membranous and usually lacerate. *Petals* ca. 5, white, elliptic, oblong or obovate, 10–20 × 6–11 mm, both surfaces glabrous. *Stamens* 6–10 mm long; *filaments* glabrous, swollen basally, basally connate for 2–4 mm and adnate to petals for ca. 1 mm. *Ovary* globose, pubescent. *Styles* 3(–4), distinct, ca. 1 mm long, glabrous.

Capsule globose or oblate, 1.5–4 cm in diam.; *pericarp* 1–2 mm thick. *Seeds* brown, globose hemispherical or polyhedral, 1–1.5 cm in diam., glabrous.

Phenology: flowering November–April, fruiting November–June.

Distribution: China and Myanmar, especially northern Myanmar (Map 4.10).

Habitat: montane evergreen forest, 400–1750 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Additional specimens examined

MYANMAR. Kachin: Putao, Naungmung, ‘buffer zone of Hkakaborazi National Park, between Pannadim village and Shingsankhu rest house’, 27°42'17"N, 97°52'41"E, 1754 m, 6 November 2015, *Armstrong et al.* 1275 ([NY02649022](#)).

Notes—*Camellia lutescens* morphologically differs from *C. wardii* by having fewer petals (usually 5) and shorter styles (ca. 1 mm long) whereas the latter has more petals (8–10) and longer styles (7–9 mm long).

[26] *Camellia wardii* Kobuski ex Merrill in *Brittonia* 4(1): 114. 1941; Sealy, A Revision of the Genus *Camellia* 153, 158, fig. 74. 1958; Hung T. Chang in *Flora Reipublicae Popularis Sinicae* 49(3): 92, t. 26: 4–5. 1998; T.L. Ming in *Flora Yunnanica* 8: 266, 292, t. 74: 6–7. 1997 & in *Acta Botanica Yunnanica* 21(2): 155. 1999 & *Monograph of the Genus Camellia* 211, 228, t. 47: 5–9. 2000; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 394, 397. 2007. —**Holotype:** MYANMAR, ‘North Burma, Pyepat’, 2100 m, 22 December 1938, *Ward* 145 ([A00024745†](#)). Isotype: [BM000603011!](#).

Shrubs or trees 2–6 m tall. *New branchlets* glabrous or puberulous; *terminal buds* pubescent. *Petioles* 5–10 mm long, glabrous or puberulous; *leaf blades* elliptic to oblong, 8–12 × 2.8–4.5 cm, coriaceous, abaxially reddish brown punctate and puberulous along midrib, adaxially glabrous, midrib abaxially elevated and adaxially flat, secondary veins 10–13 on each side of midrib, abaxially slightly raised and adaxially flat or slightly impressed, veinlets clearly visible on both surfaces, base cuneate or obtuse, margin sharply pointed serrulate, apex attenuate to caudate. *Flowers* solitary, 3–4 cm in diam., subsessile. *Bracteoles* and *sepals* 9–10, crescent or broadly ovate, 3–13 × 3.5–15 mm, outside pubescent or puberulous, inside puberulous or glabrous, margin membranous and usually lacerate. *Petals* 8–10 in 2 whorls, white, elliptic or obovate, 12–24 × 8–20 mm, outside puberulous at apex or glabrous, inside glabrous. *Stamens* 8–13 mm long; *filaments* glabrous, outer filaments basally connate for 3–5 mm. *Ovary* globose or oblate, pubescent. *Styles* 3, distinct, 7–9 mm long, puberulous and gradually becoming glabrous apically. *Capsule* globose or oblate, 1.5–4 cm in diam. *Seeds* not seen.

Phenology: flowering September–December, fruiting January.

Distribution: China and Myanmar.

Habitat: montane evergreen forest, on slopes or along streams.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Notes—In Indochina, only the holotype (*Ward 145*) collected from Myanmar was available to me. Its locality is too vague to be relocated so there is no map of this species.

4.2.8 Section *Paracamellia*

Section *Paracamellia* Sealy, A Revision of the Genus *Camellia* 192. 1958, excl. *C. grijsii* Hance; Hung T. Chang, A Taxonomy of the Genus *Camellia* 32–43. 1981, excl. *C. grijsii*, *C. lutescens* Dyer, *C. shensiensis* Hung T. Chang & *C. tenii* Sealy, & in *Flora Reipublicae Popularis Sinicae* 49(3): 22–33. 1998, excl. *C. grijsii*, *C. shensiensis* & *C. tenii*; Hung T. Chang & B.M. Bartholomew, *Camellias* 48–63. 1984, excl. *C. grijsii*, *C. lutescens*, *C. shensiensis* & *C. tenii*; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 157–158. 1999, excl. *C. grijsii* & Monograph of the Genus *Camellia* 289–310. 2000, excl. *C. grijsii*; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 409–412. 2007, excl. *C. grijsii* —**Type:** *C. drupifera* Loureiro var. *kissi* (Wallich) D. Wei Zhao = *Camellia* sect. *Oleifera* Hung T. Chang, A Taxonomy of the Genus *Camellia* 22. 1981. —**Type:** *C. oleifera* C. Abel

= *Camellia* sect. *Pierrea* Orel ex Orel, Peter G. Wilson, Curry & Luu in *Novon* 23(3): 310. 2014; Orel & Curry, In Pursuit of Hidden *Camellias* 132. 2015. **Syn. nov.** —**Type:** *C. ligustrina* Orel, Curry & Luu

= *Camellia* sect. *Lamdongia* Orel ex Orel & Curry, In Pursuit of Hidden *Camellias* 180. 2015. **Syn. nov.** —**Type:** *C. cuongiana* Orel & Curry

Bracteoles undifferentiated from sepals, both caducous after flowering; ovary pubescent; styles usually 3, distinct.

Notes—Compared with other sections, sect. *Paracamellia* may have the largest geographic distribution area in Indochina (e.g., Maps 4.11–4.12). It morphologically differs from sect. *Furfuracea* by its smooth pericarp whereas the latter has furfuraceous pericarp.

Seeds of some species from this section, e.g., *C. drupifera*, are used to extract edible oil. Those plants are widely cultivated as woody oil crop in the mountainous areas of southern China and northern Vietnam.

[27] *Camellia drupifera* Loureiro, *Flora Cochinchinensis* 2: 411. 1790; G. Don, A General History of the Dichlamydeous Plants, 1: 577. 1831; Brandis, *Indian Trees* 61. 1906, excl. syn. *Camellia kissi* Wallich; Dunn & Tutchter, *Flora of Kwangtung and Hongkong (China)* (in *Bulletin of Miscellaneous Information, Additional Series* 10) 45–46. 1912; T.L. Ming & B.M. Bartholomew in

Flora of China 12: 409–411. 2007, excl. syn. *Camellia gauchowensis* Hung T. Chang —**Neotype** (designated by Min & Bartholomew 2007: 411): CHINA, Guangxi, Liucheng, Satang Forest Station, cultivated, July 1956, *Huang 2043* (**PE01432097!**).

≡ *Thea drupifera* (Loureiro) Pierre, Flore Forestière de la Cochinchine 2(8): supra t. 119. 1887.

= *Thea confusa* Craib in Bulletin of Miscellaneous Information 1: 5. 1914; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 304, 315. 1943; D. Wei Zhao et al. in Phytotaxa 292(2): 173. 2017.—**Lectotype** (first-step designated by Craib 1925: 131): THAILAND, Chiang Mai, Doi Suthep, 1200–1500 m, 31 October 1909, *Kerr 889* (**K!**, two sheets; second-step lectotype designated by Zhao et al. [2017: 173]: **K000704304!**). Isolectotypes: **BM000603018!**, **K000704692!**, **P04511822!**, **TCD0010537!**. Syntypes: THAILAND, Chiang Mai, Doi Suthep, 1280 m, 4 September 1910, *Kerr 1363* (**BM!**, **K000704693!**, **K000704694!**, **TCD0010541!**), 18°49'N, 98°53'E, 1605 m, 20 November 1910, *Garrett 100* (**BK203731!**, **K000704697!**, **TCD0010542!**), 1700 m, 11 December 1904, *Hosseus 180* (**BM!**, **C!**, **E00681091!**, **K000704695!**, **M-0111973†**, **P04511823!**, **P04511825!**).

= *Camellia confusa* (Craib) Cohen-Stuart in Mededeelingen van het Proefstation voor Thee 40: 130, fig. 14. 1916; Craib, Florae Siamensis Enumeratio 1(1): 131. 1925; Melchior in Engler, Die Natürlichen Pflanzenfamilien, 2nd ed. 21: 126, 129. 1925; Nakai in The Journal of Japanese Botany 16(12): 692. 1940; Hung T. Chang, A Taxonomy of the Genus *Camellia* 34. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 22, 24. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 49–50. 1984.

= *Camellia oleifera* C. Abel var. *confusa* (Craib) Sealy, A Revision of the Genus *Camellia* 209, fig. 95. 1958; H. Keng in Flora of Thailand 2(2): 147–148. 1972.

= *Camellia kissi* Wallich var. *confusa* (Craib) T.L. Ming in Flora Yunnanica 8: 300. 1997, excl. syn. *Thea oxyanthera* Gagnepain, in Acta Botanica Yunnanica 21(2): 158. 1999 & Monograph of the Genus *Camellia* 306–307, t. 72, fig. 4–7. 2000, excl. syn. *Thea oxyanthera* Gagnepain; T.L. Ming & B.M. Bartholomew in Flora of China 12: 411–412. 2007, excl. syn. *Thea oxyanthera* Gagnepain.

≡ *Camellia vietnamensis* Tso C. Huang ex Hu in Acta Phytotaxonomica Sinica 10(2): 138. 1965; P.H. Hô, Cây cỏ Việt Nam 1(1): 529, fig. 1458. 1991; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 350. 2003.

Trees or shrubs up to 12 m tall. *New branchlets* puberulous; *terminal buds* puberulous or glabrous. *Petioles* 5–15 mm long, puberulous; *leaf blades* elliptic, obovate, oblong or ligulate, 5.5–13 × 2–4.5 cm, coriaceous, abaxially yellowish green and glabrous, adaxially dark green, hirsute along midrib, midrib abaxially elevated and adaxially slightly impressed or flat, secondary veins 7–11 on each side of midrib, flat or obscure on both surfaces, base attenuate, cuneate or rounded, margin sparsely serrate, apex attenuate, acute, acuminate or caudate. *Flowers* solitary, 4.5–10 cm in diam.,

subsessile. *Bracteoles* and *sepals* 6–8, crescent to broadly ovate, 1.5–20 × 3–10 mm, outside glabrous, puberulous or pubescent, inside glabrous, margin ciliolate. *Petals* 6–8 in 1–2 whorls, white, elliptic or obovate, 2.5–5.5 × 1.5–4 cm, outside glabrous, puberulous or pubescent at apex, inside glabrous, apex bilobed. *Stamens* 1–1.5 cm long; *filaments* yellow, glabrous, basally connate for 2–3 mm. *Ovary* globose, pubescent. *Styles* 3(–4), distinct or basally connate, 8–12 mm long, basally pubescent and gradually becoming glabrous apically. *Capsule* globose or oblate, 2.5–6 cm in diam., 2–5 cm in height; *pericarp* 2–8 mm thick. *Seeds* brown or fuscous, hemispherical, polyhedral or globose, 1.5–2.5 cm in diam., glabrous.

Phenology: flowering October–January, fruiting December–September.

Distribution: China, Laos, Myanmar, Thailand and Vietnam (Map 4.11).

Habitat: evergreen forest, 350–1700 m.

Conservation status: least concern (LC). This species is widespread and abundant in tropical China and Indochina (IUCN 2012).

Additional specimens examined

LAOS. Attapeu: ‘entre Phu Da Phuk et Se noi plateau des Boloven’, 500–600 m, 13 October 1928, *Poilane 15990* (**P04500183**)

Champasak: ‘plateau des Boloven’, 7 October 1928, *Poilane 15888* (**K**, **VNM00003781**).

MYANMAR. Mon: Thaton, ‘Dawna Range’, 22 February 1909, *Lace 4624* (**E00681063**, **K**).

THAILAND. Chiang Mai: Chom Thong, Ban Pha Mon, 900 m, 31 May 1979, *Vidal & Vidal 6247C* (**K**), Doi Inthanon, 9 November 1930, *Put 3406* (**BK203746**, **K**), 3 December 1964, *Bunchuai 1420* (**C**, **E00681078**), 18°30'N, 98°30'E, 1400–1700 m, 13 September 1974, *Larsen & Larsen 34521* (**BKFSN060816**), 18°40'N, 98°25'E, 1400 m, 3 January 1975, *Geesink et al. 8045* (**BKFSN060804**, **C**), 1680 m, 19 December 1983, *Fukuoka & Ito T-35316* (**BKFSN060813**), 1300 m, 12 January 1997, *Hara A730* (**BKFSN173320**), 1700 m, 18 November 1998, *Hara et al. C002* (**BKFSN173305**) & *C044* (**BKFSN173303**), ‘road to Khun Wang’, 1310 m, 24 October 2000, *Chayamarit et al. 2204* (**BKFSN173163**); Fang, Doi Ang Khang, 1490 m, 8 December 1934, *Garrett 905* (**BKFSN060834**, **E00681092**, **K**), ca. 1400 m, 22 May 1935, *Garrett 962* (**BKFSN060833**, **E00681077**, **K**); Mae Cham, Mae Sanga, 1300 m, 6 May 2000, *Sangnin & Sillapasuwat 3346* (**BKFSN138882**), ‘between 34 and 35 km, on the road to Mae Aum Watershed Management Station’, 18°30'30"N, 98°30'19"E, 1636 m, 12 November 2015, *Zhao et al. 83* (**BKF**, **TCD**); Mueang Chiang Mai, Doi Suthep, ca. 1600 m, 22 December 1920, *Kerr 4680* (**BK203745**); ca. 900 m, 1 October 1922, *Kerr 6374* (**BK203740**, **BM**, **K**), 1300 m, 20 February 1959, *Sørensen et al. 6967* (**BKFSN060827**, **C**, **K**), ca. 900 m, 17 November 1922, *Kerr 6676* (**BK203730**, **BM**, **K**) & *6676A* (**BK203741**, **BM**, **E00681089**, **K**); 1600 m, 18 November 1922, *Kerr s.n.* (**BM**), ca. 600 m, 27 April 1965, *Phengklay 1028* (**BKFSN060830**); 1050 m, 7 November 1987, *Maxwell 87-*

1379 (**BKFSN060825**); ‘east side of Doi Pui at the Chang Kian Agricultural Station’, 1350 m, 24 November 1988, *Maxwell 87-1351* (**BKFSN060851**); Samoeng, Samoeng Tai, ‘Ban Pa Kar’, 1424 m, 24 June 2008, *Jatupol 08-233* (**QBG 35892**).

Loei: Phu Kradueng, ‘top area of Phu Kradueng’, 1200–1300 m, 19 December 1982, *Koyama et al. T-31384* (**BKFSN060872**); Phu Ruea, 13 December 1966, *Umpai 311* (**BK203736**), Phu Luang, 17°17'2"N, 101°31'8"E, 1440 m, 3 November 2015, *Zhao et al. 26, 27, 32 & 33* (**BKF, TCD**); Wang Saphung, Phu Luang, 27 November 1957, *Bunpheng 958* (**C, K**), 900–1000 m, 15 November 1968, *Chermsirivathana 1057* (**BK203722**); 1410 m, 13 May 1998, *Chayamarit et al. 1357* (**BKF**)

Nan: Pua, Doi Phu Kha, 1100 m, 17 August 1995, *Pooma 1104* (**BKFSN167083**); 19°13'N, 101°5'E, 1500 m, 8 October 1998, *Srisanga 293* (**QBG 12268**) & 294 (**QBG 12269**).

Sakon Nakhon: Phu Phan, ca. 17°N, 104°E, 380–450 m, 12 November 1984, *Murata et al. T-51155* (**BKFSN115022**); ‘Huai Lub Num Lud’, 9 March 1996, *Puudjaa 195* (**BKFSN091534**).

Sukhothai: Khiri Mat, Kao Luang, ca. 1000 m, 2 May 1922, *Kerr 5917* (**BK203747**).

VIETNAM. ‘Tonkin’, *Bon 4258* (**P04511759, P04511761**); ‘Ke Non, in monte Voi’, 7 December 1885, *Bon 3068* (**P04511460**).

Binh Dinh: Qui Nhon, ‘col de Mangiang’, 900–1000 m, 19 August 1930, *Poilane 18029* (**P04500174, P04500181**).

Hanoi: Ba Vi, ‘Thu Phap’, 6 January 1965, *ĐKSVT 1100* (**HN**).

Kontum: ‘montagne Mam Ray’, 1350 m, 2 September 1930, *Poilane 18199* (**P04500193**).

Lang Son: Loc Binh, 25 April 1963, *Nguyen 7065* (**HN**).

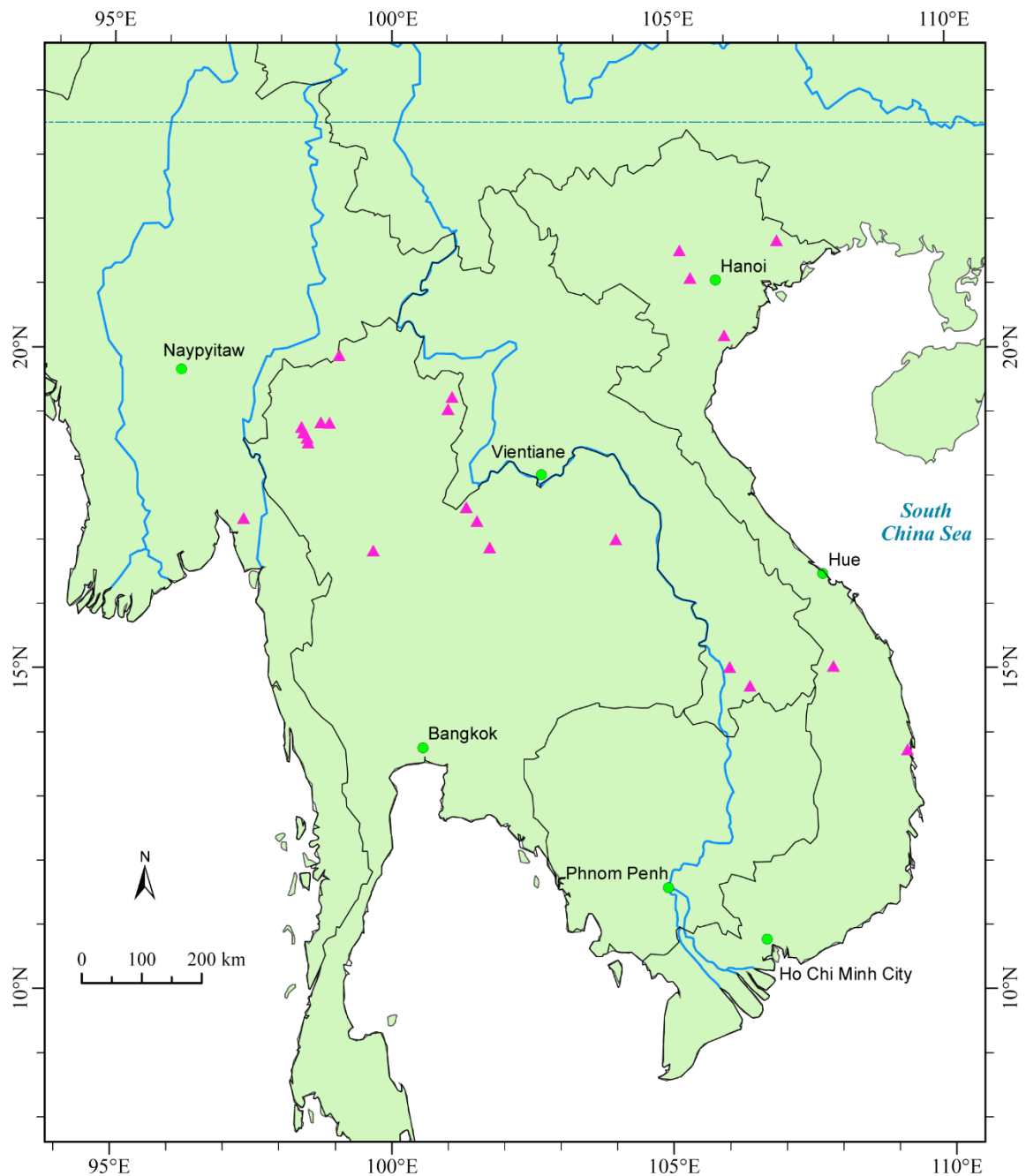
Ninh Binh: Yen Mo, Khanh Thuong, 20 December 1881, *Bon 1154* (**BKFSN060918, P04511741, P04511742**); ‘route de Yen Doi à Thi-ne’, 27 November 1913, *Chevalier 29194* (**P05278733**).

Phu Tho: Thanh Ba, 23 December 1918, *Chevalier 39548* (**P05286398**).

Notes—Four gatherings of *T. confusa* were cited in its protologue: *Kerr 889, 1363, Garrett 100 & Hosseus 180* (Craib 1914: 6). Later Craib (1925: 131) cited ‘*Kerr, 889* [type!]’ by which he selected *Kerr 889* as the lectotype (Arts. 9.17 & 40 Note 1). Ming (2000) further denoted ‘*Kerr 889* (K)’ as the lectotype but failed to fix the lectotype to a single specimen at **K**. The lectotypifications of both Craib (1925) and Ming (2000) must be followed (Art. 9.17) and **K000704304** is designated as the second-step lectotype because it has dissected flowers in its attached pocket (Zhao et al. 2017a).

Camellia drupifera morphologically differs from its two varieties, *C. drupifera* var. *kissi* and *C. drupifera* var. *stenophylla*, by its larger flower (4.5–10 cm in diam.) and thicker pericarp (2–8 mm thick) whereas the latter two have a smaller flower (1–4.5 cm in diam.) and a thinner pericarp (0.5–

1.5 mm thick).



Map 4.11. Distribution of *Camellia drupifera* (pink triangle) in Indochina.

[28] *Camellia drupifera* var. *kissi* (Wallich) D. Wei Zhao, **comb. nov.**

≡ *Camellia kissi* Wallich in Asiatick Researches 13: 429. 1820; G. Don, A General History of the Dichlamydeous Plants, 1: 576–577. 1831; Wallich, Plantae Asiaticae Rariores 3: 36, t. 256. 1832 & in The Journal of the Asiatic Society of Bengal 4(37): 48, t. 2, fig. 7–12. 1835; Loudon, Arboretum et Fruticetum Britannicum 1: 390–391, fig. 99. 1838; Sealy, A Revision of the Genus *Camellia* 192, 197–201, fig. 91. 1958, excl. syn. *Camellia mastersia* Griffith; Banerji, Contributions to the Flora of East Nepal (in Records of the Botanical Survey of India 19[2]) 27. 1965; Hung T. Chang,

A Taxonomy of the Genus *Camellia* 35, t. 6, fig. 3–4. 1981 & in *Flora Reipublicae Popularis Sinicae* 49(3): 22, 24, 25, t. 5, fig. 3–4. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 49–50. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 530, fig. 1461. 1991; T.L. Ming in *Flora Yunnanica* 8: 299–300. 1997 & in *Acta Botanica Yunnanica* 21(2): 157. 1999 & Monograph of the Genus *Camellia* 290, 303–306, t. 72, fig. 1–3. 2000, excl. syn. *Camellia lutescens* Dyer, *Camellia mastersia* Griffith & *Thea lutescens* (Dyer) Pierre; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 347. 2003; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 411. 2007, excl. syn. *Camellia lutescens* Dyer. —**Holotype**: NEPAL, 1818, *Gardner s.n.* (**BM000948697!**)

= *Camellia keina* Buchanan-Hamilton ex D. Don, *Prodromus Florae Nepalensis* 224. 1825. —

Holotype: NEPAL, ‘Narain hetty’, 9 September 1802, *Buchanan s.n.* (**BM000521691!**).

= *Camellia symplocifolia* Griffith, *Itinerary Notes of Plants Collected in the Khasyah and Bootan Mountains, 1837–38, in Affghanisthan and Neighbouring Countries. 1839 to 1841.* 40. No. 652. 1848 & *Notulae ad Plantas Asiaticas* 4: 560. 1854, ‘*Camellia simplicifolia* Griffith’. —**Lectotype (designated here)**: INDIA, ‘Khasiya hills’, *Griffith s.n.* (**TCD!**).

= *Thea bachmaensis* Gagnepain in *Notulae Systematicae* 10(3): 124. 1942 & in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 303, 312. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 173. 2017. —**Lectotype** (first-step designated by Sealy 1958: 199): VIETNAM, Thua Thien Hue, ‘Núi Bach Ma Station d’altitude de Huê’, 1400–1500 m, 12 December 1940, *Poilane 31118* (**P!**, two sheets; second-step lectotype designated by Zhao et al. [2017: 173]: **P01903389!**). Syntypes: VIETNAM, Thua Thien Hue, ‘Núi Bach Ma Station d’altitude de Huê’, 1200–1500 m, 15 December 1940, *Poilane 31184* (**P04500130!**, **P04500133!**).

= *Thea brachystemon* Gagnepain in *Notulae Systematicae* 10(3): 126. 1942 & in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 303, 312, t. 30, fig. 1–6. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 173. 2017. —**Lectotype** (designated by Zhao et al. 2017a: 173): LAOS, Attapeu, ‘entre Nong Met et B. Thuôt, plateau des Boloven’, 8 October 1928, *Poilane 15908* (**P01903386!**). Isolectotypes: **P01903387!**, **VNM00003724!**). Syntypes: LAOS, Attapeu, ‘entre Nong Met et B. Thuôt, plateau des Boloven’, 700 m, 8 October 1928, *Poilane 15917* (**P01903388!**). INDIA. Manipur: Ching Sow, 1520–2130 m, January 1882, *Watt 5182* (**K!**, **P04500196!**).

= *Thea oxyanthera* Gagnepain in *Notulae Systematicae* 10(3): 130. 1942 & in Humbert, *Supplément a la Flore Générale de l’Indo-Chine* 1(3): 303, 310, t. 29, fig. 10–14. 1943; Sealy, A *Revision of the Genus Camellia* 223–224, fig. 101. 1958. —**Holotype**: LAOS, Champasak, ‘Plateau des Boloven, entre Nong Bok Kao et Phong Tham’, 700 m, 7 October 1928, *Poilane 15890* (**P01903373!**).

= *Theopsis euonymifolia* Hu in *Acta Phytotaxonomica Sinica* 10(2): 140. 1965. —**Holotype**: CHINA, Yunnan, Pu’er, Jingdong, 1050 m, 13 December 1939, *Li 1506* (**KUN1206027†**). Isotype:

SYS00092010!.

= *Camellia osmantha* C.X. Ye, Jin L. Ma & H. Ye ex Jin L. Ma, H. Ye & C.X. Ye in *Guihaia* 32(6): 753. 2012. **Syn. nov.** —**Holotype**: CHINA, Guangxi, cultivated, December 2011, Ye 9981 (SYS).

= *Camellia ligustrina* Orel, Curry & Luu ex Orel, Peter G. Wilson, Curry & Luu in *Novon* 23(3): 310. fig. 2. 2014; Orel & Curry, In Pursuit of Hidden Camellias 132. 2015. **Syn. nov.** —**Holotype**: VIETNAM, Lam Dong, Mount Lang Biang, 1850 m, 16 December 2011, Orel & Curry 734 (NSW900397†).

= *Camellia cuongiana* Orel & Curry, In Pursuit of Hidden Camellias 180. 2015. **Syn. nov.** —**Holotype**: VIETNAM, Lam Dong, Bidoup-Nui Ba National Park, 5 November 2012, Orel *et al.* 721 (NSW901040†).

Petioles 2–7 mm long; *leaf blades* elliptic, oblong or obovate, 3–13.5 × 1.5–5 cm, apex attenuate, acuminate or caudate. *Flowers* 2–4.5 cm in diam. *Bracteoles* and *sepals* 5–12, 1.5–7 × 2.5–9 mm. *Petals* 5–6, white, elliptic or obovate, 8–25 × 4–17 mm. *Stamens* 4–9 mm long; *filaments* basally connate for 1–2 mm. *Styles* 2–7 mm long. *Capsule* globose or ovoid, 10–28 mm in diam., 13–35 mm in height; *pericarp* 0.5–1.5 mm thick. *Seeds* brown or black, hemispherical, polyhedral or globose, 1–2 cm in diam., glabrous.

Phenology: flowering October–February, fruiting March–August.

Distribution: Bhutan, Cambodia, China, India, Laos, Myanmar, Nepal, Thailand and Vietnam (Map 4.12).

Habitat: evergreen and mixed deciduous forests, 50–2150 m.

Conservation status: least concern (LC). This species is widespread and abundant in subtropical and tropical Asia (Map 4.12, IUCN 2012).

Additional specimens examined

CAMBODIA. Kampong Speu: 8 June 1930, *Poilane* 17472 (K, VNM00003725); Aoral, ‘Thmor Bang’, 3 March 2001, *Eanghourt et al.* 143 (CMUB 36089, K), ‘1.5 km west of Srea Ken’, 6 March 2001, *Eanghourt et al.* 183 (K); Phnom Sruoch, Kirirom, 10 December 1964, *Kira et al.* 738 (BKFSN060920).

Kampot: Kaoh Touch, ‘Bokor montagne’, 900–1000 m, 30 November 1933, *Poilane* 22965 (P06614731, P06614732)

LAOS. Khammouan: ‘north-eastern slopes of Phou Yang’, 17°48'36"N, 105°32'59"E, 1000 m, 24 October 2005, *Newman et al.* LAO 1010 (BKFSN183155, NUOL0003016); ‘banks of the Nam Theun near Ban Nam Jang’, 17°57'37"N, 105°24'40"E, 560 m, 26 October 2005, *Newman et al.* LAO 547 (E00226065, NUOL0003015, P05286355); ‘near Nakai’, 17°42'1"N, 105°14'26"E, 523

m, 5 November 2005, *Newman et al.* LAO 872 (**BKFSN**183423, **NUOL**0003008).

Phongsaly: 8 May 1936, *Poilane* 26006 (**K**).

Xiangkhouang: ‘Cam-la’, 21 October 1920, *Poilane* 2143 (**VNM**00003816); Pek, Phonsan, 19°38'42"N, 103°23'25"E, 1870 m, 11 December 2015, *Zhao et al.* 136(1) (**TCD**).

MYANMAR. ‘Ngawchang valley’, ca. 1200 m, 13 December 1938, *Ward* 115 (**BM**); ‘Nam Tamwi Tuang, Tuang’, 500 m, 23 March 1975, *Maxwell* 75-271 (**BK**203720).

Chin: ‘Mt. Victoria, Esaban’, 1800 m, 2 September 1956, *Ward* 22616 (**BM**), 1900 m, 25 October 1956, *Ward* 22743 (**BM**); Natma Taung National Park, ‘along the walking trail between Kanpetlet and old town village’, 21°12'12"N, 94°2'9"E, 1760 m, 1 December 2012, *Fujikawa et al.* 90414 (**TCD**), 2000 m, 6 January 2013, *Ling* 96123 (**TCD**), ‘around Kanpetlet’, 1700 m, 27 June 2013, *Ling* 92934 (**TCD**), ‘around entrance of Natma Taung National Park’, 21°12'55"N, 94°1'53"E, 1960 m, 26 August 2013, *Fujikawa et al.* 94476 (**QBG** 75540, **TCD**).

Tanintharyi: Dawei, ‘2.5 miles southeast of Paungdaw Power Station’, ca. 14°N, 98°30'E, 390 m, August 1961, *Keenan et al.* 999 (**E**00681061).

THAILAND. Chiang Mai: Chom Thong, Doi Inthanon, 3 December 1964, *Bunchuai* 1420 (**BKFSN**060820), ‘from 23 km point on the main road to Bang Nong Lum’, ca. 1100 m, 16 February 1998, *Konta et al.* 4312 (**BKF**); Mae Chaem, Doi Inthanon, 1700 m, 24 December 1996, *Hara* A178 (**BKFSN**173304).

Chanthaburi: Soi Dao, Khao Soi Dao, ca. 1400 m, 13 December 1924, *Kerr* 9651 (**BK**203727, **BM**, **C**).

Kamphaeng Phet: Pang Sila Thong, Mae Wong, 900–1140 m, 14 June 1995, *Niyomdham et al.* 4379 (**BKF**).

Kanchanaburi: Sai Yok, ‘Chongkhaosoong’, ca. 900 m, 12 August 1995, *Wongprasert s.n.* (**BKFSN**112557); ‘Tong-pha-phum, E-tong’, 28 January 2001, *Veesommai* 1.38 (**BKFSN**145916).

Khon Kean: Phu Wiang, Tap Phaya Suea, 1 December 2003, *Mattapha* 472 (**KKU**), 380 m, 10 April 2008, *Norsaengsri* 3715 (**QBG** 63715), 16°37'58"N, 102°12'59"E, 430 m, 22 December 2015, *Zhao et al.* 137 (**BKF**, **KKU**, **TCD**).

Loei: Dan Sai, ‘Phu Lom Lo’, 1500–1600 m, 8 April 1922, *Kerr* 5782 (**BK**203732, **BM**, **C**); Phu Kradueng, ca. 1200 m, 12 March 1924, *Kerr* 8695 (**BK**203922, **BM**), 16°53'–54'N, 101°47'–49'E, 31 October 1984, *Mitsuta et al.* T-40368 (**BKFSN**107567) & T-42270 (**BKFSN**060860), 1150–1250 m, 1 November 1984, *Mitsuta et al.* T-42624 (**BKFSN**060861), ‘Pha Nok En’, 1 September 1988, *Fukuoka* T-63791 (**BKFSN**103457), ‘summit plateau, trail from Than Sawan to Yhamsornue waterfall’, 1100–1200 m, 12 September 1990, *Chantaranothai et al.* 90/143 (**K**); Phu Ruea, 1300 m, 4 May 1997, *Pooma* 1550 (**BKF**), Phu Luang, 16 June 2004, *Bunwong* 296 (**KKU**), Khoknokkraba, ca. 950 m, 17 November 2000, *Wongprasert* 11-13 (**BKFSN**133293); Wang

Saphung, Phu Luang, 15 April 1968, *Chermsirivathana* 899 (**BK203742**).

Nakhon Nayok: Mueang Nakhon Nayok, Khao Yai, ca. 600 m, 12 October 1969, *Kasem* 632 (**BK203721**), 14°26'N, 101°22'E, 750 m, 11 May 1996, *Charoenchai* 31 (**BKFSN165064**, **CMUB** 18823), 14°26'10"N, 101°22'28"E, 730 m, 8 May 2003, *Charoenchai & Phomphuang* 399 (**BK263128**, **CMUB** 26064); Pak Phli, Khao Yai, 14°21'N, 101°22'E, 1200–1300 m, 29 October 1970, *Charoenphol et al.* 4205 (**BKFSN060889**).

Nakhon Ratchasima: Pak Chong, Khao Yai, 14°45'N, 102°E, 1200 m, 17 October 1969, *Beusekom & Charoenpol* 1673 (**BKFSN060885**), 750 m, 18 October 1969, *Beusekom & Charoenpol* 1694 (**BKFSN060880**), ca. 600 m, 11 August 1974, *Maxwell* 74-786 (**BK203724**), 'Orchid waterfall', 600–750 m, 18 November 1982, *Koyama et al.* T-30008 (**BKFSN060882**), 'Haew Suwat waterfall', 700–730 m, 19 November 1982, *Koyama et al.* T-30110 (**BKFSN060881**), 750 m, 2 December 1983, *Fukuoka & Ito* T-34973 (**BKFSN100637**), 14°26'10"N, 101°22'29"E, 730 m, 7 October 2002, *Charoenchai & Phomphuang* 343 (**BK263207**, **CMUB** 26356).

Nakon Si Thammarat: Lan Saka, Khao Luang, 950–1000 m, 25 May 1968, *Beusekom & Phengkhlai* 1002 (**BKFSN060906**, **C**).

Nan: Pua, Doi Phukha, 1700 m, 26 June 2008, *Pooma & Tamura* 7113 (**BKFSN188552**).

Phang-Nga: 'Khao Pawta Luang Keow', 900–1000 m, *Geesink et al.* 7690 (**BKFSN060902**).

Phetchaburi: Kaeng Krachan, 'Panoen Thung Ranger Substation', 12°52'12"N, 99°22'12"E, 123 m, 26 January 2005, *Williams et al.* 1112 (**K**), 'summit of Khao Phanoen Thung', 12°52'5"N, 99°22'20"E, 1240 m, 8 May 2005, *Middleton et al.* 3271 (**BKFSN168267**, **E00226065**).

Phitsanulok: Chat Trakan, Phu Soi Dao, 1600 m, 14 August 2000, *Suksanthan* 2684 (**QBG** 19436); Nakhon Thai, 'on the way to the headquarter of Phu Hin Rong Kla National Park', 16°57'5"N, 101°1'24"E, 1600 m, 9 November 2015, *Zhao et al.* 71 (**BKF**, **TCD**).

Prachin Buri: ca. 1000 m, 4 July 1924, *Kerr* 10824 (**BK203739**); Khao Yai, 'at the Heo Suwat Falls', 750 m, 8 July 1966, *Larsen et al.* 99 (**C**).

Ranong: 50 m, 17 November 1973, *Santisuk* 597 (**C**); 'Muang Len', 160 m, 11 January 1966, *Hansen & Smitinand* 11909 (**BKFSN060905**, **C**); Suk Samran, Khlong Na kha, ca. 9°45'N, 98°40'E, 50 m, 22 June 1974, *Geesink et al.* 7381 (**K**) & 7404 (**C**, **K**).

Sakon Nakhon: Phu Phan, 19 November 1962, *Suwanakoset* 1916 (**BKF**, **K**), 'ca. 30 km SW of Sakonnakhon city', ca. 380 m, 13 November 1984, *Murata et al.* T-48771 (**BKFSN060859**), 'Huay Yai waterfall', 22 June 2003, *Chantaranonthai et al.* s.n. (**KKU**); Sawang Daen Din, Ban Thon, 1 December 1962, *Adisai* 194 (**BK203726**).

Si Sa Ket: Kantharalak, Phanom Dongrak, 200 m, 25 November 2005, *Suddee et al.* 2632 (**BKFSN181662**, **QBG** 29057), 'Sao Thongchai Phulaor Falls, Phanom Dongrak WS, trail to

waterfalls', 200 m, 22 December 2005, *Pooma et al.* 6068 (**BKFSN183620**, **K**).

Surin: Mueang Surin, 'Arloor-Doonban Community Forest', 124 m, 3 February 2008, *Petrmitr* 840 (**CMUB** 29794)

Udon Thani: Na Yung, Phu Luang, 1050–1300 m, 8 January 1966, *Hennipman* 3556 (**BKFSN060870**, **C**, **K**).

Uttaradit: Nam Pad, Phu Soi Dao, 1613 m, 17 November 2009, *Norsaengsri & Intamusik* 6145 (**QBG** 42661).

VIETNAM. Gia Lai: K'Bang, 'Suoi Miol, 10 km from Buon Luoi', 14°14'N, 108°36'E, 940 m, 14 May 1998, *Boyce & Nguyen* 1282 (**HN**).

Khanh Hoa: Nha Trang, 1800 m, 27 June 1922, *Poilane* 4138 (**P06838094**, **P06838095**)

Lai Chau: Tam Duong, Binh Lu, 24 October 1976, *Nhan* 168 & 172 (**HN**).

Lam Dong: 'N. de Dalat', 13 September 1940, *Poilane* 30378 (**K**, **VNM00003726**); Dalat, 1450 m, 1 January 1998, *Phengklai et al.* 10781 (**BKFSN14671**), Xuan Truong, 4 April 1980, *Nhan* 798 (**HN**), '8.5 km to S from Dalat city, 11°54'N, 108°27'E', 1300–1400 m, 13 March 1997, *Averyanov et al.* *VH* 2607 (**HN**); Lac Duong, Da Chais, 12°8'51"N, 108°40'19"E, 1450 m, 3 November 2006, *Wu et al.* *WP* 1359 (**HN**).

Ninh Thuan: Ninh Hai, Vinh Hai, 'E slopes on Nui Chua mountains', 11°43'52"N, 109°8'35"E, 600–700 m, 3 April 2004, *Hiep et al.* *HLF* 4580 (**HN**); Ninh Phuoc, Ca Na, 800 m, 2 April 1923, *Poilane* 5995 (**P05108756**, **P06615009**, **P06615015**), 700 m, 29 November 1923, *Poilane* 8885 (**P06614748**), 1000m, 30 October 1925, *Poilane* 12548 (**P04500132**, **E00691446**, **K**, **VNM00003723**).

Phu Tho: Tan Son, Xuan Son, 1 February 2003, *Phuong* 6236 (**HN**).

Quang Ninh: 'près de Quang-yen', 25 November 1885, *Balansa* 1348 (**K**).

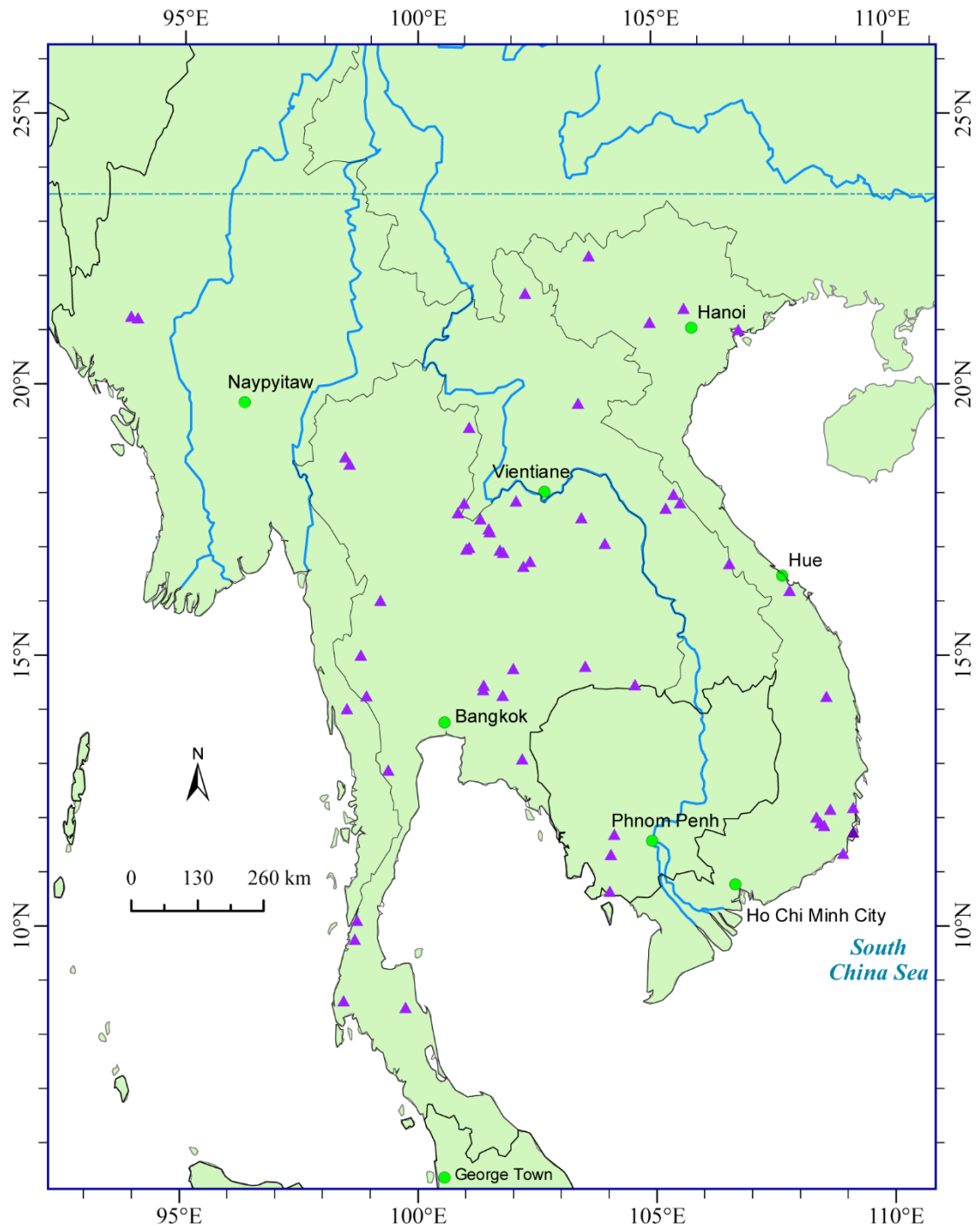
Quang Tri: Huong Hoa, Huong Phung, 10 November 2006, *Binh & Cuong* VN 1767 (**HN**).

Thua Thien Hue: 'Nui Bach Ma Station près de Huê', 1000 m, 15 April 1939, *Poilane* 29745 (**P06614744**, **P06614745**); Phu Loc, Bach Ma, 16°11'22"N, 107°50'48"E, 750–850 m, *Hiep et al.* *HLF* 1607 (**HN**).

Vinh Phuc: 'route de Vinh Yen au Tam Dao', May 1933, *Pételot* 4781 (**P04511455**, **P04525263**, **P06614759**).

Notes—Three gatherings were cited in the protologue of *T. bachmaensis*: *Poilane* 31118, 31184 & 31378 (Gagnepain 1942: 124). Gagnepain (1942) identified *Poilane* 31184 as '*Thea brachystemon*' on the specimen sheet but cited it as a syntype of *T. bachmaensis*. Sealy (1958) chose *Poilane* 31118 at **P** as the type but this single gathering has two specimens at **P** (**P01903389** & **P01903390**) so his lectotypification should be treated as the first-step (Art. 9.17 Ex. 12). Gagnepain's drawing is

attached to P01903389 therefore this sheet is designated as the second-step lectotype. The syntype *Poilane 31378* has not been found (Zhao et al. 2017a).



Map 4.12. Distribution of *Camellia drupifera* var. *kissi* (purple triangle) in Indochina.

Three gatherings were cited in the protologue of *T. brachystemon* Gagnepain: *Poilane 15908*, *15917* & *Watt 5182* (Gagnepain 1942: 125). The locality of *Poilane 15917* is same as that of *Poilane 15908* as the following words were recorded on its label: ‘Raweau de thê cuilli a coté du no. 15908’, but this is not what Gagnepain (1942: 125) cited in the protologue ‘Cambodge: Pnom-chom, prov. Kompong-chnang’. Sealy (1958) incorrectly cited the locality of *Poilane 15908* as

Cambodia whereas Ming (2000) repeated Gagnepain's incorrect record of *Poilane 15917*. The lectotype **P01903386** bears Gagnepain's drawing of a dissected flower bud (Zhao et al. 2017a).

The collection *Ward 115* from Myanmar under the name *C. costei* H. Léveillé (Merrill 1941: 115) is *C. drupifera* var. *kissi*. This variety differs from species of sect. *Camelliopsis* by its caducous bracteoles and sepals after flowering and usually three distinct styles whereas the latter has persistent bracteoles and sepals and a single style with a lobed apex.

[29] *Camellia drupifera* var. *stenophylla* (Kobuski) D. Wei Zhao

= *Camellia fluviatilis* Handel-Mazzetti in Akademie der Wissenschaften in Wien Mathematisch-Naturwissenschaftliche Klasse 59(7): 57. 1922; Nakai in The Journal of Japanese Botany 16(12): 693–694. 1940; Sealy, A Revision of the Genus *Camellia* 193, 196–197, fig. 90. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 37. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 26, t. 5, fig. 1–2. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 51. 1984; T.L. Ming in Acta Botanica Yunnanica 21(2): 157. 1999 & Monograph of the Genus *Camellia* 290, 293, t. 69, fig. 1–4. 2000; T.L. Ming & B.M. Bartholomew in Flora of China 12: 409–410. 2007. —

Lectotype (designated by Sealy 1958: 197): CHINA, Guangdong, 'Inter rupes juxta ripam fluviii Yongong ca. 40 km supra urbem Yingdak', 50 m, 6 January 1916, *Mell 44* (**A00024714†**).

Isolectotype: **C10019468†**.

= *Thea fluviatilis* (Handel-Mazzetti) Merrill in Lingnan Science Journal 7: 316. 1931.

≡ *Camellia stenophylla* Kobuski ex Merrill in Brittonia 4(1): 115. 1941. —**Holotype**: MYANMAR, Sagaing, Tamu, ca. 1000 m, 21 November 1938, *Ward 17* (**A00024735†**). Isotype: **BM000603026!**.

≡ *Camellia kissi* Wallich var. *stenophylla* (Kobuski) Sealy, A Revision of the Genus *Camellia* 201, fig. 92. 1958.

Petioles 2–4 mm long; *leaf blades* oblong to linear, 4.5–6.5 × 0.5–1.6 cm, base and apex attenuate. *Flowers* 1–1.5 cm in diam. *Bracteoles* and *sepals* 5–14, 1.5–8 × 2–7 mm. *Petals* 5–7 in 1–2 whorls, white, elliptic, 8–12 × 4–6 mm. *Stamens* ca. 30, 4–7 mm long; *filaments* basally connate for 1–2 mm. *Styles* 1.5–5 mm long, glabrous. *Capsule* globose or ovoid, 1.5–2 cm in diam.; *pericarp* 0.5–1 mm thick. *Seeds* not seen.

Phenology: flowering November–January.

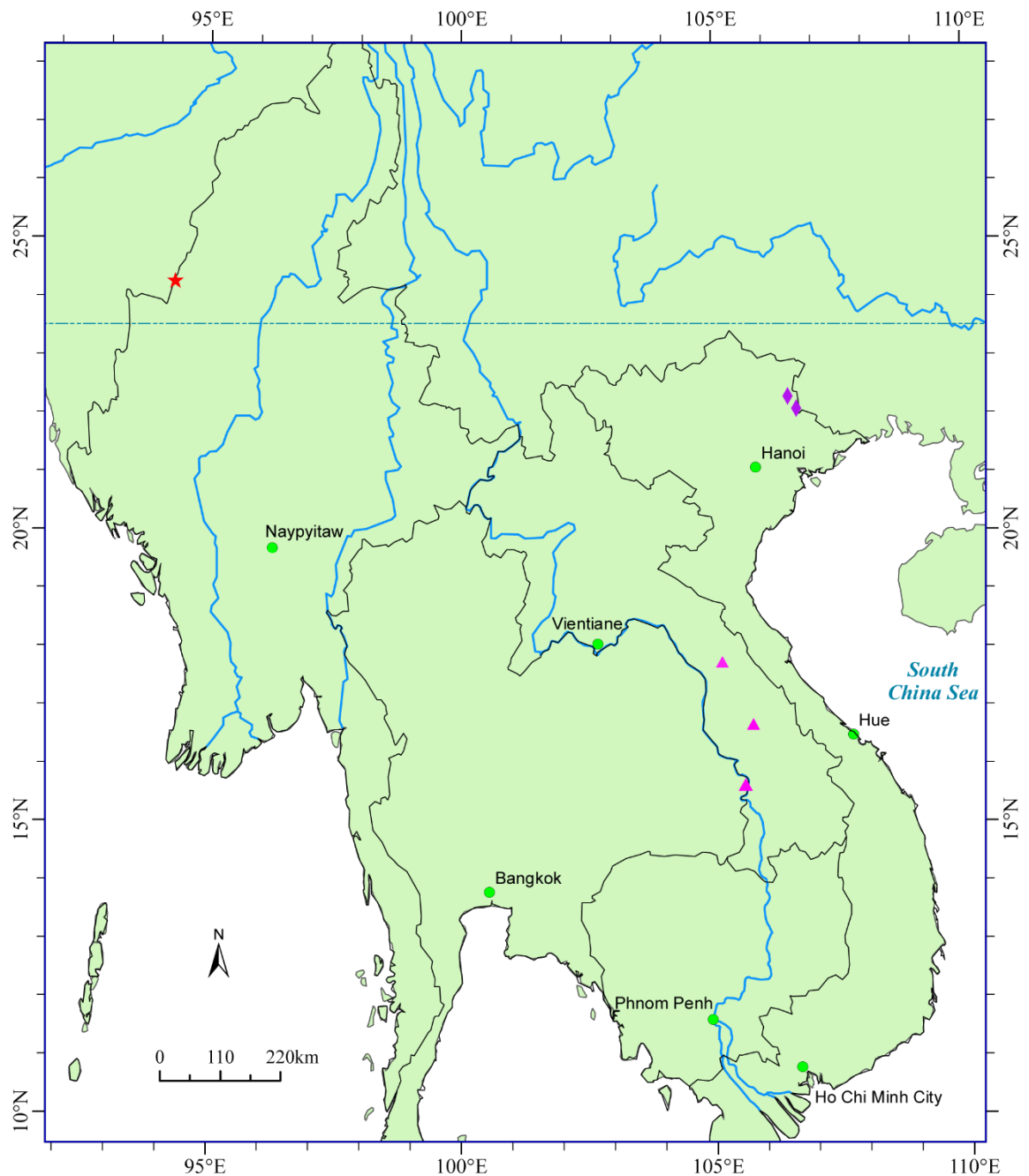
Distribution: China and Myanmar (Map 4.13).

Habitat: evergreen forest, 50–1000 m.

Conservation status: data deficient (DD), especially data from China (IUCN 2012).

Notes—This variety usually has very narrow leaf blade (0.5–1.6 cm wide) and small flower (1–1.5 cm in diam.) by which it differs from *C. drupifera* var. *kissi*. The latter has a wider leaf blade (1.5–

5 cm) and a larger Flower (1.5–4.5 cm in diam.).



Map 4.13. Distribution of *Camellia drupifera* var. *stenophylla* (red star), *C. kirinoi* (purple diamond) and *C. laotica* (pink triangle) in Indochina.

[30] *Camellia kirinoi* Ninh in Genetics and Applications 2: 37. 1999; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 347. 2003. —**Holotype:** VIETNAM, Lang Son, Van Lang, 200–300 m, 15 December 1998, *Ninh TN 9895* (**HNU!**).

Shrubs 1.5–2 m tall. *New branchlets* with spreading villous hairs, hairs ca. 2 mm long; *terminal buds* pubescent. *Petioles* 1–2 mm long, with spreading villous hairs; *leaf blades* elliptic or oblong, 4–13 × 2–3.5 cm, coriaceous, abaxially with spreading villous hairs, adaxially glabrous, midrib

abaxially elevated and adaxially channelled, secondary veins 10–13 on each side of midrib, abaxially slightly raised and adaxially slightly impressed or obscure, base subcordate or rounded, margin serrate, apex attenuate. *Flowers* solitary, ca. 1.5 cm in diam., subsessile. *Bracteoles* and *sepals* ca. 10, broadly ovate, 2–4 × 2–5 mm, outside puberulous, inside glabrous, margin membranous. *Petals* ca. 7 in 2 whorls, yellowish white, elliptic or obovate, 5–8 × 4–6 mm, outside glabrous or puberulous, inside glabrous. *Stamens* ca. 26, ca. 3 mm long; *filaments* connate and basally adnate to petals, glabrous. *Ovary* globose, pubescent. *Styles* 3, distinct, ca. 3 mm long, puberulous and gradually becoming glabrous apically. *Fruit* and *seed* not seen.

Phenology: flowering December–January.

Distribution: endemic to northern Vietnam (Map 4.13).

Habitat: evergreen forest, 200–300 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² (B1). It is known to exist at no more than five locations (Map 4.13) and may have been influenced by deforestation in the low-elevation areas (IUCN 2012).

Additional specimens examined

VIETNAM. Lang Son: Trang Dinh, That Khe, 16 December 1998, *Ninh TN 98108 & TN 98111* (HNU), January 2010, *Ninh 1003* (HNU).

Notes—This species is characterised by its spreading villous hairs on the branchlet, petiole and abaxial leaf blade in *sect. Paracamellia*.

4.2.9 Section *Piquetia*

Sect. *Piquetia* (Pierre) Sealy, A Revision of the Genus *Camellia* 108, 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 21, 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 36, 1984; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 151, 1999 & *Monograph of the Genus Camellia* 75–77, 2000.

≡ *Thea* sect. *Piquetia* Pierre, *Flore Forestière de la Cochinchine* 2(8): supra t. 119, 1887. —**Type:** *T. piquetiana* Pierre

= *Dankia* Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(2): 198, 1939. —**Type:** *D. langbianensis* Gagnepain

= *Camellia* sect. *Bidoupia* Orel, Curry & Luu ex Orel, Peter G. Wilson, Curry & Luu in *Edinburgh Journal of Botany* 69(2): 348, 2012; Orel & Curry, *In Pursuit of Hidden Camellias* 95, 2015. **Syn. nov.** —**Type:** *C. inusitata* Orel, Curry & Luu

= *Camellia* sect. *Lecomtia* Orel ex Orel & Curry, *In Pursuit of Hidden Camellias* 154, 2015. **Syn. nov.** —**Type:** *C. campanulata* Orel, Curry & Luu

Leaf blade usually large (14–52 × 2.5–12 cm); sepals and bracteoles persistent; petals yellow or red; styles distinct; capsule oblate; seeds glabrous and shiny.

Notes—This section is morphologically like sect. *Archecamellia* but differs from the latter by its non-punctate leaf blade and shiny seeds whereas sect. *Archecamellia* has a leaf that is punctate on the abaxial surface and smooth but not shiny seeds. Species of sect. *Piquetia* are all endemic to southern Vietnam (Maps 4.14–4.15).

[31] *Camellia dalatensis* V.D. Luong, Ninh & Hakoda in International Camellia Journal 44: 161. 2012. —**Holotype**: VIETNAM, Lam Dong, Dalat Plateau, 1300 m, 8 March 2012, *Ninh & Dung 12.03.01 (DLU!)*. Isotype: **DLU!**

Shrubs 4 m tall. *New branchlets* and *terminal buds* pubescent. *Petioles* 3–5 mm long, pubescent; *leaf blades* elliptic, oblong or ligulate, 18–44 × 5–10 cm, coriaceous, abaxially yellowish green and pubescent, adaxially dark green and glabrous, midrib abaxially raised and adaxially slightly raised or flat, secondary veins 13–22 on each side of midrib, abaxially raised and adaxially impressed, base subcordate or rounded, margin serrulate, apex attenuate or acute. *Flowers* solitary or up to 3 in a cluster, 4–4.5 cm in diam. *Pedicels* 9–15 mm long. *Bracteoles* 2–4, alternate, deltate to broadly ovate, 4–6 × 3–8 mm, outside pubescent, inside glabrous, margin ciliolate. *Sepals* 5, broadly ovate, 5–7 × 8–11 mm, outside pubescent, inside glabrous or sparsely sericeous, margin ciliolate. *Petals* 8–11 in 2 whorls, pale yellow, broadly elliptic or obovate, 1.5–2.5 × 2–2.5 cm, inner petals basally connate for 2–3 mm, outside pubescent, inside sericeous or glabrous. *Stamens* ca. 1.5 cm long, outer filaments basally adnate to petals for 2–4 mm, puberulous, distinct part puberulous or glabrous. *Ovary* oblate, densely pubescent. *Styles* 4–5, distinct, 1–1.5 cm long, basally swollen, pubescent. *Capsule* oblate, 4–5 cm in diam., 1.5–2.5 cm in height; *pericarp* 0.5–1 mm thick. *Seeds* brown or black, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous and shiny.

Phenology: flowering March–May, fruiting January–March.

Distribution: endemic to southern Vietnam (Map 4.14).

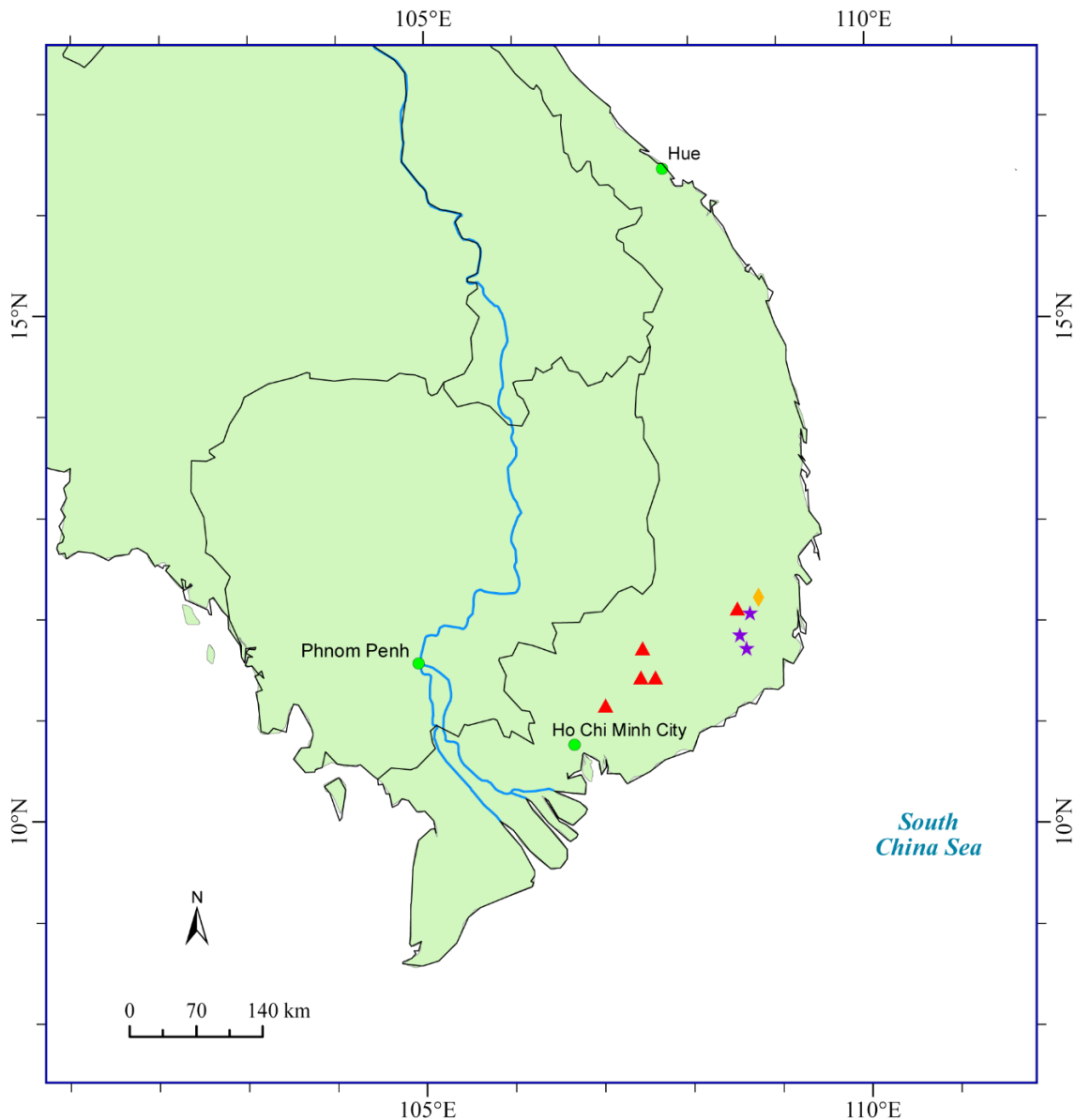
Habitat: evergreen forest, 1300–1600 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² and it is known to exist at no more than five locations (B1, Map 4.14, IUCN 2012).

Additional specimens examined

VIETNAM. Lam Dong: Bidoup Nui Ba National Park, 8 January 2013, *BD-PL-09 (SGN)*; Don Duong, 8 January 2013, *BD-PL-10, BD-PL-11 & BD-PL-12 (SGN)*; Dalat, 1600 m, 26 April 1954, *Schmid s.n. (P04511812)*, Xuan Truong, 5 May 1980, *Phuc 29 (HN)*, ‘Phat Chi–Xuan Truong’, *DL 12.03.02 (DLU)*.

Notes—This species is morphologically like *C. krempfii* but differs from the latter by its new branchlets, petiole and the abaxial surface of the leaf blade that are pubescent whereas those of the latter are glabrous.



Map 4.14. Distribution of *Camellia dalatensis* (purple star), *C. piquetiana* (red triangle) and *C. sonthaiensis* (orange diamond) in Indochina.

[32] *Camellia inusitata* Orel, Curry & Luu ex Orel, Peter G. Wilson, Curry & Luu in Edinburgh Journal of Botany 69(2): 348. 2012; Orel & Curry, In Pursuit of Hidden Camellias 95. 2015. —

Holotype: VIETNAM, Lam Dong, Bidoup-Nui Ba National Park, 19 December 2010, *Truong et al.* 464 (SGN[†]).

Shrubs 3 m tall. *New branchlets* and *terminal buds* glabrous. *Petiole* 1–4 mm long, glabrous; *leaf blades* oblong, 15–20 × 4–6 cm, coriaceous, abaxially yellowish green and adaxially dark green, both surfaces glabrous and shiny, midrib abaxially raised and adaxially slightly elevated, secondary

veins 20–26 on each side of midrib, abaxially raised and adaxially flat or obscure, base rounded or subcordate, margin serrulate, apex attenuate. *Flowers* solitary or paired, 2–3 cm in diam. *Pedicels* 1–1.5 cm long, glabrous. *Bracteoles* 2, alternate, ovate, 1–1.5 × 1–2 mm, both surfaces glabrous. *Sepals* 5, broadly ovate, 2–4 × 2–4.5 mm, both surfaces glabrous. *Petals* 5–6, light yellow, broadly obovate or elliptic, 11–15 × 9–17 mm, both surfaces glabrous. *Stamens* 6–10 cm long, basally connate for 2–3 mm, glabrous. *Ovary* globose, pubescent. *Styles* 3, distinct, ca. 5 mm long, basally puberulous and gradually becoming glabrous apically. *Capsule* oblate, ca. 4 cm in diam., 2–2.5 cm in height; *pericarp* 0.5–1 mm thick. *Seeds* brown, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous and shiny.

Phenology: flowering November–December, fruiting June.

Distribution: endemic to southern Vietnam (Map 4.5).

Habitat: evergreen forest.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² and it is known to exist at no more than five locations (B1, Map 4.5, IUCN 2012).

Additional specimens examined

VIETNAM. Lam Dong: Bidoup-Nui Ba National Park, Hon Giao, 7 November 2012, *DL* 12.11.04 (**DLU**), 23 June 2013, *DL* 13.06.01 (**DLU**).

Notes—This species is morphologically like *C. sonthaiensis* but differs from the latter by its short petiole (1–4 mm long) and by having more secondary veins of leaf blade (20–26) whereas *C. sonthaiensis* has a long petiole (7–17 mm long) and fewer secondary veins (13–16).

[33] *Camellia krempfii* (Gagnepain) Sealy in Kew Bulletin 4(2): 219. 1949 et A Revision of the Genus *Camellia* 36, fig. 7. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 17. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 32. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 528, fig. 1454. 1991; T.L. Ming & W.J. Zhang in *Acta Botanica Yunnanica* 15(1): 4–5. 1993; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 151. 1999 & Monograph of the Genus *Camellia* 78, 80, t. 2, fig. 1–3. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 347. 2003.

≡ *Thea krempfii* Gagnepain in *Notulae Systematicae* 10(3): 127. 1942; Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 304, 319–320. 1943; D. Wei Zhao et al. in *Phytotaxa* 292(2): 175. 2017. —**Lectotype** (designated by Zhao et al. 2017a: 176): VIETNAM, Khanh Hoa, ‘contreforts du Ton Ha’, 100 m, April 1912, *Krempf* 1564 (**P00700354!**). **Isolectotype:** **P01903385!**.

= *Camellia hongiaoensis* Orel & Curry in *Telopea* 17: 101. 2014; Orel & Curry, In Pursuit of Hidden *Camellias* 147, 316–318. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Khanh Hoa, in the

vicinity of the city of Nha Trang, 28 November 2013, *Ore & Curry OC 36* (NSW901917† [sheet 1 of 2], NSW849515† [sheet 2 of 2]).

Shrubs. *New branchlets* glabrous; *terminal buds* puberulous. *Petioles* 5–13 mm long, glabrous; *leaf blades* elliptic, oblong or ligulate, 22–35 × 6–9 cm, coriaceous, abaxially yellowish green and glabrous, adaxially dark green or yellowish green and glabrous, midrib abaxially raised and adaxially slightly raised or flat, secondary veins 16–23 on each side of midrib, abaxially raised and adaxially impressed, base subcordate or rounded, margin serrulate, apex attenuate or acute. *Flowers* solitary or paired, 4–5 cm in diam. *Pedicels* 8–33 mm long. *Bracteoles* 4–5, alternate, deltate to broadly ovate, 2–17 × 2.5–8 mm, outside pubescent, inside glabrous or sparsely sericeous, margin ciliate. *Sepals* 5, broadly ovate, 7–10 × 9–11 mm, outside pubescent, inside glabrous, margin ciliate. *Petals* 9–11 in 2–3 whorls, red, obovate or elliptic, 2–3 × 1.5–2.5 cm, inner petals basally connate for 2–4 mm, outside pubescent or puberulent, inside glabrous. *Stamens* 2–3 cm long, outer filaments basally adnate to petals for 5–10 mm, puberulous, distinct part puberulous or glabrous. *Ovary* oblate, densely pubescent. *Styles* 4–5, distinct, 1.5–2.5 cm long, basally swollen, pubescent and gradually becoming glabrous apically. *Capsule* oblate, 4–6 cm in diam., 2–4 cm in height; *pericarp* 0.2–0.5 mm thick. *Seeds* brown, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous and shiny.

Phenology: flowering October–February, fruiting October.

Distribution: endemic to southern Vietnam (Map 4.15).

Habitat: evergreen forest, 100–1500 m.

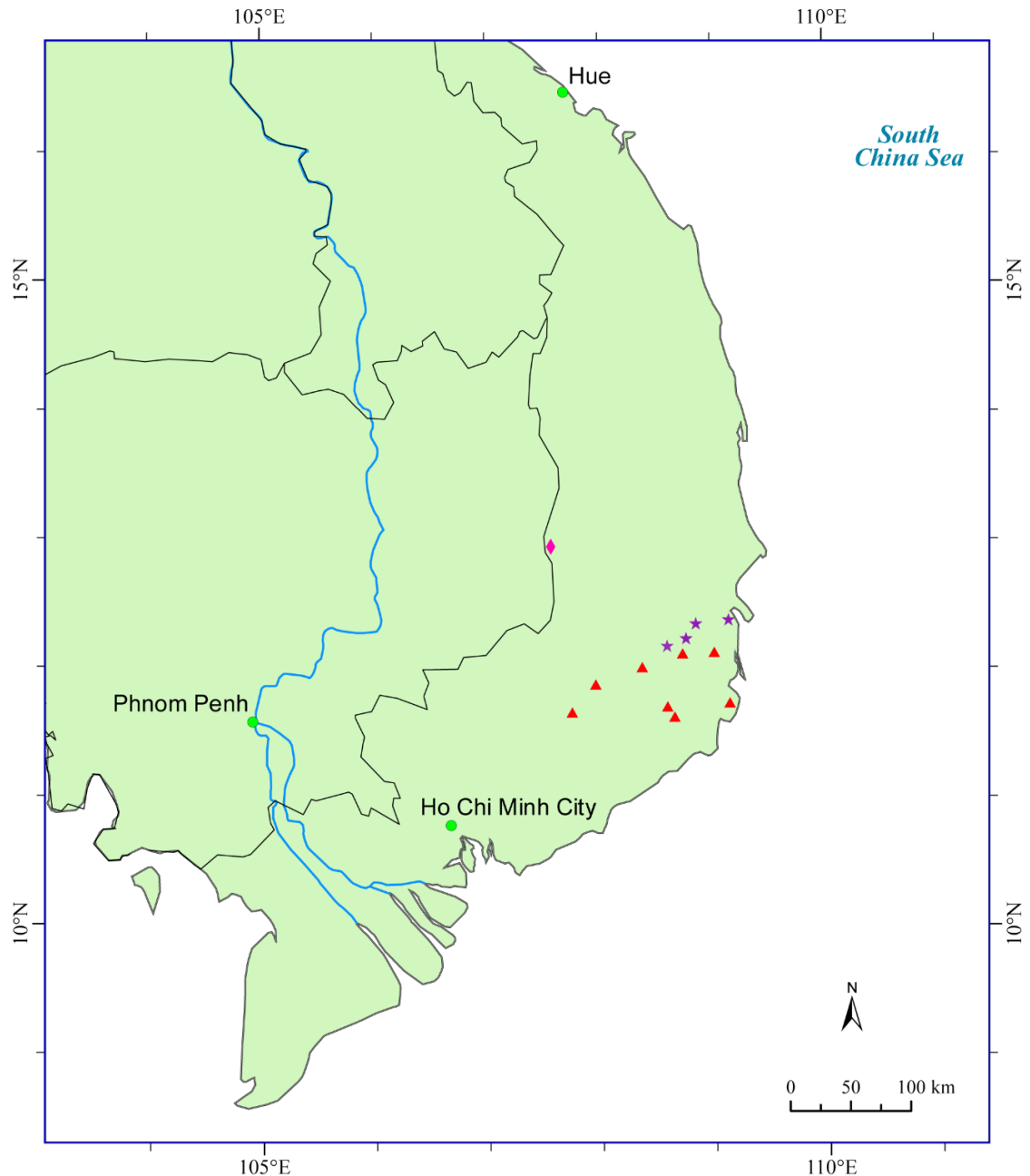
Conservation status: vulnerable (VU). The extent of occurrence of this species is estimated to be less than 20000 km². It is known to exist at no more than ten locations (Map 4.15) and may have been influenced by deforestation for land use (IUCN 2012).

Additional specimens examined

VIETNAM. Khanh Hoa: Khanh Vinh, 29 October 2013, *Nhan 70* (DLU), 18 January 2014, *Cuong 14.01.03* (DLU), Son Thai, 31 October 2013, *Truong & Gioi KH 917* (SGN).

Lam Dong: ‘Col entre Ta Dra et Ta Dung’, 1200 m, 16 February 1953, *Schmid s.n.* (P04511808), ‘Massif du Ta Dung’, 1500 m, 17 February 1953, *Schmid s.n.* (P04511809); Lac Duong, Hon Giao, 29 October 2013, *Dung DL 13.10.04* (DLU).

Notes—A single gathering was cited in the protologue of *T. krempfii* (Gagnepain 1942: 128); however, two specimens of *Krempf 1564* were found (P00700354 & P01903385). P00700354 has a manuscript diagnosis attached so it is designated as the lectotype (Zhao et al. 2017a). This species is morphologically like *C. piquetiana* but differs from the latter by its serrulate margin of leaf blade and by having more bracteoles (4–5) whereas *C. piquetiana* has leaf margin that is almost entire or sparsely serrulate and has fewer bracteoles (2–3).



Map 4.15. Distribution of *Camellia krempfii* (purple star), *C. langbianensis* (red triangle) and *C. yokdonensis* (pink diamond) Indochina.

[34] *Camellia langbianensis* (Gagnepain) P.H. Hô, *Cây cỏ Việt Nam* 1(1): 537. 1991.

≡ *Dankia langbianensis* Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(2): 198. 1939; D. Wei Zhao et al. in *Phytotaxa* 292(2): 173. 2017. —**Lectotype** (designated by Zhao et al. 2017a: 173): VIETNAM. Lam Dong: 'entre B. dlé et Dankia, Langbiang', 1200–1300 m, 26 October 1930, *Poilane 18648* (**P00754831!**). Isolectotypes: **K000704329!**, **L0012339†**, **P00754832!**.

= *Camellia vidalii* Rosmann in *Adansonia* 21(2): 319. 1999 & in *International Camellia Journal* 32: 66. 2000. **Syn. nov.** —**Holotype**: VIETNAM, Lam Dong, Bao Loc, 875 m, December 1998,

Rosmann et al. 981 (**P00834283!**). Paratype: VIETNAM, Lam Dong, Bao Loc, 875 m, December 1998, *Rosmann et al.* 982 (**P00834286!**), 983 (**P00834285!**), 985 (**P00834284!**) & 986 (**P00834287!**).

= *Camellia dongnaiensis* Orel in Novon 16(2): 244. 2006; Orel & Curry, In Pursuit of Hidden Camellias 72–77. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Lam Dong, ‘unnamed tributary, headwaters of Dong Nai river’, 17 January 2004, *Orel et al.* 21148 (**NSW**). Isotype: **VNM00018568!**.

= *Camellia oconoriana* Orel et al. in Edinburgh Journal of Botany 70(3): 440. 2013; Orel & Curry, In Pursuit of Hidden Camellias 121–127. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Lam Dong, ‘unnamed mountain about 120 km SW of Dalat’, 22 November 2010, Orel & Curry 0720 (**NSW900415†**).

= *Camellia decora* Orel & Luu in Orel & Curry, In Pursuit of Hidden Camellias 173. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Ninh Thuan, 23 March 2009, *Truong et al.* VNM 12381 (**NSW901588†**).

= *Camellia tadungensis* Orel et al. in Orel & Curry, In Pursuit of Hidden Camellias 256. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Dak Nong, Ta Dung Nature Reserve, 11 January 2011, *Truong et al.* TD 264 (**NSW901888†**).

Shrubs 4–6 m tall. *New branchlets* puberulous; *terminal buds* pubescent. *Petioles* 6–17 mm long, puberulous or glabrous; *leaf blades* elliptic, oblong or ligulate, 15–40 × 2.5–11 cm, coriaceous, abaxially yellowish or pale green and puberulous, adaxially dark green and glabrous, midrib raised on both surfaces, secondary veins 17–24 on each side of midrib, abaxially raised and adaxially impressed, base cuneate, obtuse, rounded or subcordate, margin nearly entire or sparsely serrulate, apex attenuate. *Flowers* solitary or paired, borne in the axils of leaves or on short bracteate shoots; short shoots bearing 3–5 bracts subtending flowers; *bracts* caducous; flowers 2.5–4.5 cm in diam. *Pedicels* 2–5.5 cm long, puberulous. *Bracteoles* 2–4, alternate, narrowly ovate or deltate, 1.5–6 × 1.5–3 mm, outside puberulous, inside glabrous, margin ciliolate. *Sepals* 5–6, broadly ovate or ovate, 4–7 × 4–12 mm, outside puberulous, inside glabrous, margin ciliolate. *Petals* 7–9 in 2 whorls, yellow, or with pale red fringe, broadly obovate or elliptic, 1–2.5 × 1–2.2 cm, outer surface pubescent or puberulous, inner surface glabrous. *Stamens* 1–2 cm long, outer filaments basally connate for 3–4 mm, adnate to petals for 1–2 mm, glabrous. *Ovary* oblate or ovoid, densely pubescent. *Styles* 3–5, distinct, 1–2.5 cm long, pubescent, or gradually becoming glabrous apically. *Capsule* oblate, 5–7 cm in diam., 2–3.5 cm in height; *pericarp* 0.5–3 mm thick. *Seeds* brown or black, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous and shiny. Figure 4.8.

Phenology: flowering and fruiting October–April.

Distribution: endemic to southern Vietnam (Map 4.15).

Habitat: evergreen forest, 750–1800 m.

Conservation status: near threatened (NT). This species is endemic to a small (< 20000 km², Map 4.15), partly protected area in southern Vietnam. It may be vulnerable to environmental fluctuations, such as climate change, and is likely to qualify for a threatened category in the near future (IUCN 2012).

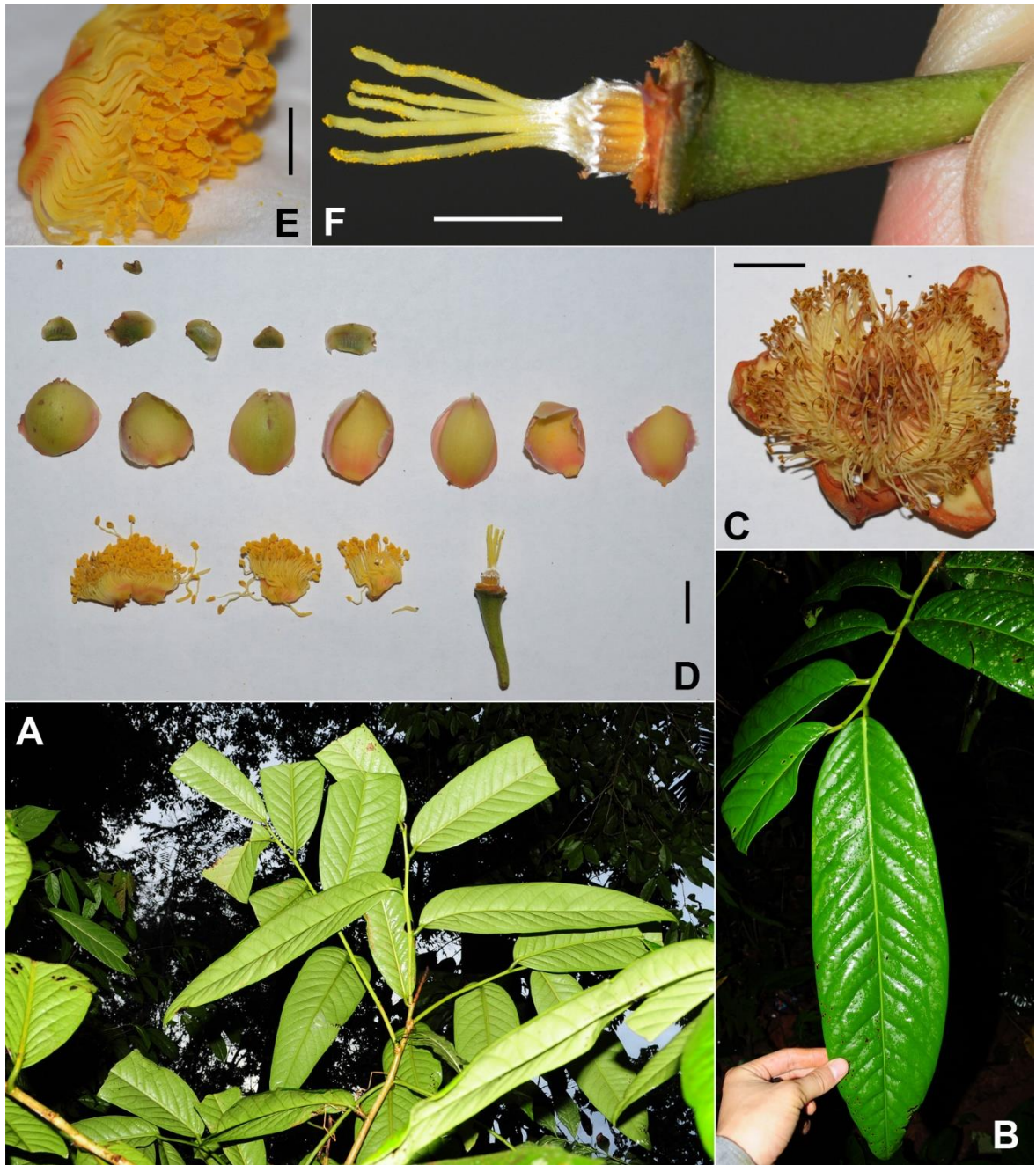


Figure 4.8. *Camellia langbianensis*. A & B: leaf branches; C: petals and androecium; D: a dissected flower bud; E: a part of androecium; F: gynoecium and pedicel. The bars represent 1 cm in C & D but indicate 5 mm in E & F, respectively.

Additional specimens examined

VIETNAM. Khanh Hoa: Cam Lam, Hon Ba, 8 April 2012, *Truong & Gioi* KH 86, KH 87 & KH 88 (SGN), 8 April 2013, *Truong & Gioi* KH 1140 (SGN),

Lam Dong: ‘massif du Braïan près de Djiling’, 1700–1800 m, 17 January 1935, *Poilane* 23959 (**P05312544**), 1200–1400 m, 3 February 1935, *Poilane* 24105 (**P06838121**); Bao Loc, ‘Pu Sapoum près Mt. ageicole de Blao’, 1000–1100 m, 10 January 1934, *Poilane* 23790 (**P04500357**), Dam Ri, 11 January 2012, *DL* 12.01.02 (**DLU**), 1 December 2012, *DL* 12.12.02 (**DLU**), 31 January 2015, *DL* 15.01.03 (**DLU**), 11°38'29"N, 107°44'25"E, 780–830 m, 30 November 2015, *Zhao & Dung* 124 (**TCD**), 125 (**TCD**, **PHH**) & 126 (**TCD**); Don Duong, Pro, 15 February 2014, *DL* 14.02.01, *DL* 14.02.02 & *DL* 14.02.03 (**DLU**), *DL* 15.10.08 (**DLU**).

Ninh Thuan: Ninh Hai, Nui Chua, 22 March 2009, *Truong & Dat* NC 198 (**SGN**), March 2010, *Luu* 749 (**SGN**), March 2011, *Luu* 750 (**SGN**), 20 April 2012, *Luu* 736 (**SGN**); Ninh Son, Phuoc Binh, ‘37 km to NE from Dalat city’, 12°6'N, 108°43'E, 1300–1400 m, 2 April 1997, *Averyanov et al.* VH 3561 (**HN**, **P05191415**, **P05247468**).

Notes—Gagnepain (1939: 198) validly published the monotypic genus *Dankia* though he did not supply a generic diagnosis but gave a detailed specific description and illustration (Arts. 38.5 & 38.6). Sealy noticed this genus in 1955 (Sealy’s letter to Dr. Sleumer H., 20 September 1955, a copy of which is attached to **K000704329**) but never mentioned it in his monograph of *Camellia* (Sealy 1958). It can be reasonably concluded that Sealy did not think *Dankia* should be merged with *Camellia*. Sealy’s view differed from that of Sleumer who remarked ‘in fact *Dankia* = *Camellia*, as can be seen from the holotype at Paris, and from a letter received by Sealy (Kew) to Sleumer in 1955’ (Sleumer H.’s remarks, 1973, attached to **K000704329**). However, Hutchinson (1967) treated this genus as a synonym of *Hydnocarpus* Gaertner whereas Hô (1991) finally transferred *D. langbianensis* into *Camellia* (Zhao et al. 2017a).

A single gathering *Poilane* 18648 was cited in the protologue of *D. langbianensis* (Gagnepain 1939). **P00754831** has Gagnepain’s drawing so it is designated as the lectotype (Zhao et al. 2017a). This species is morphologically like *C. piquetiana* but differs from the latter by its long pedicel (20–55 mm long) and glabrous filaments (Figure 4.8) whereas *C. piquetiana* has a short pedicel (5–13 mm long) and puberulous filament.

[35] *Camellia piquetiana* (Pierre) Sealy, A Revision of the Genus *Camellia* 108, fig. 52. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 21. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 36. 1984; P.H. Hô, *Cây cỏ Việt Nam* 528. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 151. 1999 & Monograph of the Genus *Camellia* 76, t. 1: 1–2. 2000; G. Richards et al. in *International Dendrology Society Yearbook* 139. 2002 & in *International Camellia Journal* 35: 56. 2003; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 349. 2003; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 198. 2005.

≡ *Thea piquetiana* Pierre, *Flore Forestière de la Cochinchine* 2(8): t. 119. 1887; Kochs in Engler, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 27(5): 590. 1900; Pitard in Lecomte, *Flore Générale de l’Indo-Chine* 1(4): 347. 1910; Gagnepain in

Supplément a la Flore Générale de l'Indo-Chine 1(3): 304, 320. 1943; D. Wei Zhao et al. in Taxon 65(5): 1183. 2016. —**Lectotype (designated here):** VIETNAM, Dong Nai, 'ad Chiao Xhan in prov. Bien Hoa', March 1877, *Pierre 1708* (**P01903371!**). Isolectotypes: **A00025007†**, **BM000603027!**, **BM000603028!**, **K000704297!**, **K000704298!**, **L.2406023†**, **NY00148779†**, **NY00148780†**, **P01903372!**, **VNM00003809!**. Syntypes: VIETNAM, Dong Nai, 'Chiao Xhan à 60 Rilom envis du H. Dongnai dans la région Sept. de la prov. de Bien Hoa aust. Coch', March 1877, *Pierre 1708* (**P00700355!**, **P01903370!**); 'in low mountain ad Chiao Xhan in prov. Bien Hoa aust. Coch', March 1877, *Pierre 1708* (**P00700356!**, **P01903369!**).

≡ *Piquetia piquetiana* (Pierre) Hallier f. in Beihefte zum Botanischen Centralblatt 39(1): 162. 1921; Melchior in Engler, Die Natürlichen Pflanzenfamilien, 2nd ed. 21: 128. 1925.

= *Camellia cattienensis* Orel ex Orel & Peter G. Wilson in Kew Bulletin 66: 566. 2012; Orel & Curry, In Pursuit of Hidden Camellias 88. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Dong Nai, Cat Tien National Park, 19 December 2007, *Orel et al.* 711 (**NSW868341†**). Isotypes: **VNM00018570!**.

= *Camellia longii* Orel & Luu ex Orel, Peter G. Wilson & Luu in Nordic Journal of Botany 32: 46, t. 2. 2014; Orel & Curry, In Pursuit of Hidden Camellias 113. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Dong Nai, Cat Tien National Park, 10 September 2009, *Long CT4* (**SGN!**). Isotype: **NSW901585†**, **SGN!**.

= *Camellia campanulata* Orel, Curry & Luu ex Orel & Curry, In Pursuit of Hidden Camellias 154. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Bin Phuoc, 'about 1 km from Cambodian border', July 2011, *Luu et al.* 1257 (**VNM**).

Shrubs 2–5 m tall. *New branchlets* and *terminal buds* puberulous. *Petiole* 4–13 mm long, sparsely puberulous or glabrous; *leaf blades* elliptic, oblong or ligulate, 14–52 × 5–12 cm, coriaceous, abaxially yellowish green or purplish green when immature and appressed puberulous, adaxially dark green and glabrous or brownish green and sparsely appressed puberulous when immature, midrib slightly raised on both surfaces, secondary veins 13–25 on each side of midrib, abaxially raised and adaxially impressed, base cuneate, obtuse or rounded, margin nearly entire or sparsely serrulate, apex attenuate. *Flowers* solitary or paired, borne in the axils of leaves or on short bracteate shoots; short shoots bearing 3–5 bracts subtending flowers; *bracts* narrowly deltate or ovate, 5–8 × 2–4 mm, outside puberulous and inside glabrous; flowers 4–6 cm in diam. *Pedicels* 5–13 mm long. *Bracteoles* 2–3, alternate, deltate or ovate, 2–6 × 1.5–3 mm, outside puberulous, inside glabrous, margin ciliolate. *Sepals* 5, ovate, 5–9 × 3–7 mm, outside puberulous, inside glabrous, margin ciliolate. *Petals* 6–10 in 2 whorls, red, purplish red or yellowish red, obovate or elliptic, 1.5–4 × 1.5–2.5 cm, inner petals basally connate for 3–5 mm, outside puberulous, inside glabrous or sparsely puberulous. *Stamens* 1–3 cm long, outer filaments basally adnate to petals for 3–5 mm, puberulous, distinct part glabrous. *Ovary* oblate, densely pubescent. *Styles* 5–7, distinct, 2–3 cm long, basally swollen, pubescent and gradually becoming glabrous apically. *Capsule* oblate,

4–6 cm in diam., 2–3 cm in height; *pericarp* ca. 0.5 mm thick. *Seeds* brown or black, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous and shiny.

Phenology: flowering December–March, fruiting February–March.

Distribution: endemic to southern Vietnam (Map 4.14).

Habitat: evergreen forest, along stream banks, 200–450 m.

Conservation status: near threatened (NT). This species is endemic to a small (< 20000 km², Map 4.14), partly protected area in southern Vietnam. It may be vulnerable to environmental fluctuations, such as climate change, and is likely to qualify for a threatened category in the near future (IUCN 2012).

Additional specimens examined

VIETNAM. 700 m, *Schmid s.n.* (P06614720).

Dong Nai: ‘Dinh quan, pro. de Bien hoa’, 20 December 1932, *Poilane 21679* (**HNL**, P05108748).

Lam Dong: Bidoup Nui Ba National Park, 23 February 2012, *Truong BD634, BD635 & BD636* (**SGN**); Cat Tien, Tien Hoang, 11°43'N, 107°26'E, 200–450 m, 22 December 1997, *Loc et al P-7605* (**HNU**); Da Huoai, Ma Da Gui, 27 January 2015, *DL 15.01.09* (**DLU**).

Notes—When Lanessan (1886: 296) described *T. piquetiana*, this species was accompanied by a very brief description. All monographers of *Camellia* have considered *T. piquetiana* validly published there (Lanessan 1886) and have cited the authorship as ‘Pierre ex Lanessan’ (Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 2000). Lanessan (1886: 280–281) did state that ‘La plus grande partie des caractères physiques est due à M. Pierre, ... Nous n’avons pu donner la description botanique du plus grand nombre des espèces qui sont nouvelles et créées par M. Pierre. Cette description se trouvera dans sa magnifique Flore forestière de la Cochinchine ...’ He did not, however, clearly attribute *T. piquetiana* to Pierre but just wrote ‘sp. nov.’ after the name without citing any author. It would be reasonable to recognise that the authorship of *T. piquetiana* (Lanessan 1886) is ‘Lanessan’, not ‘Pierre ex Lanessan’ nor ‘Pierre’. Nevertheless, Pierre (1887) described *T. piquetiana* with detailed descriptions and illustrations one year later (Zhao et al. 2016).

However, it is doubtful that the scanty description of *T. piquetiana* (Lanessan 1886) satisfies the requirement of Art. 38.1(a) for a ‘description or diagnosis’. The descriptive statement is: ‘Arbuste de 1 à 6 mètres de hauteur. Mêmes propriétés.’ Though the height (1–6 m) is different from that of *T. dormoyana* listed there, it does overlap with that of *T. chinensis* var. *cantonensis* Choisy (5–10 m) and that of *T. sasanqua* var. *loureiri* Lanessan (3–4 m) also included simultaneously. Based on Art. 38.4, We (Zhao et al. 2016) made a request for a binding decision on the descriptive statement associated with *T. piquetiana* (Lanessan 1886).

The Nomenclature Committee for Vascular Plants voted to treat the descriptive statement of *T. piquetiana* (Lanessan 1886) as ‘recommended not to treat as validly published’ (five votes for the proposal, 12 votes against the proposal, and one abstention, Applequist 2017). They thought that ‘Lanessan could not have held the opinion that a height of 1–6 m distinguished this species from others’ since there are overlapping heights between *T. dormoyana* and *T. chinensis* var. *cantonensis* or *T. sasanqua* var. *loureiri*. Therefore, it is recommended that the description of Pierre (1887) ‘be treated as the place of valid publication’ of *T. piquetiana* (Applequist 2017: 513).

Pierre (1887) cited ‘Herb. Pierre N° 1708’ in the protologue of *T. piquetiana*. However, *Pierre 1708* is a set of heterogeneous collections that were collected from different localities so the specimens of it are syntypes (Art. 9.5). Sealy (1958: 110) cited ‘*Pierre 1708* (BM, K, type-number)’, which did not lectotypify *T. piquetiana* because he did not select at least a single gathering from the heterogeneous collections of *Pierre 1708* (Art. 8.2); nor was Min’s (2000: 76) citation ‘Type: Vietnam, Bien Hoa, Chao Khan, *Pierre 1708* (P, BM, K)’ a valid lectotypification for the same reason (Art. 8.2). However, P01903371 of *Pierre 1708* is designated here as the lectotype of *T. piquetiana* because it bears a manuscript note.

[36] *Camellia sonthaiensis* Luu, V.D. Luong, Q.D. Nguyen & T.Q.T. Nguyen in *Annales Botanic Fennici* 52: 289. 2015.—**Holotype:** VIETNAM, Khanh Hoa, Khanh Vinh, Son Thai, 12°13'09"N, 108°44'46"E, ca. 900 m, 14 April 2013, *Dung DL 13.04.01 (DLU!)*. Isotype: **DLU!**, **SGN!**. Paratype: VIETNAM, Khanh Hoa, Khanh Vinh, Son Thai, 12°13'09"N, 108°44'46"E, ca. 900 m, *Dung DL 13.04.02 (DLU!, SGN!)*, *DL 13.04.03 (SGN!)*, *DL 13.04.04 (DLU!)*.

Shrubs 2–5 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 7–17 mm long, glabrous; *leaf blades* lanceolate or ligulate-lanceolate, 15–28 × 3–5.5 cm, coriaceous, abaxially yellowish green and adaxially dark green or purplish green on both surfaces when immature, glabrous, midrib abaxially raised and adaxially flat or slightly raised, secondary veins 13–16 on each side of midrib, abaxially slightly raised and adaxially slightly impressed, base rounded, margin nearly entire or very sparsely serrulate, apex attenuate. *Flowers* solitary or up to 3 in a cluster, 4–5 cm in diam. *Pedicels* 1–1.5 cm long, puberulous. *Bracteoles* 2, alternate, narrowly ovate or deltate, 1.5–3 × 1–2 mm, outside puberulous, inside glabrous, margin ciliolate. *Sepals* 5, broadly ovate, 4–6 × 3–7 mm, outside puberulous, inside glabrous, margin ciliolate. *Petals* 7 in 2 whorls, yellow, broadly obovate or elliptic, 12–16 × 13–18 mm, basally connate for 2–3 mm, outside pubescent or puberulous, inside glabrous. *Stamens* 1–1.5 cm long, outer filaments basally adnate to petals for 2–3 mm, puberulous, distinct part glabrous. *Ovary* ovoid, densely pubescent. *Styles* 3–4, distinct, 6–10 mm long, pubescent and gradually becoming glabrous apically. *Capsule* oblate, ca. 4 cm in diam., ca. 1.5 cm in height; *pericarp* 0.5–1 mm thick. *Seeds* not seen.

Phenology: flowering and fruiting in April.

Distribution: endemic to southern Vietnam (Map 4.14).

Habitat: evergreen forest, ca. 900 m.

Conservation status: critically endangered (CR). This species is known to exist at only a single location (B1, Map 4.14, IUCN 2012).

Notes—This species is morphologically like *C. langbianensis* but differs from the latter by the shape of its leaf blade (lanceolate or ligulate-lanceolate) and its short pedicel (1–1.5 cm long) whereas *C. langbianensis* has an elliptic, oblong or ligulate leaf blade and a long pedicel (2–5.5 cm long).

4.2.10 Section *Stereocarpus*

Section *Stereocarpus* (Pierre) Sealy, A Revision of the Genus *Camellia* 45. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 17. 1981, quoad *C. dormoyana* (Pierre) Sealy; Hung T. Chang & B.M. Bartholomew, *Camellias* 32, 34. 1984, quoad *C. dormoyana*; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 156. 1999, quoad *C. dormoyana* & Monograph of the Genus *Camellia* 235–240. 2000, quoad *C. dormoyana* —**Lectotype** (designated by Zhang 1981a: 17): *C. dormoyana* (Pierre) Sealy

≡ *Thea* sect. *Stereocarpus* Pierre, Flore Forestière de la Cochinchine 2(8): supra t. 119. 1887, excl. *T. drupifera* (Loureiro) Pierre

= *Camellia* sect. *Capitatae* Orel ex Orel, Peter G. Wilson, Curry & Luu in *Novon* 23(3): 315. 2014; Orel & Curry, In Pursuit of Hidden *Camellias* 142. 2015. **Syn. nov.** —**Type:** *C. capitata* Orel, Curry & Luu

= *Camellia* sect. *Dalatia* Orel ex Orel & Peter G. Wilson in *Nordic Journal of Botany* 28(3): 281. 2010; Orel & Peter G. Wilson in *International Camellia Journal* 42: 133. 2010; Orel & Curry, In Pursuit of Hidden *Camellias* 81. 2015, excl. *C. hongiaoensis* Orel & Curry, *C. decora* Orel, Curry & Luu, *C. insularis* Orel & Curry, *C. tienyenensis* Orel & Curry, *C. luuana* Orel & Curry & *C. tadungensis* Orel, Curry & Luu. **Syn. nov.** —**Type:** *C. luteocerata* Orel

= *Camellia* sect. *Obvoidea* Ninh & L.V. Dung in *International Camellia Journal* 45: 87. 2013. **Syn. nov.** —**Type:** *C. dilinhensis* Ninh & L.V. Dung

Leaf blade abaxially punctate; sepals persistent; petals yellow.

Notes—This section is morphologically like sect. *Archecamellia* and sometimes hardly differs from the latter though the *RPB2* gene tree (Figure 2.9) do not support a close relationship between them. For example, *C. dilinhensis* is categorised with species of sect. *Archecamellia* in the key. However, other species of sect. *Stereocarpus* can be distinguished from those of sect. *Archecamellia* by a single style they have whereas the distinct styles are presented in the latter.

‘*Camellia ninhii*’ is nested in the clade of sect. *Stereocarpus* (Figures 2.3–2.9). It was not validly published by Luong & Le (2016: 117) because no type was indicated there (Art. 40.1).

[37] *Camellia dilinhensis* Ninh & L.V. Dung in International Camellia Journal 45: 87. 2013. —

Holotype: VIETNAM, Lam Dong, Di Linh, 22 October 2012, *Dung & Ninh DL.12.10.01 (DLU!)*.
Isotypes: **DLU!**.

Shrubs 3–4 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 5–17 mm long, glabrous; *leaf blades* elliptic to oblong, 13–21 × 6.5–9 cm, coriaceous, abaxially yellowish green and brown punctate, adaxially dark green and shiny, glabrous on both surfaces, midrib and secondary veins abaxially raised and adaxially impressed, secondary veins 8–12 on each side of midrib, base obtuse, margin sparsely serrulate to serrulate, apex acute or attenuate. *Flowers* solitary, 3–4 cm in diam. *Pedicels* 5–7 mm long. *Bracteoles* 3–4, alternate, 2-ranked, persistent, deltate or broadly ovate, 2–3 × 1.5–3 mm, both surfaces glabrous, margin ciliolate. *Sepals* 3–5, broadly ovate, 2.5–4.5 × 4–6 mm, both surfaces glabrous, margin ciliolate. *Petals* 7–9 in 2 whorls, pale yellow, elliptic or obovate, 10–15 × 7–12 mm, basally connate for 2–3 mm, both surfaces glabrous. *Stamens* 5–10 mm long; *filaments* glabrous, outer filaments basally adnate to petals for 2–3 mm. *Ovary* oblate, pubescent. *Styles* 3, distinct, ca. 7 mm long, pubescent. *Fruit* and *seeds* not seen.

Phenology: flowering in October.

Distribution: endemic to southern Vietnam (Map 4.16).

Habitat: evergreen forest.

Conservation status: critically endangered (CR). This species is known to exist at only a single location (B1, Map 4.16, IUCN 2012).

Notes—This species is morphologically like *C. dormoyana* but differs from the latter by its distinct styles and pubescent ovary whereas *C. dormoyana* has a single style with a lobed apex and a glabrous ovary.

[38] *Camellia dormoyana* (Lanessan) Sealy, A Revision of the Genus *Camellia* 45, fig. 14. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 17–18. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 32, 34. 1984; P.H. Hô, *Cây cỏ Việt Nam* 1(1): 528, fig. 1453. 1991; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 156. 1999 & *Monograph of the Genus Camellia* 235–237, t. 52. 2000; H.H. Nguyen in *Danh Lục Các Loài Thực Vật Việt Nam* 2: 345. 2003.

≡ *Thea dormoyana* Lanessan, *Les Plantes Utiles des Colonies Françaises* 296. 1886; Pierre, *Flore Forestière de la Cochinchine* 2(8): t. 118. 1887; Kochs in Engler, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 27(5): 590. 1900; Pitard in Lecomte, *Flore Générale de l'Indo-Chine* 1(4): 341, 346, fig. 32: 25–32. 1910; Gagnepain in Humbert, *Supplément a la Flore Générale de l'Indo-Chine* 1(3): 304, 319. 1943; D. Wei Zhao et al. in *Taxon* 65(5): 1183. 2016. ('*dormayana*') —**Lectotype (designated here):** VIETNAM, Dong Nai, 'ad Chiao Xhau in prov. Bieu hoa', March 1873, *Pierre 1332 (P01903402!)*. Syntypes: VIETNAM, Dong Nai, 'ad Tri Huyen in prov. Bieu hoa', March 1873, *Pierre 1332 (K!, NY00148778†, P00700349!)*,

P00700350!, **VNM00003769!**), ‘ad Chiao Xhau in prov. Bieu hoa’, August 1873, *Pierre 1332* (**P00700347!**); Kien Giang, Phu Quoc, February 1887, *Pierre 1332* (**P01903403!**).

= *Camellia luteocerata* Orel ex Orel & Peter G. Wilson in *Nordic Journal of Botany* 28(3): 281. 2010; Orel & Peter G. Wilson in *International Camellia Journal* 42: 133. 2010; Orel & Curry, In Pursuit of Hidden Camellias 81. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Lam Dong, near Cat Tien National Park, 19 December 2007, *Orel et al.* 715 (**NSW868398†**). Isotype: **VNM00018569!**.

= *Camellia bugiamapensis* Orel, Curry, Luu & Q.D. Nguyen ex Orel et al. in *Novon* 23(3): 313, t. 3. 2014; Orel & Curry, In Pursuit of Hidden Camellias 137. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Binh Phuoc, lowland tropical forest about 1 km from the Cambodian border, within the confines of the Bu Gia Map National Park, 18 December 2011, *Truong et al.* 698 (**SGN**). Isotype: **NSW900351†**.

= *Camellia capitata* Orel, Curry & Luu ex Orel, Peter G. Wilson, Curry & Luu in *Novon* 23(3): 315. t. 4. 2014; Orel & Curry, In Pursuit of Hidden Camellias 142. 2015. **Syn. nov.** —**Holotype:** VIETNAM, Lam Dong, Cat Tien National Park, 11 November 2010, *Thai & Hiep CT5* (**SGN!**). Isotype: **NSW901715†**, **SGN!**.

= *Camellia luteopallida* V.D. Luong, T.Q.T. Nguyen & Luu in *Annales Botanic Fennici* 53: 135. 2016. **Syn. nov.** —**Holotype:** VIETNAM, Dak Nong, Gia Nghia, 21 October 2014, *Dung & Hung DL. 14.10.01* (**DLU†**). Isotype: **SGN!**. Paratype: VIETNAM, Dak Nong, Gia Nghia, 15 October 2015, *Dung & Hung DL. 15.10.02* (**SGN!**).

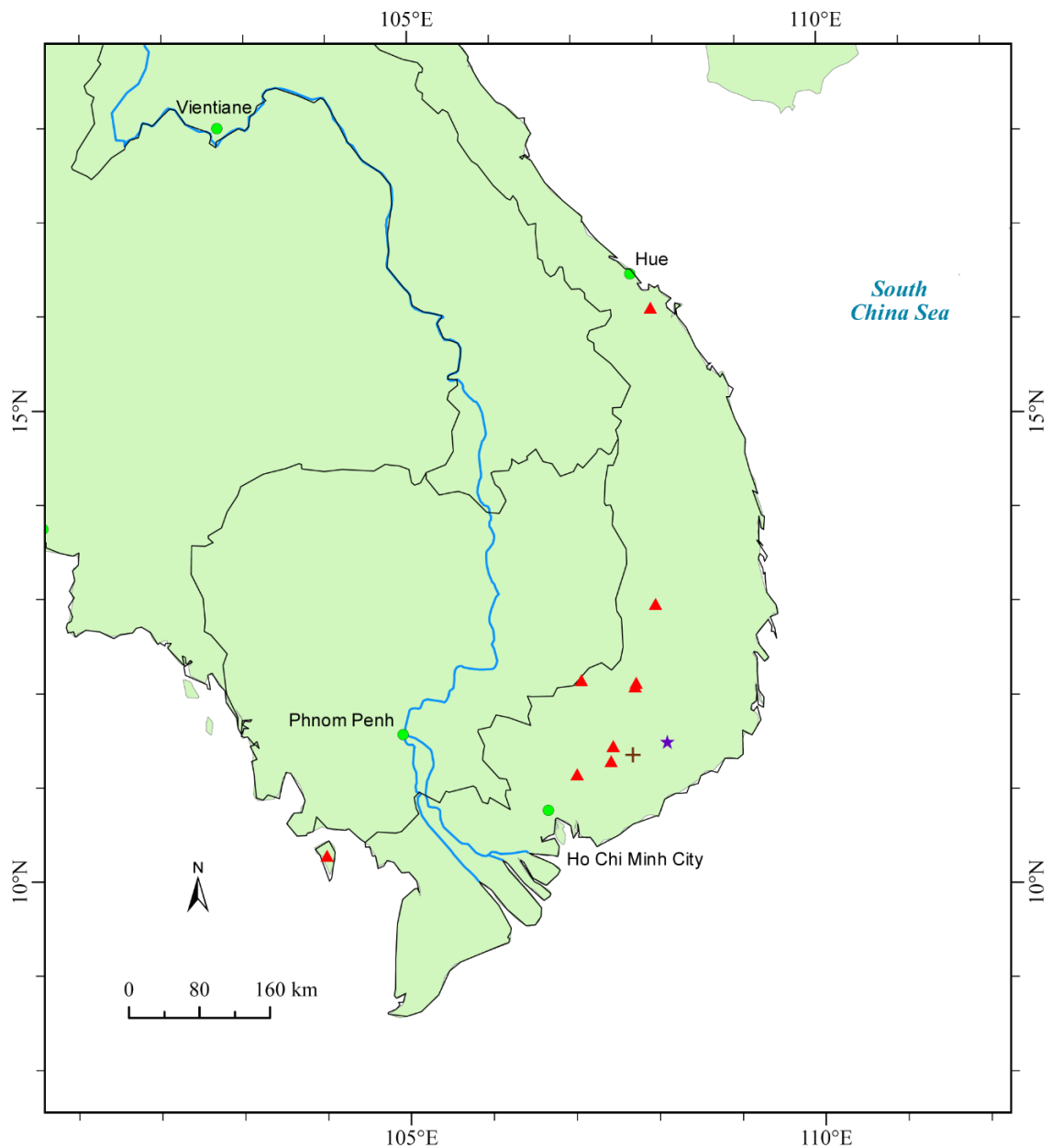
Trees or shrubs 4–10 m tall. *New branchlets* and *terminal buds* puberulous or glabrous. *Petioles* 3–7 mm long, puberulous or glabrous; *leaf blades* elliptic to oblong, 8–20 × 4–8 cm, coriaceous, abaxially yellowish green and brown or black punctate, puberulous or glabrous, adaxially dark green and shiny, glabrous, midrib abaxially raised and adaxially channelled, secondary veins abaxially elevated and adaxially impressed, secondary veins 8–13 on each side of midrib, base obtuse, rounded or subcordate, margin serrulate, apex acute or attenuate. *Flowers* solitary, borne in the axils of leaves or on short bracteate shoots; short shoots bearing up to 6 bracts subtending flowers; *bracts* 4–6 × 3–4 mm, deltate or ovate, outside puberulous; flowers 3–7 cm in diam. *Pedicel* 3–15 mm long. *Bracteoles* 3–4, alternate, 2-ranked, persistent, deltate, broadly ovate or crescent, 2–4 × 4–8 mm, outside glabrous or puberulent, inside sericeous, margin ciliolate. *Sepals* 4–6, broadly ovate, 5–22 × 7–20 cm, outside glabrous or puberulous, inside basally glabrous and becoming sericeous towards margin, margin ciliolate. *Petals* 10–15 in 2–3 whorls, yellow, elliptic or obovate, 2–4 × 1.5–2.5 cm, inner petals basally connate for 0.5–1 cm, outside basally puberulous and gradually becoming glabrous apically, inside puberulous or glabrous. *Stamens* 1.5–2.5 cm long; *filaments* glabrous, outer filaments adnate to petals for 1–1.5 cm. *Ovary* globose or oblate, glabrous. *Style* 2–3 cm long, apex (3–)5-lobed for 2–13 mm long, glabrous. *Capsule* oblate, 2.5–4.5 cm in diam., 1.5–2.5 cm in height; *pericarp* 1–2 mm thick, *Seeds* not seen.

Phenology: flowering August–March, fruiting February–May.

Distribution: endemic to Indochina, including Cambodia and Vietnam (Map 4.16).

Habitat: evergreen forests on limestone mountains.

Conservation status: near threatened (NT). This species may be vulnerable to environmental fluctuations, such as climate change, and is likely to qualify for a threatened category in the near future (IUCN 2012).



Map 4.16. Distribution of *Camellia dilinhensis* (purple star), *C. dormoyana* (red triangle) and *C. thuongiana* (brown cross) in Indochina.

Additional specimens examined

CAMBODIA. *Pierre* 20126 (**BM000603020**).

VIETNAM. *Harmand s.n.* (**P04511413**, **P04511414**).

Dak Lak: *Godefroy 960* (**P04511415**); 23 May 1979, *Tui 222* (**HN**); ‘en bordure plaine du Lac’, 400–450 m, *Schmid VN 925* (**P04511865**).

Dong Nai: ‘Dinh quan, pro: Bien hoa’, 3 December 1932, *Poilane 21598* (**IBK00118405**, **IBSC0238586**, **K**, **P01903404**, **VNM00003774**).

Lam Dong: ‘km 88 de la route colouiale 20’, 20 October 1931, *Poilane 19809* (**IBSC0238587**, **K**, **P04511410**, **SING0204917**, **VNM00003772**); Cat Tien National Park, 11 November 2010, *Thai & Hiep CT6* (**SGN**).

Thua Thien Hue: Phu Loc, Bach Ma, *Ho 4592* (**PHH**).

Notes—Accompanied by *T. piquetiana*, *T. dormoyana* was described by Lanessan (1886) with a scanty descriptive statement (see Notes of *C. piquetiana* in Section. 4.3.9, species [35]). It is doubtful that the descriptive statement of *T. dormoyana* (Lanessan 1886: 296) satisfies the requirement of Art. 38.1(a) for a ‘description or diagnosis’. It states: ‘Arbre de 10 à 15 mètres de hauteur sur 12 à 18 centimètres de diamètre. Même bois.’, which merely indicates the height and diameter of this plant. The height of this species (10–15 m) is the largest recorded and is literally distinct from those of the other three species of *Thea* listed simultaneously. The specific epithet of this species was ‘*dormayana*’ in the protologue. It should be treated as an orthographical error of ‘*dormoyana*’ because the latter was recorded on all syntypes of this species and ‘*dormoyana*’ may derive from French family name ‘Dormoy’ though there was no information to indicate whom this epithet was named after (Art. 60.1). Based on Art. 38.4, we (Zhao et al. 2016) made a request for a binding decision on the descriptive statement associated with *T. dormoyana* (Lanessan 1886). If there is a binding decision that the description published in 1886 is inadequate then *T. dormoyana* published the following year by Pierre (1887), will become the validly published name for the species (Zhao et al. 2016). Unfortunately, there is no response from the Nomenclature Committee for Vascular Plants or General Committee currently, *T. dormoyana* described by Lanessan (1886) is here provisionally treated as being validly published.

Specimens of *Pierre 1332* all bear manuscript notes ‘*Thea dormoyana* Pierre’; however, they are heterogeneous collections because the specimens of *Pierre 1332* were collected from different localities and at different times. Therefore, they are the syntypes of *T. dormoyana* (Art. 9.5).

P01903402 of *Pierre 1332* is designated here as the lectotype of *T. dormoyana* since it has a mature flower on the branchlet.

Camellia luteocerata was described in *Nordic Journal of Botany* in June 2010 (Orel & Wilson 2010b), later repeatedly published as a new species by the same authors in the *International Camellia Journal* in the same year (Orel & Wilson 2010a), a situation which is similar to that of *C. maiana* (see Notes of *C. furfuracea* in Section 4.2.5, species [21]). So, the homotypic superfluous name *C. luteocerata* published in the *International Camellia Journal* (Orel & Wilson 2010a) was

illegitimate and must be rejected (Arts. 52.1 & 52.2[a]). Moreover, Orel and Curry (2015: 81) still wrote '*Camellia luteocerata* Orel, sp. nov.' and cited the protologue as the 'first publication'.

[39] *Camellia thuongiana* V.D. Luong, A. Le & Q. Lau in Dalat University Journal of Science 6(3): 339. 2016. —**Holotype:** VIETNAM, Lam Dong, Da Huoai, Doan Ket, 2 January 2016, Thuong & Dung DL.160107 (DLU†).

Shrubs 3–5 m tall. *New branchlets* and *terminal buds* glabrous. *Petioles* 5–7 mm long, glabrous; *leaf blades* lanceolate or oblong, 12–14 × 3–4.5 cm, coriaceous, abaxially yellowish green and punctate, adaxially dark green and shiny, glabrous on both surfaces, midrib and secondary veins abaxially raised and adaxially impressed, secondary veins ca. 10 on each side of midrib, base obtuse, margin serrulate, apex attenuate. *Flowers* solitary or up to 4 in a cluster. *Pedicels* 5–11 mm long. *Bracteoles* ca. 3, alternate, 2-ranked, persistent, deltate or ovate, 1.5–3 × 1–2 mm, both surfaces glabrous. *Sepals* ca. 4, broadly ovate, 3–6 × 5–7 mm, both surfaces glabrous. *Petals* 11–13 in 2–3 whorls, pale yellow, elliptic or obovate, 7–11 × 4–6 mm, both surfaces glabrous. *Stamens* not seen. *Ovary* ovoid, pubescent. *Style* 1, ca. 7 mm long, apically 3-lobed for ca. 4 mm, glabrous. *Fruit* and *seeds* not seen.

Phenology: flowering in January.

Distribution: endemic to southern Vietnam (Map 4.16).

Habitat: evergreen forest. Map 4.16.

Conservation status: critically endangered (CR). This species is known to exist at only a single location (B1, Map 4.16, IUCN 2012).

Notes—This species is morphologically like *C. dilinhensis* but differs from the latter by its single glabrous style with a 3-lobed apex whereas *C. dilinhensis* has three distinct pubescent styles.

4.2.11 Section *Thea*

Section *Thea* Griffith, Notulae ad Plantas Asiaticas 4: 553. 1854; Dyer in Hooker f., Flora of British India 292. 1874, excl. *C. caudata* Wallich; Sealy, A Revision of the Genus *Camellia* 111–131. 1958, excl. *C. gracilipes* Merrill ex Sealy & *C. pubicosta* Merrill; Hung T. Chang, A Taxonomy of the Genus *Camellia* 108–124. 1981, excl. *C. pubicosta* & in Flora Reipublicae Popularis Sinicae 49(3): 115–137. 1998; Hung T. Chang & B.M. Bartholomew, Camellias 137–153. 1984, excl. *C. pubicosta*; T.L. Ming in Acta Botanica Yunnanica 21(2): 152–153. 1999, excl. *C. sealyana* T.L. Ming, & Monograph of the Genus *Camellia* 110–135. 2000, excl. *C. sealyana*; T.L. Ming & B.M. Bartholomew in Flora of China 12: 372–377. 2007. —**Lectotype (designated here):** *C. sinensis* (Linnaeus) Kuntze

= *Thea* Linnaeus, Species Plantarum 1: 515. 1753, 2nd ed. 1: 734–735. 1762. —**Type:** *T. sinensis* Linnaeus

= *Camellia* sect. *Glaberrima* Hung T. Chang, A Taxonomy of the Genus *Camellia* 124. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 154–155. 1984. —**Type:** *C. glaberrima* Hung T. Chang

= *Camellia* sect. *Longissima* Hung T. Chang, A Taxonomy of the Genus *Camellia* 124. 1981, excl. *C. gracilipes*; Hung T. Chang & B.M. Bartholomew, *Camellias* 153–154. 1984, excl. *C. gracilipes*.

Syn. nov. —**Type:** *C. longissima* Hung T. Chang & S.Y. Liang

Flower clearly pedicellate; bracteoles 2–4, caducous; sepals persistent; style 1, apically usually 3–5-lobed; seeds glabrous.

Notes—Griffith (1854: 553) established sect. *Thea* as a new taxon, which has priority over the name at new rank—sect. *Thea* (Linnaeus) Dyer (1874: 292) (Art. 11.4). The latter has been accepted by Sealy (1958: 111), Zhang (1981a: 108, 1981b: 87, 1998: 115), Zhang & Bartholomew (1984: 137), Min (1992: 116, 1999: 152, 2000: 110), Min & Bartholomew (2007: 372) and Orel & Curry (2015: 263) but it is illegitimate because it is a later homonym of sect. *Thea* Griff. (Art. 53.1, Zhao et al. 2017b).

Griffith (1854) listed five species under his sect. *Thea*—viz., *C. bohea* (Linnaeus) Sweet, *C. theifera* Griffith, *C. mastersia* Griffith, *C. caudata* and *C. simplicifolia* Griffith. He (Griffith 1854) did not, however, designate which species was the type of this section. Here, *C. bohea* is selected as the lectotype of sect. *Thea*. Nevertheless, the basionym of *C. bohea*, *T. bohea*, is an illegitimate replacement name for *T. sinensis* (see Section 1.2.2). Therefore, the lectotype of sect. *Thea* is *C. sinensis*.

As discussed in Section 2.4.4(j), sect. *Thea* is here enlarged to contain *C. longissima*, the type of sect. *Longissima*. Section *Thea* is morphologically like sect. *Camelliopsis* but differs from the latter by its caducous bracteoles whereas sect. *Camelliopsis* has persistent bracteoles.

Species of sect. *Thea* are usually can be used to produce beverage (e.g., tea).

[40] *Camellia sinensis* (Linnaeus) Kuntze var. ***assamica*** (Choisy) Kitamura in Acta

Phytotaxonomica et Geobotanica 14(2): 59. 1950; Sealy, A Revision of the Genus *Camellia* 119–125, fig. 55. 1958; Hung T. Chang, A Taxonomy of the Genus *Camellia* 110, 121–122. 1981; T.L. Ming in Acta Botanica Yunnanica 21(2): 153. 1999 & Monograph of the Genus *Camellia* 133–134, t. 19, fig. 4–6. 2000; H.H. Nguyen in Danh Lục Các Loài Thực Vật Việt Nam 2: 349. 2003; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 224. 2005; T.L. Ming & B.M. Bartholomew in Flora of China 12: 377. 2007; Zhao et al in Taxon 66(6): 1453. 2017.

= *Thea cochinchinensis* Loureiro, Flora Cochinchinensis 1: 338. 1790; Loudon, Arboretum et Fruticetum Britannicum 1: 395. 1838. **Syn. nov.** —**Neotype** (designated by Zhao et al. 2017b: 1453): VIETNAM, Yen Bai, Bao Ha, 21 February 1936, *Poilane* 25282 (**P04511587!**). Isonotype: **K!**.

= *Camellia theifera* Griffith in Transactions of the Agricultural and Horticultural Society of India 5: t. C. 1838. —**Lectotype** (designated by Zhao et al. 2017b: 1453): INDIA, 'Upper Assam'. Griffith s.n. (TCD0017977!, Figure 4.9). Syntypes: INDIA, 'Upper Assam'. Griffith s.n. (E00681110!, E00691478!, K!, TCD0018250! [excluding the specimen in the middle, which is a different species], TCD0018251!).



Figure 4.9. Lectotype of *Camellia theifera* (Griffith s.n., TCD0017977). Image scanned by Jacqueline Stone (TCD).

≡ *Thea viridis* L. var. *assamica* Choisy, in Mémoires de la Société de Physique et d'Histoire Naturelle de Genève 14(1): 156. 1855. — **Lectotype** (designated by Zhao et al. 2017b: 1453): INDIA, Assam, 'Chundoo', Masters s.n. (**K!**, Figure 4.10). Isolectotypes: **K!**.

≡ *Thea chinensis* Sims var. *assamica* (Choisy) Pierre, Flore Forestière de la Cochinchine 2(8): t. 114, D1, D2. 1887.



Figure 4.10. Lectotype of *Thea viridis* var. *assamica* (Masters s.n., **K**).

= *Thea yersinii* A. Chevalier in Gagnepain, Supplément a la Flore Générale de l'Indo-Chine 1(3): 310. 1943 ('*Thea yersini*'), excl. *Poilane* 7744 & 16693. **Syn. nov.** —**Lectotype** (designated by Zhao et al. 2017b: 1453): VIETNAM. Khanh Hoa, 'Massif du Hòn bà, province de Nhatrang', 1000–1500 m, 12 September 1918, *Chevalier* 38684 (**P02142599!**).

≡ *Camellia assamica* (Choisy) Hung T. Chang, in Flora Reipublicae Popularis Sinicae 49(3):133. 1998.

= *Camellia tenuistipa* Orel, Curry & Luu in Orel & Curry, In Pursuit of Hidden Camellias 263. 2015. **Syn. nov.** —**Holotype**: VIETNAM. Gia Lai: Kon Ka Kinh National Park, 22 January 2011, *Luu & Nguyen* KKK 221 (**NSW901734†**).

Trees or shrubs up to 20 m tall. *New branchlets* puberulous; *terminal buds* pubescent or puberulous. *Petioles* 2–9 mm long, puberulous to glabrous; *leaf blades* elliptic to oblong, 6–24 × 2.5–7.5 cm, coriaceous, abaxially yellowish green, glabrous or puberulous, adaxially dark or yellowish green, shiny, midrib abaxially elevated and adaxially slightly raised or flat, secondary veins 7–15 on each side of midrib, abaxially slightly elevated and adaxially flat, base cuneate or attenuate, margin serrulate, apex attenuate. *Flowers* solitary or up to 4 in a cluster, 2–4 cm in diam. *Pedicels* 4–14 mm long. *Bracteoles* 2–3, alternate, 2-ranked, caducous. *Sepals* 5, sub-orbicular or broadly ovate, 3–4.5 × 3–5 mm, outside glabrous, inside white sericeous, margin ciliolate. *Petals* 5–7 in 1–2 whorls, white, elliptic to obovate, 1–2.5 × 1–2 cm, glabrous on both surfaces, inner petals basally adnate to filaments for 1–2 mm long. *Stamens* 7–15 mm long; *filaments* pale yellow, glabrous. *Ovary* oblate or globose, pubescent. *Style* 6–15 mm long, glabrous or basally sparsely puberulous and gradually becoming glabrous apically, apically (2–)3(–4)-lobed for 1–3 mm. *Capsule* oblate, 17–35 mm in diam., 12–20 mm in height; *pericarp* 0.5–1.5 mm thick. *Seeds* brown, hemispherical, polyhedral or globose, 1.5–2 cm in diam., glabrous. Figures 4.9–4.11.

Phenology: flowering September–January, fruiting February–December.

Distribution: China, India, Laos, Myanmar, Thailand and Vietnam (Map 4.17).

Habitat: evergreen and semi-deciduous forests, 200–2700 m.

Conservation status: least concern (LC). This taxon is widespread and abundant in tropical China, India and Indochina (Map 4.17, IUCN 2012).

Additional specimens examined

LAOS. Champasack: Paksong, Nongsoung, 12 August 1998, *Pheng et al.* 98-17 (NUOL).

Khammouan: Nakai, 'near Ban Talang', 17°49'7"N, 105°2'59"E, 540 m, 9 October 2006, *Nanthavong et al.* BT 696 (**E00711125**), 17°49'13"N, 105°2'53"E, 550 m, 28 February 2007, *Vannachak et al.* BT 880 (**E00710964**, NUOL).

Xiangkhouang: 1600 m, 5 September 1929, *Poilane* 16857 (**P04511832**); Khoune, Nalan, 19° 8'23"N, 103°40'35"E, 1620 m, 9 December 2015, *Zhao et al.* 127, 128, 129, 130 & 131 (**TCD**,

equal to *Yang et al.* 5327, 5328, 5329, 5330 & 5331 at **KUN**, respectively), *Yang et al.* 5332 (**KUN**); Pek, Phou San, 2000 m, 8 April 1952, *Vidal* 1599 (**P04511828**), 19°39'1"N, 103°23'11"E, 1870 m, 11 December 2015, *Zhao et al.* 135 (**TCD**); Phookood, Ngodphae, 19°44'19"N, 103°15'03"E, 1170 m, 10 December 2015, *Yang et al.* 5335, 5336, 5337, 5338 & 5339 (**KUN**).

MYANMAR. Kachin: ‘Sumprabum Sub-Division, Mapi-Zup Confluence, on western slope of Bum Seng Bum’, 26°40'N, 97°20'E, 1200–1500 m, 17 January 1962, *Keenan et al.* 3273 (**E00691474**, **K**).

THAILAND. Chiang Mai: ‘Khun Awn’, 900 m, 30 January 1921, *Kerr* 4726 (**BK203758**, **BM**, **K**); Chiang Dao, 25 November 1963, *Bunchuai* 1359 (**BKFSN060849**, **C**, **K**); Mae On, Huai Kaeo, trail along Mae Kampong Waterfall, 1100 m, 7 September 2011, *Pooma et al.* 7791 (**BKFSN196689**); Mae On, Jae Son, 18°51'20"N, 99°22'1"E, 1500 m, 28 May 2011, *Pooma & Pattharahirantricin* 7729 (**BKFSN196803**); Mae Taeng, Mae Taman, 1300 m, 27 September 1994, *Nanakorn et al.* 1808 (**QBG** 1808); Mueang Chiang Mai, Doi Suthep, 1050 m, 7 November 1987, *Maxwell* 87-1378 (**BKFSN060836**), 15 July 1988, *Maxwell* 88-875 (**BKFSN209981**), 1 June 1993, *Maxwell* 93-522 (**BKFSN169943**, **BKFSN192202**, **CMUB** 02747), 18 September 1995, *Kopachon* s169b1 (**BM**, **CMUB** 07853).

Chiang Rai: Wiang Kaen, 600 m, 26 December 2009, *Pongamornkul* 2806 (**QBG** 51200).

Loei: Dan Sai, Pu Lom Lo, 1500 m, 8 April 1922, *Kerr* 5780 (**BK203759**, **BM**, **K**); Phu Kradueng, 16°53'–54'N, 101°47'–49'E, 1150–1250 m, November 1984, *Murata et al.* T-42519 (**BKFSN060857**) & T-42796 (**BKFSN060856**), 1160–1180 m, 2 September 1988, *Fukuoka* T-63807 (**BKFSN103447**); Phurea, Phuluang, 17°18'N, 101°30'E, 1070–1100 m, 4 November 2015, *Zhao et al.* 37, 38, 39, 40 & 41 (**BKF**, **TCD**); Na Haeo, Phu Suan Sai, 10 February 2004, *Pornpongrungrueng* 441 (**KKU**), 1300 m, 16 May 2006, *Maknoi* 850 (**QBG** 27664), 14 May 2008, *Maknoi & Srisanga* 2185 (**BKFSN190334**, **QBG** 38413), 2 September 2008, *Maknoi* 2738 (**BKFSN191010**, **QBG** 40367), 3 September 2008, *Maknoi* 2806 (**BKFSN188351**, **QBG** 40435), 17°30'N, 100°56'E, 1300–1330 m, 6 November 2015, *Zhao et al.* 49, 50, 52 & 54 (**BKF**, **TCD**), *Zhao et al.* 51 & 53 (**TCD**).

Mae Hong Son: Mae Sariang, Wat Chan, Ban Den, 988 m, 29 April 2014, *Norsaengsri* 10930 (**QBG** 77549).

Nakhon Sawan: ‘Khao Pado’, 4 June 1922, *Kerr* s.n. (**BK203756**).

Nan: Tha Wang Pha, 19°04'N, 100°40'E, 1100 m, 23 July 1992, *Larsen et al.* 43513 (**BKF**); Song Khwae, Tham Sokoan, 19°23'3"N, 100°31'5"E, 1210 m, 30 November 2011, *Laongsri et al.* 1957 (**QBG** 56767).

Phayao: Mueang Phayao, Doi Luang, 625 m, 19 November 1997, *Petrmitr* 148 (**CMUB** 13047).

Phitsanulok: Chat Trakan, Phu Miang-Phu Thong, 800 m, 18 February 2010, *Romklao*

Botanical Garden 0005/2553 (QBG 59399); Nakhon Thai, Phu Hin Rong Kla, 16°59'38"N, 101°0'9"E, 1300 m, *Zhao et al. 72 (BKF, TCD)*; 'Phu Rom Rot, one of the peaks of Phu Miang', 1200–1600 m, 3 October 1967, *Shimizu et al. T-11514 (BKFSN060844, K) & T-11515 (BKFSN060845)*, 1200–1650 m, 4 October 1967, *Shimizu et al. T-11653 (BKFSN060843, K)*.

VIETNAM. Cao Bang: Nguyen Binh, Phan Thanh, 16 May 1999, *Phuong 1599 (HN)*; Nguyen Binh, Pinai, 17 May 1999, *Phuong 1643 (HN)*.

Dak Lak: Krong Bong, Cu Pui, 1000–1200 m, 5 & 6 May 2000, *Averyanov et al. VH 6028 (HN)*, 800–900 m, 12 May 2000, *Averyanov et al. VH 6468 (HN)*.

Gia Lai: Mang Yang, Kon Ka Kinh, 22 January 2011, *Truong KKK-210, KKK-218, KKK-219, KKK-220 & KKK-555 (SGN)*.

Ha Giang: Vi Xuyen, Cao Bo, Tam Ve, 22°46'11"N, 104°49'7"E, 1700–1800 m, 13 September 2000, *Harder et al. DKH 5566 (HN, HNU 019011)*.

Hanoi: Ba Vi, 29 October 1918, *Chevalier 37814 (P05278738)*.

Hoa Binh: Da Bac, Nui Bieu, 20 June 1999, *Phuong 1978 (HN)*; Da Bac, Nui Phu Canh, 24 June 1999, *Phuong 2182 (HN)*.

Khanh Hoa: Cam Lam, Hon Ba, 1000–1500 m, 26 August 1918, *Chevalier 38745 (P05278771, P05278772)*, 1000–1500 m, 10 September 1918, *Chevalier 38665 (P04511833, P05278727)*, 4 May 2012, *Truong KH 0121 (SGN)*.

Kon Tum: Dak Gley, 1300 m, 6 December 1995, *Averyanov et al. VH 2357 (HN)*; Dak To, 1000 m, 23 September 1930, *Poilane 18361 (K, P04511838)*, 18369 (*P04511837*), 18370 (*P04511590*) & 18371 (*P04511659*); Sa Thay, Chu Mom Ray, 1480 m, 5 September 1930, *Poilane 18240 (P04511845)*, 5 September 1930, 1400–1480 m, *Poilane 18248 (K, P04511662, VNM00003745)*.

Lai Chau: Tam Duong, Ho Thau, 22°25'20"N, 103°36'13"E, 2600–2700 m, 7 December 2006, *Hiep et al. HAL 10438 (HN)*.

Lam Dong: Bao loc, 16 January 1935, *Poilane 23932 (P04511839)*; Cat Tien, Tien Hoang, 11°43'N, 107°26'E, 200–450 m, 21 December 1997, *Loc & Hiep P-7560 (HNU 019013)*; Dalat, 12 September 1940, *Poilane 30364 (K, VNM00003760, VNM00003761)*; Dalat, Ta Nung, 11°56'08"N, 108°22'47"E, 1310–1380 m, 8 November 2006, *Wu et al. WP 1456 (HN)*; Di Linh, 19 February 1935, *Poilane 24424 (VNM00003759)*; Lac Duong, Dankia, 1500–1800 m, 27 October 1930, *Poilane 18673 (P04511660)*; Lac Duong, Da Chay, 12°9'N, 108°41'E, 1500 m, 19 March 1997, *Averyanov et al. VH 2916 (HN, P05191419)*, 12°8'N, 108°39'E, 1450 m, 27 March 1997, *Averyanov et al. VN 3275 (HN, P05191416)*, 8 April 1997, *Averyanov & Binh VH 3802 (HN)*, 12 April 1997, *Averyanov & Binh VH 3884 (HN, P05233060)*.

Lao Cai: Bao Thang, *Poilane s.n. (VNM00003748, VNM00003749)*; Sa Pa, Phang Xi Pang

Pass, 22°21'10"N, 103°45'56"E, 2014 m, 19 July 2004, *Atha et al.* DA 4942 (HN).

Nghe An: Que Phong, 18 December 2002, *Binh & Cuong* VN 1027 (HN).

Ninh Binh: ‘près Cho bo’ 2 September 1926, *Poilane* 13114 (P05108760, P06838097).

Phu Tho: Tan Son, Xuan Son, 12 June 2012, *VMNB* 2065 (VNMN); November 2011, *Hoc* 18 (VNF).

Quang Ninh: Mong Cai, 8 May 1918, *Chevalier* 37894 (P05286385, P05286386, VNM00003762).

Thua Thien Hue: Nam Dong, 1300–1400 m, 10 September 1938, *Poilane* 27747 (P04511663, SING0204914).

Vinh Phuc: Tam Dao, 21°27'40"N, 105°38'59"E, 1095 m, 18 November 2015, *Zhao et al.* 105(1) (TCD).

Notes—*Camellia sinensis* var. *assamica* (Assam tea) and *C. sinensis* (tea) differ from each other mainly in characters of the leaf and occur naturally in different geographical areas (Sealy 1958, Min 2000). They have been treated both as conspecific and as separate species. Seemann (1859: 349) adopted a broad concept of tea under the name *T. chinensis* Sims to represent ‘only one species of the plant yielding the tea of commerce’, including tea and Assam tea. *Thea chinensis* is an illegitimate replacement name for *T. sinensis* because Sims (1807: t. 998) cited the latter as a synonym of the former, making *T. chinensis* nomenclaturally superfluous (Arts. 6.11, 52.1 & 52.2[e]). This broad concept of tea was accepted by Dyer (1874) and Cohen-Stuart (1919) but they applied the name *C. theifera* to it. By contrast, Wright (1962) and Zhang (1984, 1998) proposed that tea and Assam tea should be treated as two distinct species. Many researchers have, however, recognised Assam tea as a variety of *C. sinensis* (Sealy 1958, Keng 1972, Zhang 1981a, Zhang & Bartholomew 1984, Hô 1991, Min 1999, Min 2000, Min & Bartholomew 2007, Zhao et al. 2017b).

However, the currently widely used scientific name of Assam tea, ‘*C. sinensis* var. *assamica* (J.W. Masters) Kitamura’ has nomenclatural problems and two earlier published names may represent the same taxon. Therefore, the names of Assam tea are examined and typified here to clarify their nomenclatural status (Zhao et al. 2017b).

(a) *Thea viridis* var. *assamica*

Masters (1844: 63) introduced the name ‘*Thea assamica*’ for Assam tea and this has been accepted as the ‘basionym’ of *C. sinensis* var. *assamica* (Sealy 1958, Keng 1972, Zhang 1981a, Zhang & Bartholomew 1984, Hô 1991, Min 1999, 2000, Min & Bartholomew 2007) and *C. assamica* (Zhang 1998) without previous question. Both combinations are, however, based on another name and ‘*T. assamica*’ was never validly published.

In the original publication, Masters (1844) described ‘Assam tea plant’ using the name ‘*T. assamica*’ but concluded that it ‘... is identical with *Thea viridis*, described in Rees’

Cyclopaedia...’ (Masters 1844: 68). And at the end of his paper Masters (1844: 69) further explicitly stated that ‘...the trivial name “*Thea assamica*,” is here used solely for the purpose of the better understanding of this paper; there being no peculiarity in the plant to authorize burdening science with a new name.’ Therefore, Masters himself did not accept the name ‘*T. assamica*’. According to Art. 36.1(a), the name ‘*T. assamica*’ was not validly published by Masters in 1844. However, Sealy (1958: 119) and Min (2000: 133) indicated that another publication of Masters (1863) contained the name ‘*T. assamica*’. In this article Masters (1863), however, used the words ‘the Assam tea plant’, ‘the tea-plant as found in Assam’ and ‘the Assam plant’ to indicate what he meant but never mentioned the binary name ‘*T. assamica*’.

Choisy (1855: 155) adopted the name *T. viridis* to represent tea and cited ‘*T. assamica* H. Kew’ in its synonymy. He (Choisy 1855) probably learned the name ‘*T. assamica*’ from the specimens deposited at K since he wrote ‘H. Kew’. But the name ‘*T. assamica*’ recorded on the specimen sheets is not an effectively published name (Art. 30.1). Choisy (1855: 156) further divided *T. viridis* into three varieties based on the size of the leaves, including *T. viridis* var. *assamica*. The diagnosis of *T. viridis* var. *assamica* stated briefly: ‘feuilles longues de 4 à 8 pouces.’, thereby distinguishing this variety from *T. viridis* var. *vulgaris* Choisy (leaves 1–1.5 inches long) and *T. viridis* var. *cantoniensis* (Loureiro) Choisy (leaves 2–3 inches long) listed simultaneously. It was here, therefore, that *T. viridis* var. *assamica* was validly published as a new taxon (Arts. 6.9, 38.1 & 38.2) and the epithet *assamica* was legitimately used to name Assam tea for the first time. Sealy (1958: 119) and Min (2000: 133) treated *T. viridis* var. *assamica* as a ‘combination’ based on Masters’ (1844) ‘*T. assamica*’ but they were incorrect because a combination must be based on a legitimate, previously published name (Art. 6.10) and ‘*T. assamica*’ had not been validly published and thus had no status (Art. 12.1).

In his *Flore forestière de la Cochinchine*, Pierre (1887: t. 114, D1, D2) validly published the combination *T. chinensis* var. *assamica* when he referenced ‘Choisy Mém. p. 68’ to directly indicate the basionym *T. viridis* var. *assamica* (Art. 41.1). The page number Pierre (1887) cited is, however, incorrect but this should be treated as a correctable typographical error and so does not affect the valid publication of the new combination (Art. 41.3). The correct page number of Choisy’s *T. viridis* var. *assamica* is 156, or the 66th page of Choisy’s article (pages 91–186). Sealy (1958: 119) incorrectly cited page ‘67’ and Zhang (1998: 135) and Min (2000: 133) repeated Sealy’s citation.

The currently widely accepted name of Assam tea, *C. sinensis* var. *assamica*, was validly published by Kitamura (1950: 59) with the authorship cited as “(Pierre) Kitam.” and giving the reference ‘Syn. *Thea sinensis* var. *assamica* Pierre, Fl. Forest. Cochinch. pl. 114 (1887)’. This citation is regarded as an indirect reference through Pierre (1887) to the basionym *T. viridis* var. *assamica* published by Choisy (1855) (Art 41.3). The error in the author citation is correctable and does not affect the valid publication of this new combination (Art. 41.3).

Later, Wight (1962: 298) thought that Assam tea should be treated as an independent species so he proposed the intended combination '*C. assamica* (Masters)'. This name cannot be recognised as a new combination since Masters' '*T. assamica*' was not validly published and thus cannot act as a basionym (Art. 6.10) and the correct basionym, *T. viridis* var. *assamica*, was neither clearly indicated (Art. 41.5) nor indirectly referenced (Art. 41.8). Neither can it be otherwise validly published as a new species because there was no Latin description or diagnosis in the publications of Wight (1962) or Masters (1844) (Art. 39.1).

Hu & Zhang (1964: 497) recognised *Thea* and treated '*T. assamica*' as a validly published name by Masters (1844) and cited the names published by Pierre (1887) and Kitamura (1950) in its synonymy with full and direct references. Though they accepted '*T. assamica*', this name cannot be technically treated as a new species published by Hu & Zhang (1964) because no Latin description or diagnosis was included or directly referenced (Arts. 38.13 & 39.1). Neither can it be otherwise validly published as a new combination because the basionym *T. viridis* var. *assamica* and its reference was not clearly indicated as required by Art. 41.5 or indirectly referenced under Art. 41.8(a) (see Ex. 20) as Pierre (1887) provided an explicit reference to the basionym published by Choisy (1855).

Subsequently, Zhang (1984: 11) proposed the intended combination '*Camellia assamica* (Mast.) Chang' and cited the names and references of Masters (1844) and Kitamura (1950) (Kitamura 1950) and referenced 'Sealy, Rev. Gen. Camellia, 114, 1958'. This reference is full of typographical errors, it should be corrected to 'Sealy, Revis. Gen. Camellia: 119. 1958'. However, the incorrect author citation and typographical errors in the reference do not prevent the potential valid publication of this new combination (Art. 41.6), if other conditions are fulfilled based on the ICN. Unfortunately, Zhang (1984) did not clearly indicate the correct basionym as required by Art. 41.5. Meanwhile, because Sealy (1958) provided an explicit citation and referenced Choisy's *T. viridis* var. *assamica* so Art. 41.8(a) (see Ex. 20) does not apply. Therefore, '*Camellia assamica*' was not validly published as a new combination by Zhang (1984). Neither can it be otherwise validly published as a new species because there was no Latin description or diagnosis provided or directly referenced by Zhang (1984) (Arts. 38.13 & 39.1).

In *Flora Reipublicae Popularis Sinicae*, Zhang (1998: 133) listed '*Camellia assamica* (Mast.) Chang' and cited '*Thea viridis* L. var. *asamica* (Mast.) Choisy Mem. Ternstroemia & Camellia 67. 1865'. This citation should be corrected to '*Thea viridis* L. var. *assamica* Choisy, in Mém. Soc. Phys. Genève 14: 156. 1855'—besides other typographic errors, Zhang (1998: 135) only referenced the abbreviated title of the article. Here, Zhang (1998) indicated Masters' '*T. assamica*' as the 'basionym' and cited the correct basionym, *T. viridis* L. var. *assamica*, as a later synonym. But '*T. assamica*' was not validly published and has no status (Art. 12.1) so it cannot act as a basionym (Art. 6.10). Though the correct basionym was not recognised by Zhang (1998), his new combination *C. assamica* was nevertheless validly published because he did clearly mention the

correct basionym and did directly reference its author and place of valid publication (Art. 41.5) though with incorrect page number and date—these errors are treated as correctable and so they do not affect the valid publication of this new combination (Art. 41.6).

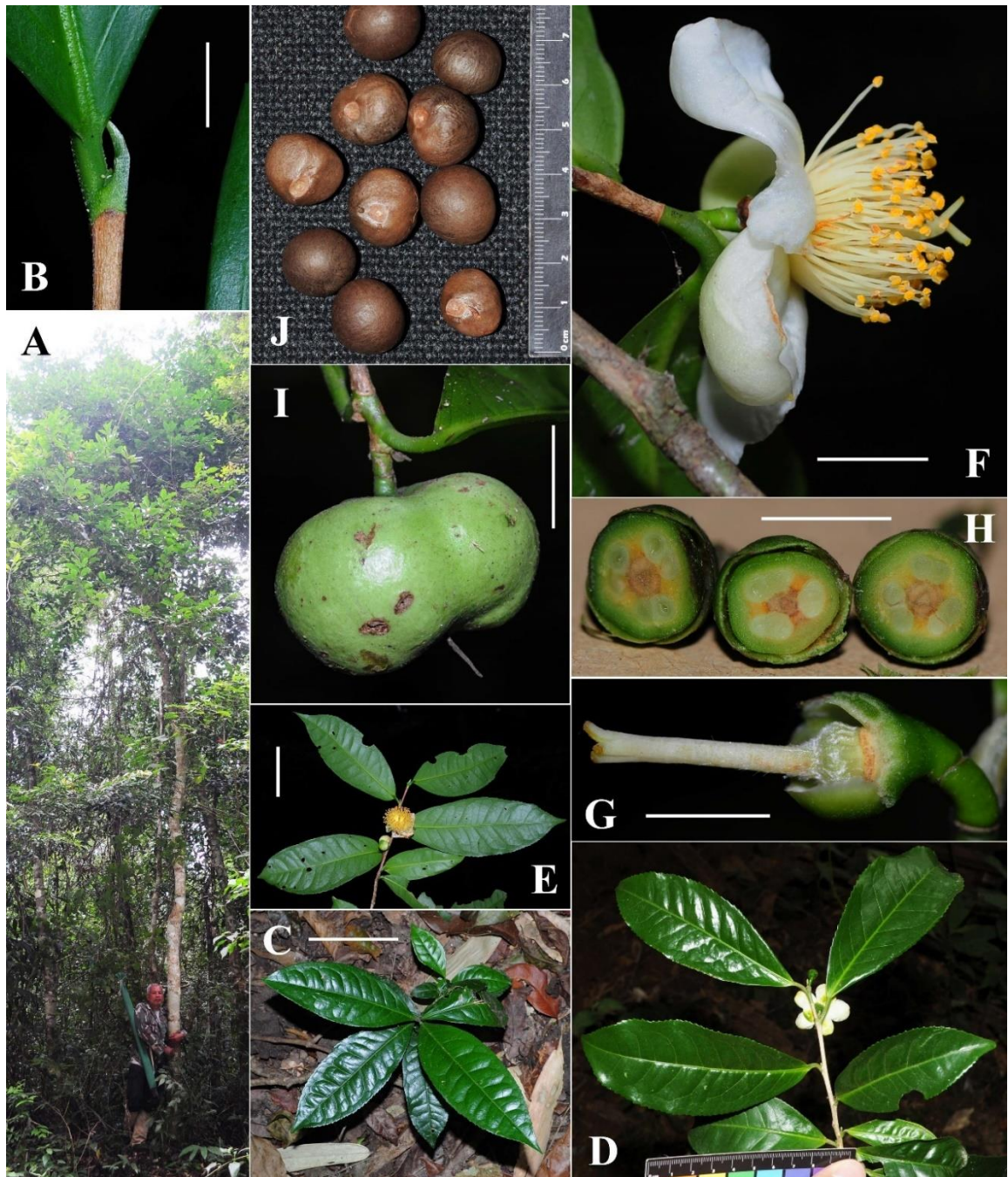


Figure 4.11. *Camellia sinensis* var. *assamica*. A: habit; B: terminal bud; C: seedlings; D & E: branchlets with flowers; F: flower; G: a flower without petals, androecium and one and half sepals; H: transections of immature fruits; I: fruit; J: seeds. The bars represent 5 mm (in B), 10 cm (in C), 5 cm (in E), 1 cm (in F), 5 mm (in G), 5 mm (in H) and 1 cm (in I). The minimum graduation of the ruler in D and J indicates 1 mm.

Unfortunately, the type of *C. sinensis* var. *assamica* has been continuously neglected by monographers who successively revised the taxonomy of *Camellia* (Sealy 1958; Zhang 1981a,

1998, Zhang & Bartholomew 1984, Min 2000, Min & Bartholomew 2007) even though this taxon has been intensively studied. A number of syntypes of *T. viridis* var. *assamica* were found at **K**. They were examined and one of them with mature flowers is designated here as the lectotype (Figure 4.10, Zhao et al. 2017b).

(b) *Camellia theifera*

Seventeen years earlier than the publication of *T. viridis* var. *assamica*, ‘the tea plant of Assam’—*C. theifera*, was published in the caption of an illustration with analysis (Griffith, 1838: t. C). Though this name is literally absent from the text of Griffith’s (1838) paper containing the illustration, it was validly published because there was a group of figures showing the details of flower and fruit of *C. theifera* (Arts. 38.8 & 38.9). Sealy (1958: 119) and Min (2000: 133) did not realise that this name had been published in 1838 and incorrectly cited instead the description of Griffith (1854) as the protologue and treated *C. theifera* as a synonym of *C. sinensis* var. *assamica*. Only the details of flower and fruit were drawn in the original illustration of *C. theifera*. In the article which this illustration accompanied, Griffith (1838: 105) reported that the leaves of Assam tea plants ‘were sufficiently coarse and varied in length from 4 to 8 inches.’ Those characters, illustrated and recorded, are consistent with those of the syntypes found at **E**, **K** and **TCD**. One of the syntypes conserved at **TCD** (**TCD0017977**) has flowers so it is designated here as the lectotype (Figure 4.9, Zhao et al. 2017b).

(c) *Thea cochinchinensis*

Thea cochinchinensis was validly published 48 years before *C. theifera* and 65 years before *T. viridis* var. *assamica* (Loureiro 1790: 338). It may represent the same taxon of Assam tea (Chevalier 1919: 529). Nevertheless, it has been suggested that this name should be abandoned (Cohen Stuart 1919) or treated as a synonym of *C. sinensis* (Seemann 1859, Merrill 1935, Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Min 2000).

Only a part of Loureiro’s collections have been preserved (Bretschneider 1881). It is reported that what remains of his specimens are conserved at **BM**, **LINN**, **LISU**, **MO** and **P** (Merrill 1935, Chaudhri et al. 1972, Stafleu & Cowan 1981). The collections at **LISU** are believed to have been destroyed (Merrill 1935, Chaudhri et al. 1972, Stafleu & Cowan 1981). I visited **BM** and **P** and searched the online database of **LINN** and **MO** but did not find any credible type material of *T. cochinchinensis*, which concurs with former reports (Cohen Stuart 1919, Merrill 1935).

The diagnosis, description and usage in the protologue of *T. cochinchinensis* are ‘sufficiently exact clearly’ (Merrill 1933: 232) to indicate one species of sect. *Thea*. In the protologue Loureiro (1790: 338) wrote: ‘Habitat culta, incultaque in provinciis Borealibus Cochinchinae’, which indicates that this species has both cultivated and wild plants in the northern provinces of Cochinchina. Though it is not clear where exactly the region ‘provinciis Borealibus Cochinchinae’ indicated by Loureiro is, its rough area may be outlined from his other records of localities in *Flora Cochinchinensis*.

Bretschneider (1881) studied and summarised several specified localities recorded by Loureiro, such as ‘Province of *Binh khang* in the southern part of Cochinchina, 14° N...’ and ‘Province of *Quang binh* in North-Cochinchina...’, by which it may be reasonable to consider that ‘provinciis Borealius Cochinchinae’ roughly indicates the area north of Hué in Vietnam since Loureiro lived at Hué, ‘the metropolis of Cochinchina’, at that time (Bretschneider 1881, Cohen Stuart 1919).

Chevalier (1919: 529) suggested for *T. cochinchinensis* that ‘Il est toutetois permis de supposer qu’il s’agit du *Thea sinensis* L. var. *assamica* Pierre’ by which he (Chevalier 1919) inferred that *T. cochinchinensis* might represent Assam tea. Chevalier (1919) also reported that the leaves of *C. tonkinensis* and *C. gilbertii* were collected by local people in Vietnam and sold as substitutes of tea. However, the morphological characters described in Loureiro’s protologue do not match those of *C. tonkinensis* (in terms of the flower colour and the number of petals; see Section 4.2.1, species [2]) or *C. gilbertii* (in terms of the number of stamens; see Section 4.2.6, species [23]).

Merrill (1935: 267) treated *T. cochinchinensis* as a synonym of *T. sinensis* and concluded that ‘I see no reason for considering that *T. cochinchinensis* Lour. represents other than a form of the common tea plant’. *Camellia sinensis* is widely cultivated in Vietnam (Pierre 1887, Hô 1991); however, credible wild material of *C. sinensis* has not been found in the area north of Hué in Vietnam (Sealy 1958, Min 2000). Instead, based on published data (see below) and my field and herbaria investigations, Assam tea is naturally distributed in this area (Map 4.17) and has been cultivated by the Vietnamese for centuries (Chevalier 1919, Sealy 1958, Min 2000). Therefore, I agree with the deduction of Chevalier (1919) that *T. cochinchinensis* may represent the same taxon as *C. theifera* and *T. viridis* var. *assamica*.

In order to further support for the identity of *T. cochinchinensis*, the natural species of sect. *Thea* distributed in Vietnam are examined and discussed as follows.

Pierre (1887) listed five varieties under *T. chinensis*, viz. *T. chinensis* var. *bohea* (Linnaeus) de Candolle, *T. chinensis* var. *viridis* (Linnaeus) de Candolle, *T. chinensis* var. *pubescens* Pierre, *T. chinensis* var. *cantonensis* (Loureiro) Pierre and *T. chinensis* var. *assamica*. The specimens he cited were, however, all collected from other places (e.g., Brazil, China, India, Japan, Malaysia and Réunion), none of them came from Cochinchina. Later, Pitard (1910) repeatedly listed these five varieties of *T. chinensis* but without citing any collection. Gagnepain (1943) did not mention *T. chinensis* var. *pubescens* but recognised that four of these five varieties of *T. chinensis* occurred in Indochina and cited collections of them. However, he (Gagnepain 1943) reported only collectors but without citing corresponding collector numbers. Based on Gagnepain’s handwritten identifications (without date) on the specimens, most of the available specimens from north of Hué in Vietnam cited under the four varieties of *T. chinensis* by him (Gagnepain 1943: 314 & 315) are Assam tea. The remainder are species that do not belong to sect. *Thea* (e.g., *Poilane 12806* [P04500202 & P04511574] under the name *T. chinensis* var. *viridis* by Gagnepain is actually *C. tsingpienensis*; see Section 4.2.2, species [12]). Later, Hô (1991: 535) recorded *C. sinensis* but

adopted the same four varieties reported by Gagnepain (1943) without citing any specimens.

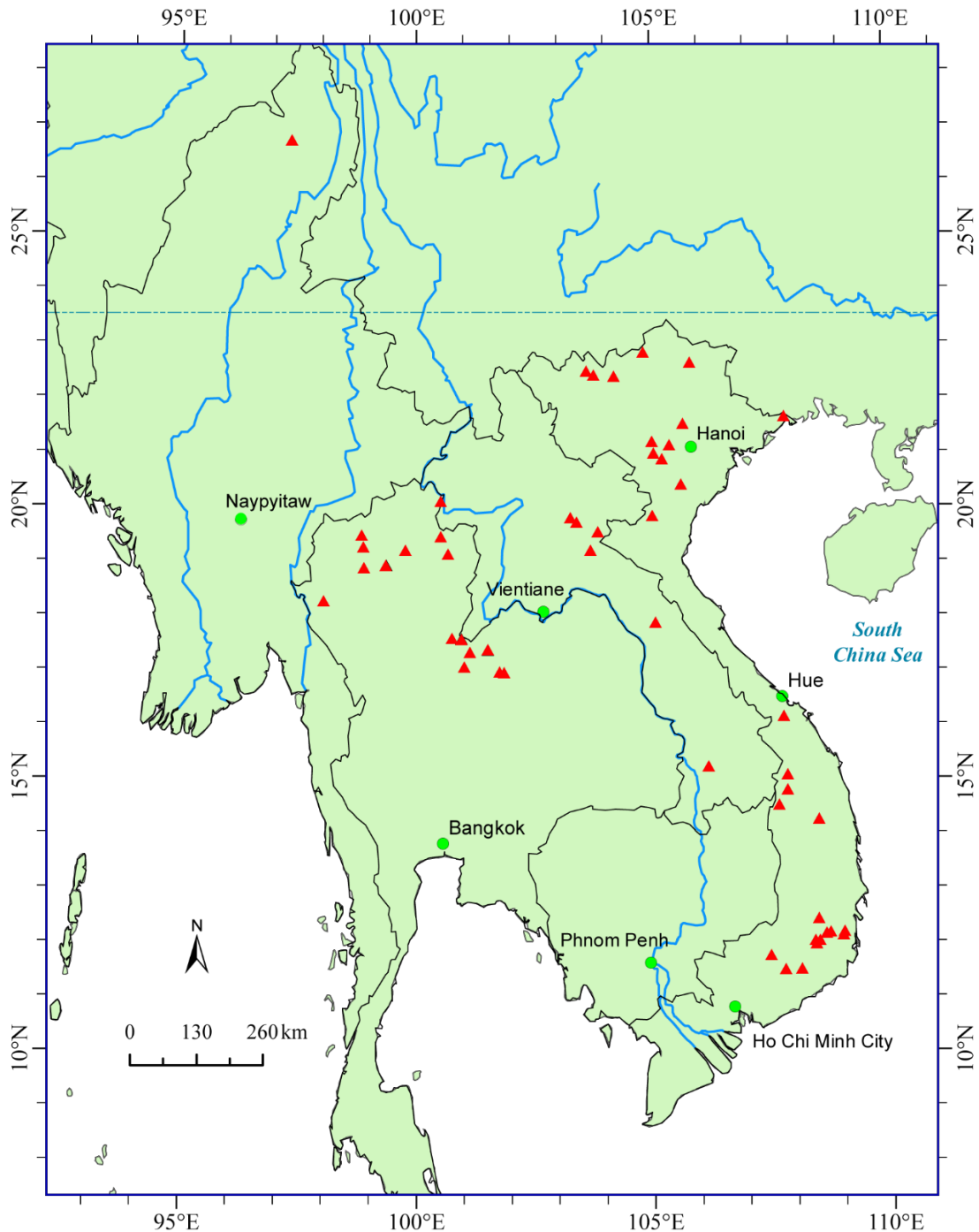
In his *Supplément a la flore générale de l'Indo-Chine*, Gagnepain (1943: 310) described *T. yersinii* (the original epithet 'yersini' in the protologue should be considered as an orthographical error of 'yersinii' because it may be named after A. Yersin [1863–1943]; Arts. 60.12 & 60C.1[b]). The collectors' numbers of the syntypes were not indicated in the protologue. I searched several herbaria and found *Chevalier* 38684 (**P**02142599, **P**05278730 & **P**05278764), 38705 (**P**05312519), 38842 (**P**02274496, **P**02274497, **P**02274498 & **P**04511724), *Poilane* 7744 (**P**04511404) and 16693 (**K**, **P**04500223, **VNM**00003825) all bore the handwriting '*Thea yersini* A. Chev.' so these are all syntypes of *T. yersinii*. However, I found that the syntypes represented three different taxa: Assam tea (*Chevalier* 38684, 38705 & 38842), *C. corallina* (*Poilane* 7744) and *C. pubicosta* (*Poilane* 16693). Nevertheless, no one has so far lectotypified the name *T. yersinii*. The characters recorded in its protologue match those of *Chevalier* 38684, 38705 and 38842. The sheet **P**02142599 of *Chevalier* 38684 at **P** is designated here as the lectotype since it bears Gagnepain's drawing. Therefore, *T. yersinii* is a synonym of Assam tea and *Poilane* 7744 and 16693 are excluded from this name.

Sealy (1958) placed *C. gracilipes* in sect. *Thea* 'as a matter of convenience'. However, this treatment is not supported by Zhang (1981a), Zhang & Bartholomew (1984), Min (2000) and the analysis here (see Notes of *C. gracilipes* in Section 4.2.3, species [15]). *Camellia pubicosta* was also placed in sect. *Thea* by Sealy (1958), Zhang (1981a) and Zhang & Bartholomew (1984), whose view is not supported by the analysis here as well (see Notes of *C. pubicosta* in Section 4.2.3, species [18]). Additionally, *C. pubicosta* naturally occurs in Vietnam (Sealy 1958, Min, 2000, also see Map 4.6) and I collected specimens in the forest of Vinh Phuc (*Zhao et al.* 107(1) & 107(2) at **TCD**, see specimens of *C. pubicosta* cited in Section 4.2.3, species [18]); however, during the field, herbarium and literature investigations, I found that local people did not use this species or plant it as a beverage or medicine source, nor did I find any information on its usage recorded on the specimens examined or in the literature available (Merrill 1942, Sealy 1958, Zhang 1981a, Zhang & Bartholomew 1984, Hô 1991, Min 2000, Nguyễn 2003, Gao et al. 2005).

A recently published species of sect. *Thea*, *C. tenuistipa*, is another synonym of Assam tea, whose type was collected in Vietnam (Orel & Curry 2015: 263).

Apart from the published data discussed above for the identity of *T. cochinchinensis*, I examined *Camellia* collections from many herbaria (see Section 4.1.1), especially those specimens collected in Vietnam (see specimens cited above). As a natural taxon, the morphological characters of Assam tea vary in its areas of distribution. For example, in the northern Vietnamese provinces of Lao Cai and Lai Chau, especially along Sino-Vietnamese border, some specimens (*Hiep et al.* HAL 10438 [**P**05108752], *Pételot* 4249 [**P**04511595] & *Poilane* 17010 [**P**04511836, **PE**01513487]) have a pedicel that is gradually swollen towards the top and/or a 3–4-lobed style. These character states might imply that Assam tea has introgressed with its neighbour *C. taliensis* (see species [41])

below), a species of sect. *Thea* occurring in southern and southwestern Yunnan, China (Zhao et al. 2014) (Assam tea usually has a slender pedicel and 3-lobed style [see Figure 4.11] whereas *C. taliensis* generally has a stout pedicel that is gradually swollen towards the top and a 5-lobed style [see Figure 4.12]). This morphological variation does not challenge the circumscription of Assam tea, on the contrary, it suggests that this taxon is naturally distributed in northern Vietnam (Map 4.17), has natural geographical boundaries and may undergo gene exchange with a phylogenetically closely species (Figure 2.9).



Map 4.17. Distribution of *Camellia sinensis* var. *assamica* (red triangle) in Indochina.

Since no original material of *T. cochinchinensis* is extant, a single specimen with mature flowers collected from northern Vietnam, *Poilane* 25282 (**P04511587**), is designated here as the neotype (Art. 9.13, Zhao et al. 2017b).

Camellia theifera, *T. cochinchinensis* and *T. viridis* var. *assamica* all represent plants of *Camellia* whose leaves can produce drinkable beverage (Loureiro 1790, Griffith 1838, Choisy 1855). On the one hand, *C. theifera* and *T. viridis* var. *assamica* were reported as endemic to Assam (Griffith 1838, Choisy 1855) and their syntypes were collected there. These two taxa share the same character states (see description above) and represent the same taxon (Assam tea) based on the analyses of their protologues and type materials. On the other hand, *T. cochinchinensis* was reported to be both indigenous to and cultivated in northern Vietnam (Loureiro 1790). According to the analysis above, the only taxon that matches this information in sect. *Thea* is Assam tea. Therefore, *C. theifera*, *T. cochinchinensis* and *T. viridis* var. *assamica* are heterotypic synonyms of the same taxon.

However, only one correct name can be used to represent a taxon of living plant below the rank of genus (Art. 11.1) and its nomenclature is based on the priority of publication (Prin. III) in the same rank (Art. 11.2). Clearly, *T. cochinchinensis* has priority over *C. theifera* and *C. assamica* in the rank of species. However, Assam tea is recognised as a variety of *C. sinensis* here because of their morphological and molecular (Su et al. 2009, Yang et al. 2016) similarities. Tea and Assam tea have the same character states of flower and fruit, only differing from each other in habit, leaf size and the shape of the leaf apex—*C. sinensis* is usually a shorter shrub and has smaller leaves than Assam tea, and its leaf apex is acute or shortly attenuate with a rounded tip. By contrast, Assam tea is generally a tall tree, has large leaves and its leaf apex is attenuate or acuminate (see description above and Figure 4.11). These differences and those of geographical distributions (Sealy 1958, Min 2000) are sufficient to warrant separation of Assam tea from *C. sinensis* at varietal level. Therefore, *Thea viridis* var. *assamica*, the basionym of *C. sinensis* var. *assamica*, has priority and the latter remains correct for Assam tea in the rank of variety (Arts. 11.2 & 11.4) and *C. theifera* and *T. cochinchinensis* are herein treated as its earlier published synonyms (Zhao et al. 2017b).

[41] *Camellia taliensis* (W.W. Smith) Melchior in Engler, *Die Natürlichen Pflanzenfamilien* 2(21): 131. 1925. Sealy, *A Revision of the Genus Camellia* 111, 127–128, fig. 57. 1958; Hung T. Chang in *Acta Scientiarum Naturalium Universitatis Sunyatseni* 20(1): 88, 92–93. 1981, 23(1): 2, 6. 1984, *A Taxonomy of the Genus Camellia* 109, 114–115. 1981 & in *Flora Reipublicae Popularis Sinicae* 49(3): 115, 123. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 137, 143. 1984; T.L. Ming in *Acta Botanica Yunnanica* 21(2): 152. 1999 & *Monograph of the Genus Camellia* 111, 118–119, t. 13, fig. 5–7. 2000; J.Y. Gao et al., *Collected Species of the Genus Camellia: An Illustrated Outline* 227. 2005; T.L. Ming & B.M. Bartholomew in *Flora of China* 12: 372, 374. 2007.

≡ *Thea taliensis* W.W. Smith in *Notes from the Royal Botanic Garden, Edinburgh* 10(46): 73.

1917; Nakai in The Journal of Japanese Botany 16(12): 704. 1940; D. Wei Zhao et al. in Phytotaxa 292(2): 177. 2017. —**Lectotype** (first-step designated by Min 2000: 119): CHINA, Yunnan, ‘Ghi Shan east of Tali Lake’, 25°48'N, 2740 m, August 1914, *Forrest 13477* (**E!**, two sheets; second-step lectotype designated by Zhao et al. [2017: 177]: **E00284542!**). Isolectotypes: **BM000611997!**, **E00284543!**, **K000704280!**, **SYS00091976!**, **SYS00091977!**). Syntypes: CHINA, Yunnan, ‘Flanks of the Mingkwong Valley’, 25°15'N, 1800–2100 m, June 1912, *Forrest 8210* (**E00117966!**, **K000704281!**); ‘western flank of the Tali Range’, 2100–2400 m, 25°40'N, August 1914, *Forrest 13503* (**E00284544!**, **K000704282!**).

= *Polyspora yunnanensis* Hu in Bulletin of the Fan Memorial Institute of Biology, Botany Series 8(3): 135. 1938. —**Lectotype (designated here)**: CHINA, Yunnan, Luxi, 1750 m, 6 February 1934, *Tsai 56805* (**PE00716167†**). Isolectotype: **KUN1206055†**.

= *Gordonia yunnanensis* (Hu) H.L. Li in Journal of the Arnold Arboretum 25(3): 307. 1944.

= *Camellia irrawadiensis* P.K. Barua in Camellian 7(4): 18, fig. 1–3. 1956; Sealy, A Revision of the Genus *Camellia* 111, 125–127, fig. 57. 1958; Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 20(1): 88, 93. 1981, 23(1): 2, 6. 1984 & A Taxonomy of the Genus *Camellia* 109, 115. 1981; Hung T. Chang & B.M. Bartholomew, *Camellias* 137, 143. 1984; J.Y. Gao et al., Collected Species of the Genus *Camellia*: An Illustrated Outline 216. 2005. —**Holotype**: MYANMAR, ‘raised from seed collected by L.O. Wilson, 1917, presumably in the region 26°–27°N, 98°–99°E (valley of Irrawadi in North Burma)’, January 1956, *Ex. Herb. I.T.A.* 3253 (consisting of 2 sheets: **K000704313!** & **K000704314!**).

= *Camellia pentastyla* Hung T. Chang in Acta Scientiarum Naturalium Universitatis Sunyatseni 20(1): 92. 1981, 23(1): 2, 5. 1984, A Taxonomy of the Genus *Camellia* 109, 114. 1981 & in Flora Reipublicae Popularis Sinicae 49(3): 115, 123. 1998; Hung T. Chang & B.M. Bartholomew, *Camellias* 137, 142. 1984. —**Lectotype (designated here)**: CHINA, Yunnan, Fengqing, cultivated, 2050 m, 12 February 1963, *Xia & Yang 28* (**KUN1206061!**). Isolectotypes: **KUN1206057!**, **KUN1206059!**, **KUN1206060!**, **KUN1206062!**, **KUN1206064!**.

= *Camellia quinquebracteata* Hung T. Chang & C.X. Ye in Acta Scientiarum Naturalium Universitatis Sunyatseni 26(1): 20, fig. 3. 1987. —**Holotype**: CHINA, Yunnan, Lianghe, Dachang, Zhaolaodi, 4 January 1983, *Zeng & Xie 17055* (**SYS**). Isotype: **KUN1206063!**.

Trees or shrubs up to 15 m tall. *New branchlets* glabrous, *terminal buds* glabrous or sparsely puberulous. *Petioles* 4–8 mm long, glabrous; *leaf blades* elliptic to oblong, 7.5–15.5 × 3–6.5 cm, thinly coriaceous, abaxially yellowish green and adaxially dark or yellowish green, shiny and glabrous on both surfaces, midrib abaxially elevated and adaxially slightly raised, secondary veins 8–14 on each side of midrib, slightly elevated on both surfaces, base attenuate to obtuse, margin sparsely serrulate to nearly entire, apex attenuate or acute. *Flowers* solitary or up to 3 in a cluster, 3–5 cm in diam. *Pedicels* 8–15 mm long. *Bracteoles* 2–4, alternate, 2-ranked, caducous. *Sepals* 5,

sub-orbicular or broadly ovate, 4–6.5 × 5.5–9 mm, outside glabrous, inside sericeous, margin ciliate. *Petals* 7–11 in 2–3 whorls, white, elliptic to obovate, 16–30 × 10–21 mm, glabrous on both surfaces, inner petals basally adnate to filaments for 2–4 mm. *Stamens* 1–2.5 cm long; *filaments* pale yellow, glabrous. *Ovary* oblate, pubescent. *Style* 11–20 mm long, basally sparsely pubescent and gradually becoming glabrous apically, apically (3–)5-lobed for 2–5 mm. *Capsule* oblate, 2.5–5 cm in diam., 2–3 cm in height; *pericarp* 1.5–4 mm thick. *Seeds* brown, hemispherical or polyhedral, 1.5–2 cm in diam., glabrous. Figure 4.12.

Phenology: flowering October–February, fruiting April–November.

Distribution: China, Myanmar and Thailand (Map 4.9).

Habitat: montane evergreen forest, 1100–2750 m.

Conservation status: least concern (LC). Though this species has undergone an over-exploitation in China (see Section 1.7, Zhao et al. 2014), the widespread and abundant individuals of *C. taliensis* in Indochina have not been influenced, especially those from the protected areas in Thailand (Map 4.9, IUCN 2012).

Additional specimens examined

MYANMAR. Chin: Nat Ma Taung National Park, ‘road between Kampetlet and Mindat, ca. 6 miles from Kampetlet’, 2184 m, 21°12'47"N, 94°1'17"E, 2184 m, 14 February 2007, *Fujikawa et al.* 50038 (**MBK**), Mt. Victoria, 1750–1850 m, *Murata et al.* 22425 (**MBK**).

Shan: ‘Mt. Mo-la-hein, Lawk Sawk State’, 2250 m, May 1937, *Dickason* 8741 (E00691479).

THAILAND. Chiang Mai: Chiang Dao, Doi Chiang Dao, ‘Den Ya Khat’, 1500 m, 4 August 2007, *Wattana* 2420 (**QBG** 30728); Chom Thong, Doi Inthanon, 1900 m, 1 May 1921, *Kerr* 5298 (**BK**203709, **BM**, **K**), 1700 m, 12 April 1960, *Smitinand* 6620 (**BKFSN**060847), 18°40'N, 98°25'E, 1700 m, 11 December 1969, *Beusekom & Phengklai* 2462 (**BKF** SN061415, P06838120), 28 May 1987, *Pooma & Werner* 14 (**BKFSN**090190), 1900–2025 m, 14 January 1994, *Fukuoka* T-62168 (**BKFSN**102755), 1700 m, 2 January 1997, *Hara* A380 (**CMUB** 16322); Fang, 1250 m, 24 February 1958, *Smitinand* 4331 (**BKFSN**060803) & 4331-A (**BKFSN**060831), Doi Ang Khang, 1700 m, 27 May 1998, *Wongprasert s.n.* (**BKFSN**121562), 1700 m, 4 November 1998, *Suksathan* 1405 (**QBG** 13639), Doi Pha Hom Pok, 1400 m, 12 February 1958, *Sørensen* 1607 (**BKFSN**060805, **C**, **K**), 1900 m, 14 February 1985, *W.N.* 1127 (**BKFSN**110125), 1920 m, 1 February 2007, *Srisanga et al.* 2919 (**CMUB** 29155, **HITBC** 143571, **QBG** 31244), 1800 m, 28 May 2009, *Pongamornkul* 2674 (**HITBC** 155605, **QBG** 51068); Mae Ai, ‘Bumuhn (Lahu) Village area’, 1150 m, 21 October 1994, *Maxwell* 94-1102 (**BKFSN**060837, **CMUB** 05366); Mae on, Ban Mae Kam Pong, 1300 m, 26 October 2007, *Pongamornkul* 2121 (**QBG** 34196); Mae Taeng, 1600–1950 m, 5 December 1977, *Santisuk* 1480 (**C**, **K**), Doi Chang, 1700–1900 m, 23 October 1979, *Shimizu et al.* T-20524 (**BKFSN**060811, **QBG** 50044), Doi Kiew Lom, Huai Nam Dang, 1700 m, 18 January 2002, *Chayamarit et al.* 3107 (**BKFSN**162068); Nanthaburi, Mae Tuen, 12 March

1991, *Smitinand s.n.* (**BKFSN119850**).

Kampaeng Phet: Klong Lam, Mae Wong, 1320 m, 30 October 2002, *Bult* 609 (**CMUB** 20961).

Mae Hong Son: Khun Yuam, 20 November 1998, *Chusie* KY308 (**QBG** 47303); Mae La Noi, Ban Dong, 1300 m, 15 December 2002, *Pongamornkul* 1871 (**QBG** 35067), 1 October 2003, *Pongamornkul* 1874 (**QBG** 35070), 29 February 2004, *Pongamornkul* 1872 (**QBG** 35068), 23 October 2005, *Pongamornkul* 2191 (**QBG** 35113), 2 May 2011, *Pongamornkul* 2899 (**QBG** 64350); Mueang Mae Hong Son, ‘along the trail to the peak of Doi Pui’, 1100–1750 m, 16 December 2007, *Tanaka et al.* HN8479 (**QBG** 35641), Doi Khun Huai Pong, 18°58'N, 98°10'E, 1850 m, 3 March 1968, *Hansen & Smitinand* 12770 (**BKFSN060846**, **C**, **E00681068**, **K**, **P04511721**); Pai, ‘en route to Doi Chang’, 1800 m, 31 May 1972, *Santisuk* 149 (**BKFSN060809**), Doi Mae Ya, 1800 m, 3 November 1999, *Suksathan* 2030 (**QBG** 16229).

Nan: Pua, Doi Phu Kha, 19°17'N, 101°7'E, 1680 m, 10 April 1999, *Srisanga & Watthana* 685 (**QBG** 14019), 7 November 1999, *Srisanga* 1190 (**QBG** 16333), 19°10'N, 101°7'E, 1700 m, 26 May 2000, *Srisanga* 1429 (**QBG** 17650), 1500 m, 11 November 2000, *Srisanga* 1769 (**QBG** 18609) & 1774 (**QBG** 18614), 1600 m, 22 August 2001, *Srisanga & Maknoi* 2027 (**QBG** 21153).

Phayao: Muang, Doi Luang, 19°5'N, 99°27'E, 1500 m, 22 April 1998, *Sidisunthorn & Gardner* 2568.0 (**CMUB** 13844); Phu Sang, ‘Doi Pha Mon Noi’, 19°44'8"N, 100°24'21"E, 1482 m, 30 April 2013, *Laongsri et al.* 2849 (**QBG** 66589); Pong, Phu Lanka, 1500 m, 4 September 2006, *Watthana & Pumicong* 2141 (**QBG** 28151).

Tak: Umpang, Umpang, ‘near top of Khao Kheeo’, 2150 m, 25 April 2001, *Bult* 419 (**CMUB** 18159).

Notes—Three gatherings were cited in the protologue of *T. taliensis*: *Forrest* 13477, 13503 & 8210 (Anonymous 1917: 73 & 74). The proposed lectotypification of Min (2000: 118) was not effected when he cited ‘Lectotype: Yunnan, Tali, *G. Forrest* 13477 (E, K)’ because the single herbarium where the lectotype was conserved was not specified (Art. 9.22). It was, however, made legitimate when Min (2000: 119) wrote ‘*G. Forrest* 13477 (模式 [means type], E)’. Since there are two duplicates of *Forrest* 13477 at **E** (**E00284542** & **E00284543**), the second-step lectotype is narrowed to **E00284542** because it has flowers and **E00284543** does not (Zhao et al. 2017a).

Camellia pentastyla was described by Zhang (1981b: 92) in *Acta Scientiarum Naturalium Universitatis Sunyatseni*, which was published in February 1981. This species was repeatedly published with same Latin diagnosis and description and identical type cited in Zhang’s (1981a: 114) monograph of *Camellia* which was published in April 1981. Therefore, the homotypic repeated name *C. pentastyla* published later (Zhang 1981a) was illegitimate and must be rejected (Arts. 52.1 & 52.2[a]). A single gathering, *Xia & Yang* 28 at **KUN**, was designated as the type of *C. pentastyla* (Zhang 1981b); however, six specimens of it were found at **KUN**. Two sheets (**KUN1206057** & **KUN1206064**) are labelled ‘HOLOTYPUS’ and three (**KUN1206059**,

KUN1206061 & **KUN1206062**) labelled 'ISOTYPUS' using the stamp of **KUN** whereas four (**KUN1206060**, **KUN1206061**, **KUN1206062** & **KUN1206064**) bear Zhang's manuscript notes '*Camellia pentastyla* Chang n. sp.' and 'Typus!'. All six sheets are not labelled as being part of a single specimen (Art. 8.3) and the holotype has not been clearly identified. So, these specimens are all syntypes of *C. pentastyla* (Art. 40 Note 1). **KUN1206061** is designated here as the lectotype of *C. pentastyla*.

Keng (1972: 146) recorded the occurrence of *C. pleurocarpa* in Thailand based on a single collection *Smitinand 4331-A* at **BKF**, which is *C. taliensis*. *Camellia pleurocarpa* differs from *C. taliensis* by its leaf blade that is punctate on the abaxial surface and by its five distinct styles whereas the latter has a leaf that is non-punctate and a single style with a lobed apex.



Figure 4.12. *Camellia taliensis*. A: habit; B: branch; C: leaf buds; D: a dissected flower; E, F & G: transections of young fruits; H: immature fruits. The bars represent 5 cm, 5 mm, 2 cm, 2 mm, 2 mm, 2 mm & 2 cm in B, C, D, E, F, G & H, respectively.

4.2.12 Taxonomically unresolved species

[42] *Camellia calcicola* T.L. Ming, Monograph of the Genus *Camellia* 86, t. 4, fig. 1–3. 2000. — **Holotype**: VIETNAM, Nghe An, Quy Chau, Ke Can, 170–210 m, 26 January 1965, *Sino-Vietnam Exp. 1790* (KUN1205979!). Isotypes: **HN!**, **IBK00118042!**, **IBK00118043!**, **IBK00118044!**, **IBK00118045!**, **PE01679143!**, **VFM!**.

Shrubs, 4 m tall. *New branchlets* and *terminal buds* puberulent. *Petioles* 2–8 mm long, puberulent; *leaf blades* oblong, 20–33 × 6–8.5 cm, thinly coriaceous, abaxially yellowish green, puberulent along midrib, dark brown punctate, adaxially dark green and glabrous, midrib and secondary veins abaxially elevated and adaxially impressed, secondary veins 16–23 on each side of midrib, base subcordate, margin sparsely serrulate, apex attenuate or acuminate. *Flowers* solitary or paired, ca. 6 cm in diam. *Pedicels* 2–4 mm long. *Bracteoles* 4–5, alternate, 2-ranked, deltate or ovate, 1.5–5 × 2–6 mm, outside puberulent or pubescent, inside glabrous or sparsely sericeous, margin ciliate. *Sepals* 5, ovate, 6–15 × 7–10 mm, outside pubescent, inside sericeous, margin membranous and ciliate. *Petals* 11–12 in 2–3 whorls, red, elliptic or obovate, 2–3.5 × 1.5–2.5 cm, outer petals puberulent on both surfaces, inner ones glabrous. *Stamens* 1.5–2 cm long; *filaments* yellow, glabrous, outer filaments basally connate for 7–8 mm. *Ovary* ovoid, pubescent. *Styles* 3, distinct, 2.5–3 cm long, basally puberulent and gradually becoming glabrous apically. *Capsule* immature. *Seeds* not seen.

Phenology: flowering in January.

Distribution: endemic to northern Vietnam (Map 4.2).

Habitat: evergreen forest, 170–210 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² (B1). It is known to exist at no more than five locations (Map 4.2) and may be influenced by deforestation for land use in the low-elevation areas (IUCN 2012).

Additional specimens examined

VIETNAM. 1991, *Lg 143* (VFM).

Nghe An: Quy Chau, Ke Can, 23 November 1963, *Can C1* (VFM).

Notes—Min & Zhang (1993: 7) described *C. calcicola* and cited the type as ‘Sino-Vietnam Exp. 1790 (Type, KUN, IBG)’. Since the single herbarium or institution in which the type was conserved was not specified (Art. 40.7), this species was not validly published there (Min & Zhang 1993). However, this name was subsequently validated in Min’s (2000: 86) monograph because he referenced the Latin description in Min & Zhang (1993: 7) (Art. 39.1) and indicated the single specimen deposited at KUN (No. 52815) as the type.

Camellia calcicola is like species of sect. *Archecamellia* but differs from the latter by its red flower

whereas the latter have yellow flowers. It may be placed in sect. *Cylindria* with *C. amplexicaulis*; however, molecular analysis of *C. calcicola* is needed to explore this deduction because *C. amplexicaulis* is positioned uniquely on the ITS (Vijayan et al. 2009) and *RPB2* (Figure 2.9) gene trees.

[43] *Camellia laotica* (Gagnepain) T.L. Ming in Acta Botanica Yunnanica 21(2): 153. 1999 & Monograph of the Genus Camellia 136, 140–141 t. 21, fig. 4–5. 2000.

≡ *Thea laotica* Gagnepain in Notulae Systematicae 10(3): 128. 1942; Gagnepain in Humbert, Supplément a la Flore Générale de l'Indo-Chine 1(3): 304, 316–317, t. 30, fig. 7–12. 1943; Sealy, A Revision of the Genus Camellia 221–222, fig. 99. 1958; D. Wei Zhao et al. in Phytotaxa 292(2): 176. 2017. — **Lectotype** (first-step designated by Sealy 1958: 222): LAOS, Savannakhet, 'entre Lang a xinhxa ne et L. xoan', 10 April 1927, *Poilane* 13693 (**P!**, two sheets; second-step lectotype designated by Zhao et al. [2017: 174]: **P04511456!**). Isolectotypes: **A00025098†**, **K000704322!**, **P04511457!**, **VNM00003799!**). Syntypes: LAOS, Savannakhet, 'entre Lao-bao et Muong-non', 17 April 1927, *Poilane* 13268 (**P01903384!**, **P04511458!**, **VNM00003798!**).

Shrubs up to 5 m tall. *New branchlets* puberulous; *terminal buds* pubescent. *Petioles* 2–6 mm long, puberulous; *leaf blades* elliptic to oblong, 4–12 × 1–6 cm, thinly coriaceous, abaxially sparsely appressed pubescent, especially along midrib, adaxially glabrous, midrib and secondary veins abaxially elevated and adaxially channelled, secondary veins 6–8 on each side of midrib, base attenuate, margin sparsely serrulate, apex attenuate to shortly caudate. *Flowers* solitary or up to 3 in a cluster. *Pedicels* 7–13 mm long, puberulous to glabrous. *Bracteoles* 2, opposite or alternate, caducous. *Sepals* 3–4, sub-orbicular or broadly ovate, 3–8 × 6–9 mm, outside glabrous or pubescent, inside sericeous, margin ciliolate. *Petals* 5, white, broadly ovate to obovate, 8–12 × 5–7 mm, glabrous on both surfaces, margin ciliolate. *Stamens* 5–7 mm long; *filaments* glabrous. *Ovary* ovoid, glabrous. *Style* 5–7 mm long, glabrous, apically 3–5-lobed for 1–2 mm. *Capsule* globose, 12–20 mm in diam.; *pericarp* 2–3 mm thick. *Seeds* immature, glabrous.

Phenology: flowering October, fruiting April–August.

Distribution: endemic to Indochina, including Laos and Thailand (Map 4.13).

Habitat: evergreen or mixed deciduous forests, 400–750 m.

Conservation status: vulnerable (VU). The extent of occurrence of this species is estimated to be less than 20000 km² (B1). It is known to exist at no more than ten locations (Map 4.13).

Additional specimens examined

LAOS. 'entre Muông Hong et Lao-bao', 15 August 1927, *Poilane* 13577 (**P06615028**, **P06615029**, **VNM00003806**).

Khammouan: Nakai, Oudom Souk, 17°42'N, 105°8'E, 603 m, 4 April 2005, *Nanthavong* &

Lamxay BT 159 (E00711126, NUOL0003049), ‘hill behind Nam Theun 2 watershed protection office, (Phu Ark)’, 17°42'52"N, 105°7'83"E, 740 m, *Nanthavong et al. BT 159* (E00737400).

THAILAND. Ubon Ratchathani: Khong Chiam, ‘Ban Na Klang Pho, Dong Na Tham forest’, ca. 400 m, 24 October 1998, *Wongprasert s.n.* (**BKF** 124376).

Notes—Three gatherings were cited in the protologue of *T. laotica*: *Poilane* 13268, 13693 & 13743 (Gagnepain 1942: 128). Sealy (1958) selected *Poilane* 13693 at **P**, consisting of two specimens (**P04511456** & **P04511457**), as the lectotype and, unfortunately, this first-step lectotypification (Art. 9.17 Ex. 12) must be followed (Art. 9.19) though there is Gagnepain’s drawing of a dissected flower bud attached on *Poilane* 13268 (**P01903384**). **P04511456** is designated as the second-step lectotype because it has two immature fruits in its attached pocket (Zhao et al. 2017a).

Another syntype, *Poilane* 13743, was excluded from *T. laotica* and recognised as representing a new species by Sealy (1958: 221) but he only named it ‘*Camellia* sp.’ because he thought ‘...in the absence of corolla, androecium, fruits and seeds, it seems unwise to give it a name’. However, Min (1999: 158) subsequently gave it a name, *C. sealyana* T.L. Ming, to honour Sealy (Zhao et al. 2017a, see species [46] below).

Camellia laotica is morphologically similar to species of sect. *Thea* but differs from the latter by that the number of its sepals (3–4) is fewer than that of sect. *Thea* (5).

[44] *Camellia megasepala* Hung T. Chang & Ninh ex Hung T. Chang in *Acta Scientiarum Naturalium Universitatis Sunyatseni* 35(1): 79. 1996; Hung T. Chang in *International Camellia Journal* 30: 80. 1998; T.L. Ming, *Monograph of the Genus Camellia* 86–87. 2000; Ninh in *International Camellia Journal* 39: 58. 2007. —**Holotype:** VIETNAM, Bac Kan, Vuon quoc gia Ba Be, 26 October 1998, *Ninh s.n.* (SYS00094818!). Isotype: **HNU!**.

Shrubs or trees 2–12 m tall. *New branchlets* and *terminal buds* pubescent. *Petioles* 3–7 mm long, pubescent; *leaf blades* elliptic, obovate or oblong, 15–28 × 7–11.5 cm, coriaceous, abaxially pale green, pubescent and brown punctate, adaxially dark green, glabrous and shiny, midrib abaxially elevated and adaxially channelled, secondary veins 11–14 on each side of midrib, abaxially raised and adaxially slightly impressed, base subcordate, margin serrulate or rounded, apex acuminate or attenuate. *Flowers* solitary, 5–10 cm in diam. *Pedicels* 2–9 mm long, bracteoles 6–7, alternate, crescent, broadly ovate or deltate, 2–23 × 5–22 mm, outside pubescent, inside glabrous or puberulous, margin membranous and ciliolate. *Sepals* 7–8, ovate or deltate, 25–37 × 23–31 mm, outside pubescent, inside glabrous or puberulous at base, margin membranous and ciliolate. *Petals* 9–12 in 2–3 whorls, white, obovate, 4–5.5 × 2–3.5 cm, outside glabrous or puberulous at apex, inside glabrous, basally connate for 3–5 mm. *Stamens* 2–3 cm long; *filaments* puberulous, outer filaments basally adnate to petals for 1–3 mm. *Ovary* globose to ovoid, densely pubescent. *Styles* 3, ca. 3 cm long, basally connate for 1–13 mm, pubescent and gradually becoming glabrous apically. *Capsule* oblate, immature. *Seeds* not seen.

Phenology: flowering October–March.

Distribution: endemic to northern Vietnam (Map 4.9).

Habitat: evergreen forest, 200–400 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² (B1). It is known to exist at no more than five locations (Map 4.9) and may be influenced by deforestation for land use in the low-elevation areas (IUCN 2012).

Additional specimens examined

VIETNAM. Bac Kan: Ba Be, Nam Mau, Ba Be National Park, 28 October 1998, *Ninh 187974* (HNU), 22°23'22"N, 105°37'9"E, 300–400 m, 23 December 2002, *Regalado et al. HLF 625* (HN).

Tuyen Quang: Na Hang, 300 m, 1 January 1994, *Ninh 9422* (HNU), Vinh Yen, ‘forest Kem Khanh, Ban Chou, along irrigation ditch from Ban Chou to Na Hang’, 22°21'4"N, 105°25'35"E, ca. 300 m, 6 March 1994, *Harder et al. 2368* (HN), Vinh Yen, ‘on trail from Thac Mo to Ban Chu’, 22°21'9"N, 105°25'20"E, ca. 240 m, 20 June 2002, *Cham et al. HLF-292* (HN).

Notes—This species probably has the largest flower of known *Camellia* species in Indochina. It might represent a different section because it has a leaf blade that is punctate on the abaxial surface, a large white flower with basally connate styles. However, molecular data and more collections are needed to investigate its phylogenetic position.

[45] *Camellia rubriflora* Ninh & Hakoda in International Camellia Journal 30: 77. 1998. —

Holotype: VIETNAM, Vinh Phu, Tam Dao, 600–650 m, 23 January 1998, *Ninh TN9810* (HNU).

Shrubs 3–5 m tall. *New branchlets* puberulent; *terminal buds* glabrous. *Petioles* 5–8 mm long, puberulent; *leaf blades* elliptic or oblong, 11.5–15 × 4.5–6 cm, coriaceous, abaxially pale green and dark brown punctate, adaxially dark green, both surfaces glabrous, midrib and secondary veins abaxially elevated and adaxially channelled, secondary veins 11–14 on each side of midrib, base cuneate or obtuse, margin sparsely serrulate, apex attenuate or acuminate. *Flowers* solitary, ca. 5 cm in diam. *Pedicels* 3–5 mm long. *Bracteoles* and *sepals* 9–10, glabrous. *Petals* ca. 12 in 2–3 whorls, red. *Ovary* glabrous. *Styles* 3, distinct, ca. 3 cm long. *Fruit* and *seeds* not seen.

Phenology: flowering in January.

Distribution: endemic to northern Vietnam (Map 4.7).

Habitat: evergreen forest, 600–650 m.

Conservation status: critically endangered (CR). This species is known to exist at only a single location (Map 4.7) and may have undergone an over-exploitation (B1, IUCN 2012).

Additional specimens examined

VIETNAM. Vinh Phuc: Tam Dao, cultivated, 18 November 2015, *Zhao et al. 113(1)* (TCD).

Notes—I visited HNU but failed to see the type of *C. rubriflora*. Descriptions of flower characters are based on the protologue. The *RPB2* gene tree (Figure 2.9) suggests that *C. lanceolata* and this species might be recognised as members of sect. *Furfuracea*; however, I know so little about *C. rubriflora* that it is better to leave its position unresolved here.

[46] *Camellia sealyana* T.L. Ming in Acta Botanica Yunnanica 21(2): 158. 1999 & Monograph of the Genus Camellia 121. 2000. —**Holotype**: LAOS, Salavan, ‘entre L. Sung et L. Lôi’, 13 April 1927, Poilane 13743 (P01903383!).

Shrubs 1–2 m tall. *New branchlets* and *terminal buds* pubescent. *Petioles* 3–6 mm long, puberulous; *leaf blades* elliptic, 3.5–8.5 × 1.5–4 cm, thinly coriaceous, abaxially puberulous and dark brown punctate, adaxially glabrous and shiny, midrib and secondary veins abaxially elevated and adaxially channelled, secondary veins 5–8 on each side of midrib, base obtuse or cuneate, margin sparsely serrulate, apex obtuse or acute. *Flowers* solitary or paired. *Pedicels* 1–3 mm long, puberulous. *Bracteoles* 2–3, alternate, caducous. *Sepals* 3–4, broadly ovate, 4–6 × 4.5–8 mm, outside puberulous, inside sericeous, margin membranous. *Petals* and *stamens* not seen. *Ovary* ovoid, glabrous. *Styles* 3, distinct, ca. 3 mm long, glabrous. *Capsule* globose, immature. *Seeds* not seen.

Phenology: flowering in April.

Distribution: endemic to Laos (Map 4.7).

Habitat: unknown, 200–300 m.

Conservation status: endangered (EN). The extent of occurrence of this species is estimated to be less than 5000 km² (B1). It is known to exist at no more than five locations (Map 4.7).

Additional specimens examined

LAOS. Salavan: ‘entre L. a Lôi et L. La air’, 200–300 m, Poilane 13238 (P06615016, P06615017).

Notes—This species is morphologically like species of sect. *Heterogenea* but lacking the characteristic state of veinlets that can be clearly visible on both surfaces of leaf blade of the latter. Molecular data of *C. laotica* are needed to resolve its phylogenetic position.

[47] *Camellia yokdonensis* N.V. Dung & Hakoda ex Le, Hakoda & Ninh in International Camellia Journal 48: 120. 2016. —**Holotype**: VIETNAM, Dak Lak, Yok Don National Park, TN 05-1-20 (HNU).

Distribution: endemic to southern Vietnam (Map 4.15).

Conservation status: data deficient (DD, see Notes below).

Notes—No collection of this species were available to me so there is no description here. *Camellia*

yokdonensis was invalidly published by Hakoda et al. (2007) because it lacked a Latin description or diagnosis (Art. 39.1). It was later validated by Le et al. (2016). Hakoda et al. (2007) supplied two coloured photos of this species from which some critical characters could be seen. It may be characterised by its short petiole, long leaf blade (15–20 cm, according to Hakoda et al. 2007) and a red flower with short pedicel and styles (10–13 mm, according to Hakoda et al. 2007). However, I have too little knowledge about it to make a confident judgement on its taxonomic position.

4.3 Summary of names

Among 47 accepted specific and infraspecific taxa of *Camellia* in Indochina, 27 of them are endemic to this area. The number of taxa in each country of Indochina can be found in Table 4.2 below. Vietnam has the most taxa of *Camellia* in Indochina, harbouring 40 species and varieties and 23 of them are endemic. By contrast, Cambodia has the least taxa, only one species (*C. dormoyana*, see Section 4.2.10, species [38]) and one variety (*C. drupifera* var. *kissi*, see Section 4.2.8, taxon [28]) were recorded to this country.

Table 4.2. Number of accepted specific and infraspecific taxa of *Camellia* in each country of Indochina.

Country	No. of taxa	No. of endemic taxa
Cambodia	2	0
Laos	7	1
Myanmar	8	0
Thailand	7	1
Vietnam	40	23

There are 17 synonyms of *Camellia* recognised here, including *Bembiciopsis* (syn. nov.), *Calpandria*, *Camelliastrum*, *Dankia*, *Desmitus*, *Drupifera*, *Glyptocarpa*, *Kemelia*, *Piquetia*, *Sasanqua*, *Stereocarpus*, *Thea*, *Theaphyla*, *Theopsis*, *Tsia*, *Tsubaki* and *Yunnanea*. They can be found on the pages 80–81.

Eleven accepted sections, including *Arhecamellia*, *Camelliopsis*, *Corallina*, *Cylindriea*, *Furfuracea*, *Gilbertia* (new section), *Heterogenea*, *Paracamellia*, *Piquetia*, *Stereocarpus* and *Thea*, are ranged from Section 4.2.1 to 4.2.11. They can be searched using Table of contents. Their synonyms (25 synonyms, including 10 new ones) are listed in Table 4.3 below.

Accepted names of specific and infraspecific taxa and their synonyms are listed in Table 4.4 below. In total, there are 159 names, including 47 accepted names and 112 synonyms. Among them, 42 new synonyms are recognised in this work (Table 4.4).

Table 4.3. Synonyms of recognised sections of *Camellia* in Indochina

Synonym	Accepted section name	Syn. nov.?	Section	Page
<i>Camellia</i> sect. <i>Bidoupia</i>	<i>Piquetia</i>	√	4.2.9	156
<i>Camellia</i> sect. <i>Capitatae</i>	<i>Stereocarpus</i>	√	4.2.10	168
<i>Camellia</i> sect. <i>Chrysantha</i>	<i>Archecamellia</i>		4.2.1	85
<i>Camellia</i> sect. <i>Dalatia</i>	<i>Stereocarpus</i>	√	4.2.10	168
<i>Camellia</i> sect. <i>Eriandria</i>	<i>Camelliopsis</i>		4.2.2	102
<i>Camellia</i> sect. <i>Glaberrima</i>	<i>Thea</i>		4.2.11	173
<i>Camellia</i> sect. <i>Lamdongia</i>	<i>Paracamellia</i>	√	4.2.8	143
<i>Camellia</i> sect. <i>Lecomtia</i>	<i>Piquetia</i>	√	4.2.9	156
<i>Camellia</i> sect. <i>Longissima</i>	<i>Thea</i>	√	4.2.11	174
<i>Camellia</i> sect. <i>Luteoflora</i>	<i>Archecamellia</i>	√	4.2.1	85
<i>Camellia</i> sect. <i>Obvoidea</i>	<i>Stereocarpus</i>	√	4.2.10	168
<i>Camellia</i> sect. <i>Oleifera</i>	<i>Paracamellia</i>		4.2.8	143
<i>Camellia</i> sect. <i>Pierrea</i>	<i>Paracamellia</i>	√	4.2.8	143
<i>Camellia</i> sect. <i>Pleurocarpus</i>	<i>Archecamellia</i>		4.2.1	85
<i>Camellia</i> sect. <i>Theopsis</i>	<i>Camelliopsis</i>		4.2.2	102
<i>Camellia</i> sect. <i>Yersinia</i>	<i>Corallina</i>	√	4.2.3	114
<i>Camellia</i> subg. <i>Metacamellia</i>	<i>Camelliopsis</i>		4.2.2	102
<i>Camelliastrum</i>	<i>Camelliopsis</i>		4.2.2	102
<i>Dankia</i>	<i>Piquetia</i>		4.2.9	156
<i>Thea</i>	<i>Thea</i>		4.2.11	173
<i>Thea</i> sect. <i>Camelliopsis</i>	<i>Camelliopsis</i>		4.2.2	102
<i>Thea</i> sect. <i>Euthea</i>	<i>Camelliopsis</i>		4.2.2	102
<i>Thea</i> sect. <i>Piquetia</i>	<i>Piquetia</i>		4.2.9	156
<i>Thea</i> sect. <i>Stereocarpus</i>	<i>Stereocarpus</i>		4.2.10	168
<i>Theopsis</i>	<i>Camelliopsis</i>		4.2.2	102

Table 4.4 Names of specific and infraspecific taxa of *Camellia* in Indochina. Accepted names are printed in bold in the first column.

Name	Accepted as	Syn. nov.?	Taxon No.	Page
<i>Camellia albata</i>	<i>C. furfuracea</i>	√	[21]	130
<i>Camellia amplexicaulis</i>	<i>C. amplexicaulis</i>	—	[19]	123
<i>Camellia assamica</i>	<i>C. sinensis</i> var. <i>assamica</i>		[40]	177
<i>Camellia assimilis</i>	<i>C. caudata</i>		[10]	104
<i>Camellia aurea</i>	<i>C. petelotii</i>	√	[8]	99
<i>Camellia bugiamapensis</i>	<i>C. dormoyana</i>	√	[38]	170
<i>Camellia calcicola</i>	<i>C. calcicola</i>	—	[42]	193
<i>Camellia campanulata</i>	<i>C. piquetiana</i>	√	[35]	165
<i>Camellia capitata</i>	<i>C. dormoyana</i>	√	[38]	170
<i>Camellia cattienensis</i>	<i>C. piquetiana</i>	√	[35]	165
<i>Camellia caudata</i>	<i>C. caudata</i>	—	[10]	103
<i>Camellia caudata</i> var. <i>gracilis</i>	<i>C. caudata</i>		[10]	105
<i>Camellia chrysantha</i> var. <i>macrophylla</i>	<i>C. euphlebica</i>		[1]	86
<i>Camellia confusa</i>	<i>C. drupifera</i>		[27]	144
<i>Camellia connata</i>	<i>C. connata</i>	—	[24]	137
<i>Camellia corallina</i>	<i>C. corallina</i>	—	[14]	114
<i>Camellia cordatula</i>	<i>C. flava</i>		[2]	89
<i>Camellia cucphuongensis</i>	<i>C. flava</i>		[2]	89

Table 4.4 continued

Name	Accepted as	Syn. nov.?	Taxon No.	Page
<i>Camellia cuongiana</i>	<i>C. drupifera</i> var. <i>kissi</i>	√	[28]	149
<i>Camellia curryana</i>	<i>C. furfuracea</i>	√	[21]	129
<i>Camellia cylindracea</i>	<i>C. amplexicaulis</i>	√	[19]	124
<i>Camellia dalatensis</i>	<i>C. dalatensis</i>	—	[31]	157
<i>Camellia decora</i>	<i>C. langbianensis</i>	√	[34]	162
<i>Camellia dilinhensis</i>	<i>C. dilinhensis</i>	—	[37]	168
<i>Camellia dongnaiensis</i>	<i>C. langbianensis</i>	√	[34]	162
<i>Camellia dormoyana</i>	<i>C. dormoyana</i>	—	[38]	169
<i>Camellia drupifera</i>	<i>C. drupifera</i>	—	[27]	143
<i>Camellia drupifera</i> var. <i>kissi</i>	<i>C. drupifera</i> var. <i>kissi</i>	—	[28]	147
<i>Camellia drupifera</i> var. <i>stenophylla</i>	<i>C. drupifera</i> var. <i>stenophylla</i>	—	[29]	154
<i>Camellia duyana</i>	<i>C. furfuracea</i>	√	[21]	130
<i>Camellia elizabethae</i>	<i>C. petelotii</i>	√	[8]	99
<i>Camellia erubescens</i>	<i>C. petelotii</i>	√	[8]	99
<i>Camellia euphlebia</i>	<i>C. euphlebia</i>	—	[1]	85
<i>Camellia euphlebia</i> var. <i>macrophylla</i>	<i>C. euphlebia</i>	—	[1]	86
<i>Camellia flava</i>	<i>C. flava</i>	—	[2]	89
<i>Camellia fleuryi</i>	<i>C. fleuryi</i>	—	[20]	126
<i>Camellia fluviatilis</i>	<i>C. drupifera</i> var. <i>stenophylla</i>	—	[29]	154
<i>Camellia furfuracea</i>	<i>C. furfuracea</i>	—	[21]	128
<i>Camellia gaudichaudii</i>	<i>C. gaudichaudii</i>	—	[22]	133
<i>Camellia gilbertii</i>	<i>C. gilbertii</i>	—	[23]	134
<i>Camellia gracilipes</i>	<i>C. gracilipes</i>	—	[15]	117
<i>Camellia gracilis</i>	<i>C. caudata</i>	—	[10]	104
<i>Camellia harlandii</i>	<i>C. nervosa</i>	√	[17]	119
<i>Camellia hirsuta</i>	<i>C. hirsuta</i>	—	[3]	93
<i>Camellia hongiaoensis</i>	<i>C. krempfii</i>	√	[33]	159
<i>Camellia hulungensis</i>	<i>C. hulungensis</i>	—	[4]	94
<i>Camellia indochinensis</i>	<i>C. indochinensis</i>	—	[5]	95
<i>Camellia insularis</i>	<i>C. euphlebia</i>	√	[1]	86
<i>Camellia inusitata</i>	<i>C. inusitata</i>	—	[32]	158
<i>Camellia irrawadiensis</i>	<i>C. taliensis</i>	—	[41]	189
<i>Camellia keina</i>	<i>C. drupifera</i> var. <i>kissi</i>	—	[28]	148
<i>Camellia kirinoi</i>	<i>C. kirinoi</i>	—	[30]	155
<i>Camellia kissi</i>	<i>C. drupifera</i> var. <i>kissi</i>	—	[28]	147
<i>Camellia kissi</i> var. <i>confusa</i>	<i>C. drupifera</i>	—	[27]	144
<i>Camellia kissi</i> var. <i>stenophylla</i>	<i>C. drupifera</i> var. <i>stenophylla</i>	—	[29]	154
<i>Camellia krempfii</i>	<i>C. krempfii</i>	—	[33]	159
<i>Camellia langbianensis</i>	<i>C. langbianensis</i>	—	[34]	161
<i>Camellia laotica</i>	<i>C. laotica</i>	—	[43]	194
<i>Camellia ligustrina</i>	<i>C. drupifera</i> var. <i>kissi</i>	√	[28]	149
<i>Camellia limonia</i>	<i>C. indochinensis</i>	—	[5]	95
<i>Camellia limonia</i> f. <i>obvata</i>	<i>C. indochinensis</i>	—	[5]	96
<i>Camellia longii</i>	<i>C. piquetiana</i>	√	[35]	165
<i>Camellia lucii</i>	<i>C. amplexicaulis</i>	√	[19]	124
<i>Camellia luteocerata</i>	<i>C. dormoyana</i>	√	[38]	170
<i>Camellia luteopallida</i>	<i>C. dormoyana</i>	√	[38]	170
<i>Camellia lutescens</i>	<i>C. lutescens</i>	—	[25]	140
<i>Camellia maiana</i>	<i>C. furfuracea</i>	√	[21]	129
<i>Camellia megasepala</i>	<i>C. megasepala</i>	—	[44]	195
<i>Camellia micrantha</i>	<i>C. micrantha</i>	—	[6]	97
<i>Camellia minima</i>	<i>C. micrantha</i>	√	[6]	97
<i>Camellia murauchii</i>	<i>C. murauchii</i>	—	[7]	98
<i>Camellia muricatula</i>	<i>C. lutescens</i>	√	[25]	141
<i>Camellia nematodea</i>	<i>C. nematodea</i>	—	[16]	118
<i>Camellia nervosa</i>	<i>C. nervosa</i>	—	[17]	119
<i>Camellia oconoriana</i>	<i>C. langbianensis</i>	√	[34]	162
<i>Camellia oleifera</i> var. <i>confusa</i>	<i>C. drupifera</i>	—	[27]	144
<i>Camellia osmantha</i>	<i>C. drupifera</i> var. <i>kissi</i>	√	[28]	149
<i>Camellia pachyandra</i>	<i>C. lutescens</i>	√	[25]	141

Table 4.4 continued

Name	Accepted as	Syn. nov.?	Taxon No.	Page
<i>Camellia pentastyla</i>	<i>C. taliensis</i>		[41]	189
<i>Camellia petelotii</i>	<i>C. petelotii</i>	–	[8]	99
<i>Camellia phanii</i>	<i>C. euphlebia</i>	√	[1]	86
<i>Camellia piquetiana</i>	<i>C. piquetiana</i>	–	[35]	164
<i>Camellia pleurocarpa</i>	<i>C. pleurocarpa</i>	–	[9]	100
<i>Camellia pubicosta</i>	<i>C. pubicosta</i>	–	[18]	120
<i>Camellia quinquebracteata</i>	<i>C. taliensis</i>		[41]	189
<i>Camellia reflexa</i>	<i>C. furfuracea</i>	√	[21]	130
<i>Camellia rosmannii</i>	<i>C. euphlebia</i>	√	[1]	86
<i>Camellia rubriflora</i>	<i>C. rubriflora</i>	–	[45]	196
<i>Camellia sealyana</i>	<i>C. sealyana</i>	–	[46]	197
<i>Camellia sinensis</i> var. <i>assamica</i>	<i>C. sinensis</i> var. <i>assamica</i>	–	[40]	174
<i>Camellia sonthaiensis</i>	<i>C. sonthaiensis</i>	–	[36]	167
<i>Camellia stenophylla</i>	<i>C. drupifera</i> var. <i>stenophylla</i>		[29]	154
<i>Camellia suaveolens</i>	<i>C. furfuracea</i>		[21]	129
<i>Camellia symplocifolia</i>	<i>C. drupifera</i> var. <i>kissi</i>		[28]	148
<i>Camellia tadungensis</i>	<i>C. langbianensis</i>	√	[34]	162
<i>Camellia taheishanensis</i>	<i>C. lutescens</i>		[25]	141
<i>Camellia taliensis</i>	<i>C. taliensis</i>	–	[41]	188
<i>Camellia tenuistipa</i>	<i>C. sinensis</i> var. <i>assamica</i>	√	[40]	177
<i>Camellia thanxaensa</i>	<i>C. petelotii</i>	√	[8]	99
<i>Camellia theifera</i>	<i>C. sinensis</i> var. <i>assamica</i>		[40]	174
<i>Camellia thuongiana</i>	<i>C. thuongiana</i>	–	[39]	173
<i>Camellia tienyenensis</i>	<i>C. euphlebia</i>	√	[1]	86
<i>Camellia tonkinensis</i>	<i>C. flava</i>	√	[2]	89
<i>Camellia triantha</i>	<i>C. caudata</i>		[10]	105
<i>Camellia tsaii</i>	<i>C. tsaii</i>	–	[11]	110
<i>Camellia tsingpienensis</i>	<i>C. tsingpienensis</i>	–	[12]	111
<i>Camellia tsingpienensis</i> var. <i>pubisepala</i>	<i>C. tsingpienensis</i> var. <i>pubisepala</i>	–	[13]	112
<i>Camellia tubiformis</i>	<i>C. caudata</i>		[10]	105
<i>Camellia vidalii</i>	<i>C. langbianensis</i>	√	[34]	161
<i>Camellia vietnamensis</i>	<i>C. drupifera</i>		[27]	144
<i>Camellia viscosa</i>	<i>C. furfuracea</i>	√	[21]	130
<i>Camellia wardii</i>	<i>C. wardii</i>	–	[26]	142
<i>Camellia wardii</i> var. <i>muricatula</i>	<i>C. lutescens</i>	√	[25]	141
<i>Camellia yokdonensis</i>	<i>C. yokdonensis</i>	–	[47]	197
<i>Camelliastrum assimile</i>	<i>C. caudata</i>		[10]	105
<i>Camelliastrum caudatum</i>	<i>C. caudata</i>		[10]	105
<i>Camelliastrum gracile</i>	<i>C. caudata</i>		[10]	105
<i>Dankia langbianensis</i>	<i>C. langbianensis</i>		[34]	161
<i>Gordonia yunnanensis</i>	<i>C. taliensis</i>		[41]	189
<i>Piquetia piquetiana</i>	<i>C. piquetiana</i>		[35]	165
<i>Polyspora yunnanensis</i>	<i>C. taliensis</i>		[41]	189
<i>Thea amplexicaulis</i>	<i>C. amplexicaulis</i>		[19]	123
<i>Thea assimilis</i>	<i>C. caudata</i>		[10]	104
<i>Thea bachmaensis</i>	<i>C. drupifera</i> var. <i>kissi</i>		[28]	148
<i>Thea bolovenensis</i>	<i>C. furfuracea</i>		[21]	129
<i>Thea brachystemon</i>	<i>C. drupifera</i> var. <i>kissi</i>		[28]	148
<i>Thea caudata</i>	<i>C. caudata</i>		[10]	104
<i>Thea chinensis</i> var. <i>assamica</i>	<i>C. sinensis</i> var. <i>assamica</i>		[40]	176
<i>Thea cochinchinensis</i>	<i>C. sinensis</i> var. <i>assamica</i>	√	[40]	174
<i>Thea confusa</i>	<i>C. drupifera</i>		[27]	144
<i>Thea connata</i>	<i>C. connata</i>		[24]	137
<i>Thea corallina</i>	<i>C. corallina</i>		[14]	114
<i>Thea dormoyana</i>	<i>C. dormoyana</i>		[38]	169
<i>Thea drupifera</i>	<i>C. drupifera</i>		[27]	144
<i>Thea flava</i>	<i>C. flava</i>		[2]	89
<i>Thea fleuryi</i>	<i>C. fleuryi</i>		[20]	127
<i>Thea fluviatilis</i>	<i>C. drupifera</i> var. <i>stenophylla</i>		[29]	154
<i>Thea furfuracea</i>	<i>C. furfuracea</i>		[21]	129

Table 4.4 continued

Name	Accepted as	Syn. nov.?	Taxon No.	Page
<i>Thea fusiger</i>	<i>C. tsaii</i>		[11]	110
<i>Thea gaudichaudii</i>	<i>C. gaudichaudii</i>		[22]	133
<i>Thea gilbertii</i>	<i>C. gilbertii</i>		[23]	135
<i>Thea gracilis</i>	<i>C. caudata</i>		[10]	105
<i>Thea indochinensis</i>	<i>C. indochinensis</i>		[5]	95
<i>Thea krempfii</i>	<i>C. krempfii</i>		[33]	159
<i>Thea laotica</i>	<i>C. laotica</i>		[43]	194
<i>Thea lutescens</i>	<i>C. lutescens</i>		[25]	140
<i>Thea nematodea</i>	<i>C. nematodea</i>		[16]	118
<i>Thea nervosa</i>	<i>C. nervosa</i>		[17]	119
<i>Thea oxyanthera</i>	<i>C. drupifera</i> var. <i>kissi</i>		[28]	148
<i>Thea petelotii</i>	<i>C. petelotii</i>		[8]	99
<i>Thea piquetiana</i>	<i>C. piquetiana</i>		[35]	164
<i>Thea pleurocarpa</i>	<i>C. pleurocarpa</i>		[9]	100
<i>Thea taliensis</i>	<i>C. taliensis</i>		[41]	188
<i>Thea tonkinensis</i>	<i>C. flava</i>	√	[2]	89
<i>Thea tsaii</i>	<i>C. tsaii</i>		[11]	110
<i>Thea viridis</i> var. <i>assamica</i>	<i>C. sinensis</i> var. <i>assamica</i>		[40]	176
<i>Thea yersinii</i>	<i>C. sinensis</i> var. <i>assamica</i>	√	[40]	177
<i>Theopsis caudata</i>	<i>C. caudata</i>		[10]	105
<i>Theopsis euonymifolia</i>	<i>C. drupifera</i> var. <i>kissi</i>		[28]	148

4.4 Conclusions

Species of *Camellia* in Indochina were examined, described and discussed with illustrations, distribution maps, conservation assessments, nomenclatural notes and a key to them. In total, 11 sections, including *Archecamellia*, *Camelliopsis*, *Corallina*, *Cylindriea*, *Furfuracea*, *Gilbertia*, *Heterogenea*, *Paracamellia*, *Piquetia*, *Stereocarpus* and *Thea*, 43 species and four varieties of *Camellia* are recognised in Indochina, including six species whose taxonomic positions are unresolved. One new section, *Gilbertia*, and two new combinations, *C. drupifera* var. *kissi* and *C. drupifera* var. *stenophylla*, are proposed here. Among them, 27 species are endemic to Indochina. Vietnam and Cambodia have the most (40 taxa) and least (2 taxa) species and varieties, respectively. There are 17 synonyms of *Camellia* identified, including one new synonym, *Bembiciopsis*, and three of them are lectotypified here. In the rank of section, 25 synonyms are recognised, including ten new ones, and two of them are lectotypified. Under 47 accepted specific and infraspecific taxa, 112 synonyms are recognised, including 30 names that are lectotypified or neotypified here and 42 new synonyms.

Chapter 5 Conclusions and perspectives

Camellia contains 100–300 species (Zhang 1998, Min 2000), including economically important plants, such as tea, camellias and oil camellia. Using molecular phylogenetic approaches, several efforts were made previously to resolve the taxonomic controversies of *Camellia* but without yielding a robust classification (Xiao 2001, Vijayan et al. 2009, Fang et al. 2010). These attempts were reviewed and it suggested that not only DNA markers selected but also a lack of key samples from Indochina, including Cambodia, Laos, Myanmar, Thailand and Vietnam, have impeded the efforts for a new phylogenetic classification of *Camellia*. However, Indochinese species of *Camellia* have not been investigated in a thorough way (Sealy 1958, Zhang 1981a, Min 2000), and recently, many new species of *Camellia* have been described based on collections from Indochina. In this context, nomenclatural and taxonomic problems may tangle with phylogenetic ones and could exacerbate the difficulties of phylogenetic analysis of this group—this Ph.D. project aimed to untangle these issues with emphasis on Indochinese species of *Camellia*, rather than examining this genus globally to engulf around 900 names (see IPNI) in four years.

Among several DNA markers, the single copy nuclear *RPB2* 11–16 and 23 intron regions were found to be very informative for the phylogenetic reconstruction of *Camellia*. The phylogenetic accuracy and resolution of *RPB2* gene trees were effectively improved by adding Indochinese species compared to Xiao's (2001) work. A new classification of *Camellia* was proposed based on the *RPB2* gene trees and other data to provisionally categorise Indochinese species into ten amended sections: *Archecamellia*, *Camelliopsis*, *Corallina*, *Cylindriea*, *Furfuracea*, *Heterogenea*, *Paracamellia*, *Piquetia*, *Stereocarpus* and *Thea*. Molecular dating with *RPB2* data and four fossil calibration points suggested that the crown age of *Camellia* was around 48.5 Ma. Most of the recognised sections diversified in the Early and Middle Miocene. Finally, species of *Camellia* in Indochina were examined, described, assessed and discussed with illustrations, distribution maps, conservation status, nomenclatural notes and a key to them. Overall, 11 sections, including the new sect. *Gilbertia*, 43 species and four varieties of *Camellia* were recognised in Indochina. Among them, 27 species are endemic to this area.

However, several perspectives arise from this research and they may supply new insights into future research.

A comprehensive phylogenetic tree of *Camellia* with a nearly exhaustive sampling of known species could be achieved in the near future. I am working on this with the verified methods from this Ph.D. programme. As I mentioned above, this project does not aim to reconstruct the phylogenetic tree of *Camellia* globally, even though a relatively well-represented tree was generated here (Figure 2.9). Clearly, more data from non-Indochinese countries, especially China, are needed for this purpose. It is a great pity that Xiao's (2001) *RPB2* data have not been uploaded to an open-accessed database, e.g., GenBank, and my efforts to contact him or his Ph.D. supervisor

on this issue were in vain. Nevertheless, samples from China were collected during my self-funded trips and they will be added to the phylogenetic analysis soon.

There may be more species of *Camellia* to be found and described from Indochina. At least three new species, two from Laos (my correspondence with Dr. Shuichiro Tagane in March 2017) and one from Vietnam (my reviewing of a submitted manuscript), are being described or going through the publication process. I also encountered some interesting specimens that may qualify for several new names; however, I prefer to amass more data on them, especially data from their genomes. Additionally, compared to Thailand and Vietnam, countries including Cambodia, Laos and Myanmar in Indochina have not been explored and collected sufficiently. I would not be surprised if more new species of *Camellia* are described based on the collections from such countries, especially Cambodia (see Table 4.2).

A new taxonomic revision of known *Camellia* species based on the phylogenetic classification may not be achieved very soon. On the one hand, the taxonomic work becomes money and intelligence consuming. Increasingly, it relies on the up-to-date and reproducible approaches, especially those of genomics. On the other hand, classical works, including nomenclature, specimen examination and field collecting, are still of fundamental importance for this subject. However, disproportionately poor funding and reward is driving researchers out of this discipline: I have to consider a transition from plant systematics to other research areas in order to, hopefully, publish one or two papers in the SCI (Science Citation Index) journals which have high impact factors, to secure a decent job to live. However, regardless of the impact factor, the fundamental work of taxonomic revision must be done to facilitate related practices, such as breeding of tea, camellias and oil camellia, and other research. I hope that I can accomplish this taxonomic work before I become too old to remember so many names, if everything goes well.

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Appendixes

As parts of my Ph.D. work, three published peer-reviewed papers are listed as follows:

- (a) Zhao DW, Parnell JAN, Dubéarnès A. 2016. Requests for binding decisions on the descriptive statements associated with *Thea dormoyana* and *T. piquetiana*. *Taxon* 65: 1183.
- (b) Zhao DW, Parnell JAN, Hodkinson TR. 2017. Typification of names in the genus *Camellia* (Theaceae). *Phytotaxa* 292: 171–179.
- (c) Zhao DW, Parnell JAN, Hodkinson TR. 2017. Names of Assam tea: their priority, typification and nomenclatural notes. *Taxon* 66: 1447–1455.

REQUESTS FOR BINDING DECISIONS ON APPLICATION OF THE CODE

Edited by John McNeill & John Wiersema

(44–45) Requests for binding decisions on the descriptive statements associated with *Thea dormoyana* and *T. piquetiana***Dongwei Zhao, John A.N. Parnell & Anne Dubéarnès***Herbarium, Botany Department, School of Natural Sciences, Trinity College Dublin, the University of Dublin and Trinity Centre for Biodiversity Research, School of Natural Sciences, Trinity College Dublin, the University of Dublin, Dublin 2, Ireland*Author for correspondence: Dongwei Zhao, zhaod@tcd.ie**DOI** <http://dx.doi.org/10.12705/655.29>

Four names of *Thea* L., nowadays treated as a synonym of *Camellia* L., were listed in *Les plantes utiles des colonies françaises* published under the direction of J.L. de Lanessan, including two species that are the subject of this request: *Thea dormoyana* Laness. and *T. piquetiana* Laness. (Pl. Util. Col. Franç.: 296. 1886). Each of these species was accompanied by a very brief description. All monographers of *Camellia* have considered the two names validly published and have cited the authorship as “Pierre ex Lanessan” (e.g., Sealy, Revis. Gen. *Camellia*: 45 & 108. 1958; Chang, Taxon. Gen. *Camellia*: 17 & 21. 1981; Chang & Bartholomew, *Camellias*: 34 & 36. 1984; Ming, Monogr. Gen. *Camellia*: 76 & 235. 2000). Lanessan (l.c.: 280–281) did state that “La plus grande partie des caractères physiques est due à M. Pierre, ... Nous n’avons pu donner la description botanique du plus grand nombre des espèces qui sont nouvelles et créées par M. Pierre. Cette description se trouvera dans sa magnifique *Flore forestière de la Cochinchine* ...” He did not, however, clearly attribute *T. dormoyana* and *T. piquetiana* to Pierre but just wrote “sp. nov.” after the names without citing any author. It would be reasonable to recognize that the authorship of these two names is “Laness.”, not “Pierre ex Laness.” nor “Pierre”. However, Pierre described *T. dormoyana* and *T. piquetiana* with detailed descriptions and illustrations one year later (Pierre, Fl. Forest. Cochinch.: t. 118 & 119 [respectively]. 25 Jan 1887).

The scanty descriptions of these two names published in 1886 form the subject of this request under Art. 38.4 of the *ICN* (McNeill & al. in *Regnum Veg.* 154. 2012).

(44) *Thea dormoyana* Laness., Pl. Util. Col. Franç.: 296. 1886 (‘*dormayana*’) [*Angiosp.: The.*].

Its description (Lanessan, l.c.: 296) states “Arbre de 10 à 15 mètres de hauteur sur 12 à 18 centimètres de diamètre. Même bois.”, which

merely indicates the height and diameter of this plant. The height of this species recorded (10–15 m) is the largest and literally distinct from those of the other three species of *Thea* listed simultaneously.

The specific epithet of this species was “*dormayana*” in the protologue. It should be treated as an orthographical error of “*dormoyana*” because the latter was recorded on all syntypes of this species and “*dormoyana*” may derive from French family name “Dormoy” though there was no information to indicate whom this epithet was named after (Art. 60.1 of *ICN*). If there is a binding decision that the description published in 1886 is inadequate then *T. dormoyana* Pierre (l.c.: t. 118) published the following year, will become the validly published name for the species.

(45) *Thea piquetiana* Laness., Pl. Util. Col. Franç.: 296. 1886 [*Angiosp.: The.*].

The description in the protologue (Lanessan l.c.: 296) is: “Arbuste de 1 à 6 mètres de hauteur. Mêmes propriétés.” Though the height (1–6 m) is different from that of *T. dormoyana*, it does overlap with that of *T. chinensis* var. *cantonensis* Choisy (5–10 m) and that of *T. sasanqua* var. *loureiri* Laness. (3–4 m) also included simultaneously. If there is a binding decision that this description is inadequate then *T. piquetiana* Pierre (l.c.: t. 119) published the following year, would become the validly published name for the species.

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Typification of names in the genus *Camellia* (Theaceae)

DONGWEI ZHAO*, JOHN A. N. PARNELL & TREVOR R. HODKINSON

Herbarium, Botany Department, School of Natural Sciences, Trinity College Dublin, the University of Dublin and Trinity Centre for Biodiversity Research, Trinity College Dublin, the University of Dublin, Dublin 2, Ireland;

e-mail: zhaod@tcd.ie

*author for correspondence

Abstract

Nomenclatural types for 18 names actually belonging to the genus *Camellia* are designated here. The following names are lectotypified: *Camellia caudata*, *C. indochinensis*, *Dankia langbianensis*, *Thea bachmaensis*, *T. brachystemon*, *T. confusa*, *T. connata*, *T. corallina*, *T. fleuryi*, *T. gaudichaudii*, *T. gilbertii*, *T. krempfii*, *T. laotica*, *T. nematodea*, *T. nervosa*, *T. pleurocarpa*, *T. taliensis* and *T. tonkinensis*.

Key words: Indochina, nomenclature, taxonomy

Introduction

Camellia Linnaeus (1753: 698) (Theaceae, Ericales, Asterids, APG IV 2016) is an economically important genus including tea, oil camellia and several horticultural species. It is mainly distributed in East and Southeast Asia and its taxonomy is highly controversial. The number of recognized *Camellia* species varies between 120 (Ming 2000, Ming & Bartholomew 2007) and 280 (Chang 1998) and more than 30 new species have been described since the latest monograph in 2000 (Orel & Curry 2015).

The confusion in the taxonomy of *Camellia* can be traced back to Linnaeus who described *Thea* Linnaeus (1753: 515) and *Camellia* simultaneously. *Thea* was treated as a synonym of *Camellia* by Sweet (1818) but was frequently used until the work of Sealy (1958). The types of many *Camellia* names remain unclear even though the taxonomy of this genus has been successively revised by Sealy (1958), Chang (1981, 1998), Chang & Bartholomew (1984), Ming (1999, 2000) and Ming & Bartholomew (2007).

As part of a taxonomic revision of *Camellia* species in Indochina, names that need typification have been identified and they are listed below with the lectotypes designated here, accompanied by isolectotypes, syntypes and nomenclatural notes. Recently accepted *Camellia* names are provisionally used in this paper as they are currently being evaluated by the first author.

Materials and methods

This work is based on the study of the specimens kept in the following public herbaria (acronyms according to Thiers 2016): ABD, BK, BKF, BM, C, CMUB, DLU, E, FU, GXFI, GXMI, HITBC, HN, HNL, HNNU, HNU, IBK, IBSC, K, KKK, KUN, L, MBK, P, PE, PHH, QBG, SGN, SING, SYS, TCD, VFM, VNF, VNM, VNMN and herbarium of Department of Biology, National University of Laos. The digital images of specimens from herbaria A, G, HK, L, LINN, MICH, MO, NY, P, TAI, US were examined on their websites. The first author also examined specimen photos from CDBI, HIB, HNWP, IFP, LBG, NAS, WUK and XJBI on the website of Chinese Virtual Herbarium (CVH, <http://www.cvh.org.cn/>) and studied type specimen images from herbaria GZU, M, PH and S on the website of JSTOR (<https://plants.jstor.org/>). Herbarium NSW sent high quality images of specimens in a USB key to us for the research.

The types are selected according to Art. 9.3 of the Melbourne Code (McNeill *et al.* 2012, hereafter ICN). The names typified are given in alphabetical order (accepted names are in bold italics). Further nomenclatural and/or taxonomical notes and links to the available type images are provided.

Typification of the names

Camellia caudata Wallich (1832: 36)

Lectotype (designated here):—INDIA. [Meghalaya: Khasia Hills], the district of Sylhet, November 1827, *H. Bruce s.n.* in *Wallich 978* (K barcode K001110475! right-hand specimen, image of the lectotype is available at <http://apps.kew.org/herbcat/getImage.do?imageBarcode=K001110475>).

Notes:—The name *C. caudata* was published by Wallich (1829) without a description or a diagnosis or a reference to a former one (and thus is a nomen nudum), and according to Art. 38.1 of the ICN it was not validly published. The name was validated later by Wallich (1832) providing a Latin description (Chang & Bartholomew 1984, Ming & Bartholomew 2007).

Wallich (1832) cited in the protologue “Cat. Herbar. Ampl. Procur. Britan. Ind. Orient. n. 978” and stated that *C. caudata* was native to “the mountains bordering on the district of Sillet”. Clark C.B. thought that the locality recorded by Wallich was indicating “Khasia” of India (Anonymous 1913) and Sealy (1958) followed this deduction.

Another frequently recorded locality for the syntypes of *C. caudata* is Pundua, which is indicated as “Pundua ~ Bangladesh” on The Wallich Catalogue website (<http://wallich.rbge.info/node/11472>). Moreover, an anonymous article on Royal Botanic Garden Edinburgh website (<http://stories.rbge.org.uk/archives/5029>) has a comment “...Pundua could be modern day Companiganj, or close to it, and not to be confused with Pandua in W Bengal”. However, the current Companiganj in Bangladesh is an alluvial plain and its elevation is generally below 50 m. *Camellia caudata* is usually distributed in the montane evergreen forest between 200 m and 2200 m (Ming 2000) and it is therefore unlikely to occur in the low alluvial plain in Companiganj. Clark further commented that “...all the collections marked ‘Pundua’ came (certainly to me) from Khasia—no collector at Pundua would attempt collecting southward thence in the swamps...” (Anonymous 1913). Therefore, Clark’s deduction of the locality (Anonymous 1913) is followed here.

The lectotype (specimen on the right side of K001110475) has mature flowers. *Wallich 978* is a set of heterogeneous collections that were collected by different collectors at different times, so the other specimens of *Wallich 978*, excluding the lectotype, are not treated as isolectotypes but recognized as syntypes here (Arts. 8.2, 8.3 and 9.5 of the ICN).

Additional specimens examined (syntypes):—INDIA. *Wallich 978* (A barcode 00024746 [digital photo!], G barcode G00354806 [digital photo!], P barcodes P04500104! and P04500138!); [Meghalaya: Khasia Hills], Pundua, *Wallich 978* (BM!, E barcodes E00273841! and E00273843! left-hand specimen, G barcodes G00354841 [digital photo!] and G00354852 [digital photo!], K barcodes K000380533!, K000380534! and K001110475! left-hand specimen, L matrix code L.2399754 [digital photo!], P barcode P04500117!, S No. S09-47084 [digital photo!], TCD!); Sylhet mountain, *Wallich 978* (K barcode K001110474! left-hand specimen).

Camellia indochinensis Merrill (1939: 347)

Lectotype (designated here):—VIETNAM. Lang Son: near Van Linh, 17 November 1938, *Pételot 6459* (A barcode 00024750 [digital photo!], image of the lectotype is available at http://kiki.huh.harvard.edu/databases/specimen_search.php?mode=details&id=66501; isolectotypes A barcode 00024721 [digital photo!], NY barcode 00385754 [digital photo!], P barcode P04511510!, US barcode 00113901 [digital photo!]).

Notes:—Merrill cited a single gathering *Pételot 6459* in the protologue. Five specimens of this gathering were found in herbaria A, NY, P and US so they are syntypes (Art. 40 Note 1 of the ICN). Only A barcode 00024750 bears manuscript notes “*Camellia (Thea) indochinensis* Merr. n. sp.” and “Type” on the label and the sheet, respectively, so it is selected here as the lectotype. The isolectotype P04511510 bears the wrong collector’s number “5459”, it should be 6459 because this specimen was collected by Pételot at the same place and on the same day as the duplicates of *Pételot 6459* that are so labelled in herbaria A, NY and US. Both Sealy (1958) and Ming (2000) cited the wrong number “*Pételot 5459*” in their monographs.

Dankia langbianensis Gagnepain (1939: 198)

≡ *Camellia langbianensis* (Gagnep.) Hô (1991: 537)

Lectotype (designated here):—VIETNAM. [Lam Dong]: entre B. dlé et Dankia, Langbiang, 1200–1300 m, 26 October 1930, *Poilane 18648* (P barcode P00754831!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p00754831>; isolectotypes K barcode K000704329!, L barcode L 0012339 [digital photo!], P barcode P00754832!).

Notes:—Gagnepain validly published the monotypic genus *Dankia* Gagnepain (1939: 198) though he did not supply a generic diagnosis but gave a detailed specific description and illustration (Arts. 38.5 and 38.6 of the ICN). Sealy noticed this genus in 1955 (Sealy's letter to Dr. Sleumer H., 20 September 1955, a copy of which is attached to K000704329) but never mentioned it in his monograph of *Camellia* in 1958. It can be reasonably concluded that Sealy did not think *Dankia* should be merged with *Camellia*. Sealy's view differed from that of Sleumer who remarked “in fact *Dankia* = *Camellia*, as can be seen from the holotype at Paris, and from a letter received by Sealy (Kew) to Sleumer in 1955” (Sleumer H.'s remarks, 1973, attached to K000704329). However, Hutchinson (1967) treated this genus as a synonym of *Hydnocarpus* Gaertner (1788: 288) whereas Hô (1991) finally transferred *D. langbianensis* into *Camellia*.

A single gathering *Poilane 18648* was cited in the protologue of *D. langbianensis*. The specimen P00754831 has Gagnepain's drawing so it is designated here as the lectotype.

Thea bachmaensis Gagnepain (1942: 124)

= *Camellia kissi* Wallich (1820: 429)

Lectotype (first-step designated by Sealy 1958: 199):—VIETNAM. [Thua Thien Hue]: Núi Bach Ma Station d'altitude de Huê, 1400–1500 m, 12 December 1940, *Poilane 31118* (P!, two sheets; second-step lectotype designated here: P barcode P01903389!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903389>; isolectotype P barcode P01903390!).

Notes:—Three gatherings were cited in the protologue: *Poilane 31118*, *31184* and *31378*. Gagnepain identified *Poilane 31184* as “*Thea brachystemon*” but cited it as a syntype of *T. bachmaensis*. Sealy (1958) chose *Poilane 31118* at P as the type but this single gathering has two specimens in P (barcodes P01903389 and P01903390) so his lectotypification should be treated as the first-step (Art. 9.17 Ex. 12 of the ICN). Gagnepain's drawing is attached to P01903389 therefore this sheet is designated here as the second-step lectotype. The syntype *Poilane 31378* has not been found.

Additional specimens examined (syntypes):—VIETNAM. [Thua Thien Hue]: Núi Bach Ma Station d'altitude de Huê, 1200–1500 m, 15 December 1940, *Poilane 31184* (P barcodes P04500130! and P04500133!).

Thea brachystemon Gagnepain (1942: 125)

= *Camellia kissi*

Lectotype (designated here):—LAOS. [Attapeu]: entre Nong Met et B. Thuôt, plateau des Boloven, 8 October 1928, *Poilane 15908* (P barcode P01903386!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903386>; isolectotypes P barcode P01903387!, VNM barcode VNM00003724!).

Notes:—Three gatherings were cited in the protologue: *Poilane 15908*, *15917* and *Watt 5182*. The locality of *Poilane 15917* is same as that of *Poilane 15908* as the following words were recorded on its label: “Raweau de thé cuilli a coté du no. 15908”, but this is not what Gagnepain cited in the protologue “Cambodge: Pnom-chom, prov. Kompong-chnang”. Sealy (1958) incorrectly cited the locality of *Poilane 15908* as Cambodia whereas Ming (2000) repeated Gagnepain's incorrect record of *Poilane 15917*. The lectotype P01903386 bears Gagnepain's drawing of a dissected flower bud.

Additional specimens examined (syntypes):—LAOS. [Attapeu]: entre Nong Met et B. Thuôt, plateau des Boloven, 700 m, 8 October 1928, *Poilane 15917* (P barcode P01903388!). INDIA. Manipur: Ching Sow, 5000–7000 ft, January 1882, *Watt 5182* (K!, P barcode P04500196!).

Thea confusa Craib (1914: 5)

≡ *Camellia kissi* Wall. var. *confusa* (Craib) Ming (1997: 300)

Lectotype (first-step designated by Craib 1925: 131):—THAILAND. Chiang Mai: Doi Soutep, 4000–5000 ft, 31 October 1909, *Kerr 889* (K!, two sheets; second-step lectotype designated here: K barcode K000704304!, the image of the lectotype is available at <http://apps.kew.org/hercat/getImage.do?imageBarcode=K000704304>; isolectotypes BM barcode BM000603018!, K barcode K000704692!, P barcode P04511822!, TCD barcode TCD0010537!).

Notes:—Four gatherings were cited in the protologue: *Kerr 889*, *1363*, *Garrett 100* and *Hosseus 180*. Later Craib (1925) cited “*Kerr, 889* [type!]” by which he selected *Kerr 889* as the lectotype (Arts. 9.17 and 40 Note 1 of the ICN). Ming (2000) further denoted “*Kerr 889* (K)” as the lectotype but failed to fix the lectotype to a single specimen at K. The lectotypifications of both Craib (1925) and Ming (2000) must be followed (Art. 9.17 of the ICN) and K000704304 is designated here as the second-step lectotype because it has dissected flowers in its attached pocket.

Additional specimens examined (syntypes):—THAILAND. [Chiang Mai]: Doi Soutep, 4200 ft, 4 September 1910, *Kerr 1363* (BM!, K barcodes K000704693! and K000704694!, TCD barcode TCD0010541!); Doi Sute, 18°49’N, 98°53’E, 1605 m, 20 November 1910, *Garrett 100* (BK barcode 203731!, K barcode K000704697!, TCD barcode TCD0010542!); Doi-Sutep, 1700 m, 11 December 1904, *Hosseus 180* (BM!, C!, E barcode E00681091!, K barcode K000704695!, M barcode M-0111973 [digital photo!], P barcodes P04511823! and P04511825!).

Thea connata Craib (1914: 6)

≡ *Camellia connata* (Craib) Craib (1925: 131)

Lectotype (first-step designated by Sealy 1958: 146):—THAILAND. [Chiang Mai]: Doi Sute, 5000 ft, 25 June 1911, *Kerr 1878* (K!, two sheets; second-step lectotype designated here: K barcode K000704325!, the image of the lectotype is available at <http://apps.kew.org/hercat/getImage.do?imageBarcode=K000704325>; isolectotypes BM barcode BM000603019!, K barcode K000704326!, P barcode P04511820!, TCD barcode TCD0010539!).

Notes:—Craib (1914) cited two gatherings “*Kerr 1878*, *2732*” in the protologue. Sealy (1958) designated the collection “*A.F.G. Kerr 1878*” in K as the type but this collection has two duplicates at K (barcodes K000704325 and K000704326). So Sealy’s lectotypification can be considered as the first-step (Art. 9.17 Ex. 12 of the ICN). The specimen K000704325 has more flowers and detailed collection information so it is designated here as the second-step lectotype.

Additional specimens examined (syntypes):—THAILAND. [Chiang Mai]: Doi Sute, 5500 ft, 6 October 1912, *Kerr 2732* (BM barcode BM000603029!, K!, TCD barcode TCD0010540!).

Thea corallina Gagnepain (1942: 126)

≡ *Camellia corallina* (Gagnep.) Sealy (1958: 132)

Lectotype (first-step designated by Ming 2000: 147):—VIETNAM. [Da Nang]: Ba-Na, près de Tourane, 1000–1100 m, 28 February 1939, *Poilane 29135* (P, two sheets; second-step lectotype designated here: P barcode P04511818!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p04511818>; isolectotypes K!, K barcode K000380544!, KUN barcode 1205985!, P barcode P01903407!, VNM barcodes VNM00003765! and VNM00003766!).

Notes:—Gagnepain (1942) cited three gatherings *Poilane 29135*, *29165* and *29920* in the protologue. Ming’s (2000) citation “Lectotype: Vietnam, Tourane, *Poilane 29135* (K, P)” on page 145 was not an effected lectotypification because the single herbarium in which the lectotype was housed was not specified (Art. 9.22 of the ICN). He subsequently, however, cited the specimen “*E. Poilane...29135* (后选模式 [means lectotype], P)” on page 147 of the same publication (Ming 2000) by which the lectotypification was legitimized (Art. 7.10 of the ICN) and, according to Art. 9.17 Ex. 12 of the ICN, should be treated as the first-step because there are two specimens of this gathering at P (barcodes P01903407 and P04511818). The specimen P04511818 bears Gagnepain’s drawing of a dissected flower and so it is designated here as the second-step lectotype.

Additional specimens examined (syntypes):—VIETNAM. [Da Nang]: Ba-Na, près de Tourane, 1200–1500 m, 1 March 1939, *Poilane 29165* (A barcode 00025096 [digital photo!], P barcodes P04511817! and P04511819!); [Thua Thien Hue]: Núi Bach Ma Station d’altitude près de Hué, 500–1000 m, 22 April 1939, *Poilane 29920* (A barcode 00025095 [digital photo!], K barcode K000380543!, P barcodes P01903406! and P04511816!, VNM barcodes VNM00003767! and VNM00003768!).

Thea fleuryi Chevalier (1919: 531)

≡ *Camellia fleuryi* (A.Chev.) Sealy (1949: 217)

Lectotype (first-step designated by Ming 2000: 218):—VIETNAM. [Khanh Hoa]: Nha Trang, massif de Hòn Bà, 1000 m, 20–22 September 1918, *Chevalier 38672* (P!, four sheets; second-step lectotype designated here: P barcode P00700353!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p00700353>; isolectotypes P barcodes P00700351!, P00700352! and P05312518!).

Notes:—Chevalier (1919) did not cite a specific specimen in the protologue but wrote “Mss. in Herb., espèce arborescente éroissant dans la forêt vierge du Hon-bà par 1000 m. d’altitude”. The elevation in the protologue matches with that of *Chevalier 38672*. The specific epithet “*fleuryi*” is, however, clearly named after F. Fleury, the collector of *Fleury 38794* (Sealy [1958] cited “*T. Fleury* [in herb. *A. Chevalier 38794*]”), so it might be reasonable to select *Fleury 38794* as the lectotype though its elevation is 800 m and differs from that in the protologue. Nevertheless, Ming (2000) chose *Chevalier 38672* (P) as the lectotype (Art. 9.19 of the ICN) but this collection has four duplicates (barcodes P00700351, P00700352, P00700353 and P05312518) there. It should be considered as the first-step lectotypification (Art. 9.17 Ex. 12 of the ICN). The specimens P00700353 bears Gagnepain’s drawing so it is designated here as the second-step lectotype.

Additional specimens examined (syntypes):—VIETNAM. [Khanh Hoa]: Nha Trang, massif de Hòn Bà, 800 m, September 1918, *Fleury 38794* (P barcodes P00700357!, P00700358!, P00700359! and P00700360!).

Thea gaudichaudii Gagnepain (1942: 127)

≡ *Camellia gaudichaudii* (Gagnep.) Sealy (1949: 217)

Lectotype (designated here):—VIETNAM. [Da Nang]: Tourane, *Gaudichaud 271* (P barcode P01903397!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903397>; isolectotype P barcode P01903398!).

Notes:—*Gaudichaud 271* was one of the syntypes of *C. hongkongensis* Seemann (1859: 342) but Gagnepain (1942) recognized this single gathering to represent a different species. Three sheets of this gathering were found at P (barcodes P01903397, P01903398 and P01903399) and all bear Gagnepain’s manuscript note “*Thea gaudichaudii* Gagnep.”. There is a red tag “TYPE” attached on the sheet P01903397 that is absent on the other two sheets. However, the red tag was used after 2003 (correspondence with Dr. Sovanmoly Hul of herbarium P, Colhelper ID: 54849), and thus was not so labelled by Gagnepain himself. So these three sheets are syntypes (Art. 40 Note 1 of the ICN).

The specimen P01903398 has one gynoeceum in the attached pocket but P01903397 has two of them with bracteole fragments, so the latter is designated here as the lectotype. The plant material of P01903399 may be mixed with *C. hongkongensis* so it is not recognized as an isolectotype of *T. gaudichaudii*.

Thea gilbertii Chevalier (1919: 531)

≡ *Camellia gilbertii* (A.Chev.) Sealy (1958: 136)

Lectotype (first-step designated by Ming 2000: 149):—VIETNAM. Phu Tho: Thanh Ba, October 1917, *Gilbert 37714* (P!, four sheets; second-step lectotype designated here: P barcode P01903392!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903392>; isolectotypes P barcodes P01903393!, P01903394! and P01903395!).

Notes:—No specific specimen was cited in the protologue. Chevalier wrote “Mss. in Herb., ...assez répandu dans les forêts du Tonkin (provinces de Phu-tho, de Tuyên-quang, de Mon-cay, etc.)” in the protologue. *Gilbert 37714* (P) was selected by Ming (2000) as the lectotype but this collection has four duplicates at P (barcodes P01903392, P01903393, P01903394 and P01903395). So Ming’s lectotypification should be treated as the first-step (Art. 9.17 Ex. 12 of the ICN). The second-step lectotype is here narrowed to P01903392 because this sheet has a dissected mature flower in its pocket which is lacking in the isolectotype materials.

The specific epithet of this species was “*gilberti*” in the protologue. It should be treated as an orthographical error of “*gilbertii*” according to Arts. 60.12 and 60C.1 (b) of the ICN.

Additional specimens examined (syntypes):—VIETNAM. [Phu Tho]: Thanh Ba, June 1918, *Gilbert 37541* (P barcode P05191437!); October 1917, *Gilbert s. n.* (VNM barcode VNM00003764!); December 1917, *Gilbert 37715* (P barcode P01903396!); 23 December 1918, *Chevalier 39552* (P barcodes P05191436!, P05248031! and P05248032!).

Thea krempfii Gagnepain (1942: 127)

≡ *Camellia krempfii* (Gagnep.) Sealy (1949: 219)

Lectotype (designated here):—VIETNAM. Khanh Hoa: contreforts du Ton Ha, 100 m, April 1912, *Krempf 1564* (P barcode P00700354!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p00700354>; isolectotype P barcode P01903385!).

Notes:—A single gathering was cited in the protologue; however, two specimens of *Krempf 1564* were found at P (barcodes P00700354 and P01903385). The specimen P00700354 has a manuscript diagnosis so it is designated here as the lectotype.

Thea laotica Gagnepain (1942: 128)

≡ *Camellia laotica* (Gagnep.) Ming (1999: 153)

Lectotype (first-step designated by Sealy 1958: 222):—LAOS. Savannakhet: entre Lang a xinhxa ne et L. xoan, 10 April 1927, *Poilane 13693* (P!, two sheets; second-step lectotype designated here: P barcode P04511456!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p04511456>; isolectotypes A barcode 00025098 [digital photo!], K barcode K000704322!, P barcode P04511457!, VNM barcode VNM00003799!).

Notes:—Three gatherings were cited in the protologue: *Poilane 13268*, *13693* and *13743*. Sealy (1958) selected *Poilane 13693* at P, consisting of two specimens (barcodes P04511456 and P04511457), as the lectotype and, unfortunately, this first-step lectotypification (Art. 9.17 Ex. 12 of the ICN) must be followed (Art. 9.19 of the ICN) though there is Gagnepain's drawing of a dissected flower bud attached on *Poilane 13268* (P01903384). The specimen P04511456 is designated here as the second-step lectotype because it has two immature fruits in its attached pocket.

Another syntype, *Poilane 13743*, was excluded from *T. laotica* and recognized as representing a new species by Sealy (1958) but he only named it "*Camellia* sp." because he thought "...in the absence of corolla, androecium, fruits and seeds, it seems unwise to give it a name". However, Ming (1999) subsequently gave it a name, *Camellia sealyana* Ming (1999: 158), to honour Sealy.

Additional specimens examined (syntypes):—LAOS. Savannakhet: entre Lao-bao et Muong-non, 17 April 1927, *Poilane 13268* (P barcodes P01903384! and P04511458!, VNM barcode VNM00003798!).

Thea nematodea Gagnepain (1942: 129)

≡ *Camellia nematodea* (Gagnep.) Sealy (1958: 135)

Lectotype (first-step designated by Sealy 1958: 136):—VIETNAM. [Khanh Hoa]: km. 25, route de Nhatrang à Ninh-hoa, 100 m, 24 October 1923, *Poilane 8371* (P!, three sheets; second-step lectotype designated here: P barcode P01903377!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903377>; isolectotypes K barcodes K000380545! and K000380546!, KUN barcode 1206031!, P barcodes P01903376! and P05312500!, VNM barcodes VNM00003802!, VNM00003803! and VNM00003804!).

Notes:—A single gathering *Poilane 8371* was cited in the protologue. Sealy (1958) selected a part of this single gathering conserved in P (barcodes P01903376, P01903377 and P05312500) as the type, which should be considered as the first-step lectotypification (Art. 9.17 Ex. 12 of the ICN). It is further narrowed to P01903377 as the second-step lectotype here because this sheet bears Gagnepain's drawing.

Thea nervosa Gagnepain (1942: 129)

≡ *Camellia nervosa* (Gagnep.) Chang (1981: 96)

Lectotype (first-step designated by Sealy 1958: 222):—VIETNAM. [Lam Dong]: massif du Braïan, près de Djiring, 14 February 1935, *Poilane 24305* (P!, three sheets; second-step lectotype designated here: P barcode P01903375!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903375>; isolectotypes A barcode 00025099 [digital photo!], K barcodes K000704303! and K000704698!, KUN barcode 1206034!, P barcodes P01903374! and P04511810!, PE barcode 01432084!, SING barcode SING 0204889!, VNM barcode VNM00003807!).

Notes:—Two gatherings were cited in the protologue: *Poilane 24305* and *13576*. Sealy (1958) chose *Poilane 24305* (P), consisting of three sheets (barcodes P01903374, P01903375 and P04511810), to be the type, which should be treated as the first-step lectotypification (Art. 9.17 Ex. 12 of the ICN). It is narrowed to P01903375 as the second-step lectotype here since this sheet bears Gagnepain's drawing. Another syntype, *Poilane 13576*, has been recognized as a different species (Sealy 1958, Chang 1981, Ming 2000).

Thea pleurocarpa Gagnepain (1942: 130)

≡ *Camellia pleurocarpa* (Gagnep.) Sealy (1958: 38)

Lectotype (designated here):—VIETNAM. [Thanh Hoa]: La Han, 500 m, 5 August 1920, *Poilane 1731* (P barcode P01903367!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903367>; isolectotypes A barcode 00025100 [digital photo!], K barcode K000704302!, P barcodes P01903368! and P04500229!).

Notes:—A single gathering *Poilane 1731* was cited in the protologue. Only P01903367 and P04500229 have fruits but the former also has seeds so it is designated here as the lectotype.

Thea taliensis Smith (1917: 73)

≡ *Camellia taliensis* (W.W.Sm.) Melchior (1925: 131)

Lectotype (first-step designated by Ming 2000: 119):—CHINA. Yunnan: Ghi Shan east of Tali Lake, 25°48'N, 9000 ft, August 1914, *Forrest 13477* (E!, two sheets; second-step lectotype designated here: E barcode E00284542!, the image of the lectotype is available at <http://data.rbge.org.uk/herb/E00284542>; isolectotypes BM barcode BM000611997!, E barcode E00284543!, K barcode K000704280!, SYS barcodes SYS00091976! and SYS00091977!).

Notes:—Three gatherings were cited in the protologue: *Forrest 13477*, *13503* and *8210*. The lectotypification of Ming (2000) was not effected when he cited “Lectotype: Yunnan, Tali, G. *Forrest 13477* (E, K)” on page 118 (Art. 9.22 of the ICN) but was later made legitimate when he wrote “G. *Forrest 13477* (模式 [means type], E)” on page 119 of the same publication (Ming 2000). Since there are two duplicates of *Forrest 13477* at E (barcodes E00284542 and E00284543), the second-step lectotype is narrowed to E00284542 because it has flowers and E00284543 does not.

Additional specimens examined (syntypes):—CHINA. Yunnan: Flanks of the Mingkwong Valley, 25°15'N, 6000–7000 ft, June 1912, *Forrest 8210* (E barcode E00117966!, K barcode K000704281!); western flank of the Tali Range, 7000–8000 ft, 25°40'N, August 1914, *Forrest 13503* (E barcode E00284544!, K barcode K000704282!).

Thea tonkinensis Pitard (1910: 343)

≡ *Camellia tonkinensis* (Pit.) Cohen-Stuart (1916: 67)

Lectotype (designated here):—VIETNAM. [Hanoi]: vallée de Lankok (Mont. Bavi), 24 November 1887, *Balansa 3860* (P barcode P01903514!, the image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p01903514>; isolectotype P barcode P01903515!).

Notes:—Pitard cited “Tonkin: forêt de la vallée de Lankok (*Balansa*)” in the protologue. Only *Balansa 3860*, consisting of two duplicates at P (barcodes P01903514 and P01903515), was found that accords with the protologue. The specimen P01903514 bears a drawing and Pitard’s slip “*Thea tonkinensis* sp. n.” so it is designated here as the lectotype.

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Names of Assam tea: Their priority, typification and nomenclatural notes

Dongwei Zhao, John A.N. Parnell & Trevor R. Hodgkinson

Herbarium, Botany Department, School of Natural Sciences, Trinity College Dublin, the University of Dublin; and Trinity Centre for Biodiversity Research, Trinity College Dublin, the University of Dublin, Dublin 2, Ireland

Author for correspondence: Dongwei Zhao, zhaod@tcd.ie

ORCID DWZ, <https://orcid.org/0000-0002-7761-7127>; JANP, <https://orcid.org/0000-0002-1624-8807>;

TRH, <https://orcid.org/0000-0003-1384-7270>

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Abstract Various names have been used for Assam tea and they are typified here. The currently widely used name, *Camellia sinensis* var. *assamica*, is a combination based on *Thea viridis* var. *assamica*, not “*T. assamica*” because the latter was never validly published. Two earlier published names, *C. theifera* and *T. cochinchinensis*, and two later ones, *C. tenuistipa* and *T. yersinii*, may represent the same taxon and are treated as synonyms of *T. viridis* var. *assamica* because the latter has priority at the rank of variety and therefore is the correct name for Assam tea.

Keywords Assam tea; *Camellia sinensis* var. *assamica*; *Camellia tenuistipa*; *Camellia theifera*; *Thea cochinchinensis*; *Thea yersinii*

■ INTRODUCTION

Tea, *Camellia sinensis* (L.) Kuntze (Theaceae), is one of the most popular beverage sources in the world. Tea was firstly recorded and used by the Chinese more than two millennia ago (Fang, 1998; Lu & al., 2016). It has been recognized and subsequently enjoyed by people in the Western world for centuries in large part due to the efforts of the British East India Company (Jackson, 1870), whose botanists found and verified the occurrence of wild tea plants in Assam (Assam tea) in the second quarter of the 19th century (Anonymous, 1835; Griffith, 1838; Sealy, 1958).

Linnaeus (1753: 515) established the genus *Thea* L. for the species *T. sinensis* L. But he (Linnaeus, 1762: 734 & 735) subsequently replaced *T. sinensis* with *T. bohea* L., an illegitimate replacement name for *T. sinensis* (because Linnaeus, 1762, cited all the referenced illustrations of *T. sinensis* under *T. bohea*, this makes the latter nomenclaturally superfluous; Art. 6.11, 52.1 & 52.2[d] of the ICN; McNeill & al., 2012), and added *T. viridis* L. Since then, both *T. bohea* and *T. viridis* have been treated as the heterotypic synonyms of the same species (Sims, 1807; Seemann, 1859; Sealy, 1958; Chang, 1981, 1998; Chang & Bartholomew, 1984; Ming, 2000; Ming & Bartholomew, 2007). Similarly, *Thea* has been treated as a synonym of *Camellia* L. (Sweet, 1818) and Kuntze (1887) proposed the combination *C. sinensis*, which is the currently widely used scientific name of tea.

Assam tea and tea differ from each other mainly in characters of the leaf and occur naturally in different geographical areas (Sealy, 1958; Ming, 2000). They have been treated both as conspecific and as separate species. Seemann (1859: 349)

adopted a broad concept of tea under the name *T. chinensis* Sims to represent “only one species of the plant yielding the tea of commerce”, including tea and Assam tea. *Thea chinensis* is another illegitimate replacement name for *T. sinensis* because Sims (1807: t. 998) cited the latter as a synonym of the former, making *T. chinensis* nomenclaturally superfluous (Art. 6.11, 52.1 & 52.2[e]). This broad concept of tea was accepted by Dyer (1874) and Cohen-Stuart (1919) but they applied the name *C. theifera* Griff. to it. By contrast, Wight (1962) and Chang (1984, 1998) proposed that tea and Assam tea should be treated as two distinct species. Many researchers have, however, recognized Assam tea as a variety of *C. sinensis* (Sealy, 1958; Keng, 1972; Chang, 1981; Chang & Bartholomew, 1984; Hô, 1991; Ming, 1999, 2000; Ming & Bartholomew, 2007).

However, the currently widely used scientific name of Assam tea, “*C. sinensis* var. *assamica* (J.W.Mast.) Kitam.” has nomenclatural problems and two earlier published names may represent the same taxon. Therefore, the names of Assam tea are examined and typified here to clarify their nomenclatural status.

■ TYPIIFICATION OF THE NAMES

Thea viridis var. *assamica*

Masters (1844: 63) introduced the name “*Thea assamica*” for Assam tea and this has been accepted as the “basionym” of *C. sinensis* var. *assamica* (Choisy) Kitam. (Sealy, 1958; Keng, 1972; Chang, 1981; Chang & Bartholomew, 1984; Hô, 1991; Ming, 1999, 2000; Ming & Bartholomew, 2007) and *C. assamica* (Choisy) Hung T.Chang (Chang, 1998) without previous

question. Both combinations are, however, actually based on another name and “*T. assamica*” was never validly published.

In the original publication, Masters (1844) described “Assam tea plant” using the name “*T. assamica*” but concluded that it “... is identical with *Thea viridis*, described in Rees’ Cyclopaedia ...” (Masters, 1844: 68). And at the end of his paper Masters (1844: 69) further explicitly stated that “... the trivial name ‘*Thea assamica*,’ is here used solely for the purpose of the better understanding of this paper; there being no peculiarity in the plant to authorize burdening science with a new name.” Therefore, Masters himself did not accept the name “*T. assamica*”. According to Art. 36.1(a), the name “*T. assamica*” was not validly published by Masters in 1844. However, Sealy (1958: 119) and Ming (2000: 133) indicated that another publication of Masters (1863) contained the name “*T. assamica*”. In this article Masters (1863), however, used the words “the Assam tea plant”, “the tea-plant as found in Assam” and “the Assam plant” to indicate what he meant but never mentioned the binary name “*T. assamica*”.

Choisy (1855: 155) adopted the name *T. viridis* to represent tea and cited “*T. assamica* H. Kew” in its synonymy. He (Choisy, 1855) probably learned the name “*T. assamica*” from the specimens deposited at K since he wrote “H. Kew”. But the name “*T. assamica*” recorded on the specimen sheets is not an effectively published name (Art. 30.1). Choisy (1855: 156) further divided *T. viridis* into three varieties based on the size of the leaves, including *T. viridis* var. *assamica* Choisy. The diagnosis of *T. viridis* var. *assamica* stated briefly: “feuilles longues de 4 à 8 pouces”, thereby distinguishing this variety from *T. viridis* var. *cantoniensis* (Lour.) Choisy (leaves 2–3 inches long) and *T. viridis* var. *vulgaris* Choisy (leaves 1–1.5 inches long) listed simultaneously. It was here, therefore, that *T. viridis* var. *assamica* was validly published as a new taxon (Art. 6.9, 38.1 & 38.2) and the epithet *assamica* was legitimately used to name Assam tea for the first time. Sealy (1958: 119) and Ming (2000: 133) treated *T. viridis* var. *assamica* as a “combination” based on Masters’s (1844) “*T. assamica*” but they were incorrect because a combination must be based on a legitimate, previously published name (Art. 6.10) and “*T. assamica*” had not been validly published and thus had no status (Art. 12.1).

In his *Flore forestière de la Cochinchine*, Pierre (1887: t. 114, D¹, D²) validly published the combination *T. chinensis* var. *assamica* (Choisy) Pierre when he referenced “Choisy Mém. p. 68” to directly indicate the basionym *T. viridis* var. *assamica* (Art. 41.1). The page number Pierre (1887) cited is, however, incorrect but this should be treated as a correctable typographical error and so does not affect the valid publication of the new combination (Art. 41.3). The correct page number of Choisy’s *T. viridis* var. *assamica* is 156, or the 66th page of Choisy’s article (pages 91–186). Sealy (1958: 119) incorrectly cited page “67” and Chang (1998: 135) and Ming (2000: 133) repeated Sealy’s citation.

The currently widely accepted name of Assam tea, *C. sinensis* var. *assamica*, was validly published by Kitamura (1950: 59) with the authorship cited as “(Pierre) Kitam.” and giving the reference “Syn. *Thea sinensis* var. *assamica* Pierre, Fl. Forest. Cochinch. pl. 114 (1887)”. This citation is regarded

as an indirect reference through Pierre (1887) to the basionym *T. viridis* var. *assamica* published by Choisy (1855) (Art. 41.3). The error in the author citation is correctable and does not affect the valid publication of this new combination (Art. 41.3).

Later, Wight (1962: 298) thought that Assam tea should be treated as an independent species so he proposed the intended combination “*C. assamica* (Masters)”. This name cannot be recognized as a new combination since Masters’s “*T. assamica*” was not validly published and thus cannot act as a basionym (Art. 6.10) and the correct basionym, *T. viridis* var. *assamica*, was neither clearly indicated (Art. 41.5) nor indirectly referenced (Art. 41.8). Neither can it be otherwise validly published as a new species because there was no Latin description or diagnosis in the publications of Wight (1962) or Masters (1844) (Art. 39.1).

Hu & Chang (1964: 497) recognized *Thea* and treated “*T. assamica*” as a validly published name by Masters (1844) and cited the names published by Pierre (1887) and Kitamura (1950) in its synonymy with full and direct references. Though they accepted “*T. assamica*”, this name cannot be technically treated as a new species published by Hu & Chang (1964) because no Latin description or diagnosis was included or directly referenced (Art. 38.13 & 39.1). Neither can it be otherwise validly published as a new combination because the basionym *T. viridis* var. *assamica* and its reference was not clearly indicated as required by Art. 41.5 or indirectly referenced under Art. 41.8(a) (see Ex. 20) as Pierre (1887) provided an explicit reference to the basionym published by Choisy (1855).

Subsequently, Chang (1984: 11) proposed the intended combination “*Camellia assamica* (Mast.) Chang” and cited the names and references of Masters (1844) and Kitamura (1950) and referenced “Sealy, Rev. Gem. Camellia, 114, 1958”. This reference is full of typographical errors, it should be corrected to “Sealy, Revis. Gen. Camellia: 119. 1958”. However, the incorrect author citation and typographical errors in the reference do not prevent the potential valid publication of this new combination (Art. 41.6), if other conditions are fulfilled based on the ICN. Unfortunately, Chang (1984) did not clearly indicate the correct basionym as required by Art. 41.5. Meanwhile, because Sealy (1958) provided an explicit citation and referenced Choisy’s *T. viridis* var. *assamica* so Art. 41.8(a) (see Ex. 20) does not apply. Therefore, “*Camellia assamica*” was not validly published as a new combination by Chang (1984). Neither can it be otherwise validly published as a new species because there was no Latin description or diagnosis provided or directly referenced by Chang (1984) (Art. 38.13 & 39.1).

In *Flora Reipublicae Popularis Sinicae*, Chang (1998: 133) listed “*Camellia assamica* (Mast.) Chang” and cited “*Thea viridis* L. var. *asamica* (Mast.) Choisy Mem. Ternstroemia & Camellia 67. 1865”. This citation should be corrected to “*Thea viridis* L. var. *assamica* Choisy in Mém. Soc. Phys. Genève 14: 156. 1855”—besides other typographic errors, Chang (1998: 135) only referenced the abbreviated title of the article. Here, Chang (1998) indicated Masters’s “*T. assamica*” as the “basionym” and cited the correct basionym, *T. viridis* var. *assamica*, as a later synonym. But “*T. assamica*” was not validly

published and has no status (Art. 12.1) so it cannot act as a basionym (Art. 6.10). Though the correct basionym was not recognized by Chang (1998), his new combination *C. assamica* was nevertheless validly published because he did clearly mention the correct basionym and did directly reference its author and place of valid publication (Art. 41.5) though with incorrect page number and date. We prefer to treat these errors as correctable and so they do not affect the valid publication of this new combination (Art. 41.6).

Unfortunately, the type of *C. sinensis* var. *assamica* has been continuously neglected by monographers who successively revised the taxonomy of *Camellia* (Sealy, 1958; Chang, 1981, 1998; Chang & Bartholomew, 1984; Ming, 2000; Ming & Bartholomew, 2007) even though this taxon has been intensively studied. A number of syntypes of *T. viridis* var. *assamica* were found at K. They were examined and one of them with mature flowers is designated below as the lectotype (Fig. 1).



Fig. 1. Lectotype of *Thea viridis* L. var. *assamica* Choisy (Masters s.n., K). Photo: D.W. Zhao.

Camellia theifera

Seventeen years earlier than the publication of *T. viridis* var. *assamica*, “the tea plant of Assam”—*C. theifera*, was published in the caption of an illustration with analysis (Griffith, 1838: t. C). Though this name is literally absent from the text of Griffith (1838) containing the illustration, it was validly published because there was a group of figures showing the details of flower and fruit of *C. theifera* (Art. 38.8 & 38.9). Sealy (1958: 119) and Ming (2000: 133) did not realise that this name had been published in 1838 and incorrectly cited instead the description of Griffith (1854) as the protologue and treated *C. theifera* as a synonym of *C. sinensis* var. *assamica*.

Only the details of flower and fruit were drawn in the original illustration of *C. theifera*. In the article which this illustration accompanied, Griffith (1838: 105) reported that the leaves of Assam tea plants “were sufficiently coarse and varied in length from 4 to 8 inches”. Those characters, illustrated and recorded, are consistent with those of the syntypes found at E (barcodes E00681110 & E00691478), K and TCD (barcodes TCD0017977, TCD0018250 [exclude the specimen in the middle, which is a different species] & TCD0018251). One of the syntypes conserved at TCD (barcode TCD0017977) has flowers so it is designated below as the lectotype (Fig. 2).

Thea cochinchinensis

Thea cochinchinensis Lour. was validly published 48 years before *C. theifera* and 65 years before *T. viridis* var. *assamica* (Loureiro, 1790: 338). It may represent the same taxon of Assam tea (Chevalier, 1919: 529). Nevertheless, it has been suggested that this name should be abandoned (Cohen-Stuart, 1919) or treated as a synonym of *C. sinensis* (Seemann, 1859; Merrill, 1935; Sealy, 1958; Chang, 1981; Chang & Bartholomew, 1984; Ming, 2000).

Only a part of Loureiro’s collections have been preserved (Bretschneider, 1881). It is reported that what remains of his specimens are conserved at BM, LINN, LISU, MO and P (Merrill, 1935; Chaudhri & al., 1972; Stafleu & Cowan, 1981). The collections at LISU are believed to have been destroyed (Merrill, 1935; Chaudhri & al., 1972; Stafleu & Cowan, 1981). The first author visited BM and P and searched the online database of LINN and MO but did not find any credible type material of *T. cochinchinensis*, which concurs with former reports (Cohen-Stuart, 1919; Merrill, 1935).

The diagnosis, description and usage in the protologue of *T. cochinchinensis* are “sufficiently exact clearly” (Merrill, 1933: 232) to indicate one species of sect. *Thea* Griff. of *Camellia*—a monophyletic group that includes *C. sinensis* (Vijayan & al., 2009) and the species in this section can be used to produce tea. Griffith (1854: 553) established sect. *Thea* as a new taxon. It has priority over the combination sect. *Thea* (L.) Dyer in 1874 (Art. 11.4). The latter has been accepted by Sealy (1958: 111), Chang (1981: 108; 1998: 115), Chang & Bartholomew (1984: 137), Ming (1992: 116; 1999: 152; 2000: 110), Ming & Bartholomew (2007: 372) and Orel & Curry (2015: 263), but it is illegitimate because it is a later homonym of

sect. *Thea* Griff. (Art. 53.1). In the protologue Loureiro (1790: 338) wrote: “Habitat culta, incultaque in provinciis Boreali-bus Cochinchinae”, which indicates that this species has both cultivated and wild plants in the northern provinces of Cochinchina. Though it is not clear where exactly the region “provinciis Boreali-bus Cochinchinae” indicated by Loureiro is, its rough area may be outlined from his other records of localities in *Flora Cochinchinensis*. Bretschneider (1881) studied and summarised several specified localities recorded by Loureiro, such as “Province of *Binh khang* in the southern part of Cochinchina, 14° N. ...” and “Province of *Quang binh* in North-Cochinchina ...”, by which it may be reasonable to consider that “provinciis Boreali-bus Cochinchinae” roughly indicates the area north of Hué in Vietnam since Loureiro lived at Hué, “the metropolis of Cochinchina”, at that time (Bretschneider, 1881; Chevalier, 1919).

Chevalier (1919: 529) suggested for *T. cochinchinensis* that “Il est tout-à-fait permis de supposer qu’il s’agit du *Thea*

sinensis L. var. *assamica* Pierre” by which he (Chevalier, 1919) inferred that *T. cochinchinensis* might represent Assam tea. Chevalier (1919) also reported that the leaves of *C. tonkinensis* (Pit.) Cohen-Stuart and *C. gilbertii* (A.Chev.) Sealy were collected by local people in Vietnam and sold as substitutes of tea. However, the morphological characters described in Loureiro’s protologue do not match those of *C. tonkinensis* (in terms of the flower colour and the number of petals) or *C. gilbertii* (in terms of the number of stamens).

Merrill (1935: 267) treated *T. cochinchinensis* as a synonym of *T. sinensis* and concluded that “I see no reason for considering that *T. cochinchinensis* Lour. represents other than a form of the common tea plant.” *Camellia sinensis* is widely cultivated in Vietnam (Pierre, 1887; Hô, 1991); however, credible wild material of *C. sinensis* has not been found in the area north of Hué in Vietnam (Sealy, 1958; Ming, 2000). Instead, based on published data (see below) and the first author’s field and herbaria investigations (see Appendix 1), Assam tea is naturally distributed in this area and has been cultivated by the Vietnamese for centuries (Chevalier, 1919; Sealy, 1958; Ming, 2000). Therefore, we agree with the deduction of Chevalier (1919) that *T. cochinchinensis* may represent the same taxon as *C. theifera* and *T. viridis* var. *assamica*.

In order to further support for the identity of *T. cochinchinensis*, the natural species of sect. *Thea* of *Camellia* distributed in Vietnam are examined and discussed as follows.

Pierre (1887) listed five varieties under *T. chinensis*, viz. *T. chinensis* var. *assamica*, *T. chinensis* var. *bohea* (L.) DC., *T. chinensis* var. *cantonensis* (Lour.) Pierre, *T. chinensis* var. *pubescens* Pierre and *T. chinensis* var. *viridis* (L.) DC. The specimens he cited were, however, all collected from other places (e.g., Brazil, China, India, Japan, Malaysia and Réunion), none of them came from Cochinchina. Later, Pitard (1910) repeatedly listed these five varieties of *T. chinensis* but without citing any collection. Gagnepain (1943) did not mention *T. chinensis* var. *pubescens* but recognized that four of these five varieties of *T. chinensis* occurred in Indochina and cited collections of them. However, he (Gagnepain, 1943) reported only collectors but without citing corresponding collector numbers. Based on Gagnepain’s handwritten identifications (without date) on the specimens, most of the available specimens from north of Hué in Vietnam cited under the four varieties of *T. chinensis* by him (Gagnepain, 1943: 314 & 315) are Assam tea (see Appendix 1). The remainder are species that do not belong to sect. *Thea* (e.g., *Poilane 12806* [P barcodes P04500202 & P04511574] under the name *T. chinensis* var. *viridis* by Gagnepain is actually *C. tsingpiensis* Hu). Later, Hô (1991: 535) recorded *C. sinensis* but adopted the same four varieties reported by Gagnepain (1943) without citing any specimens.

In *Supplément à la flore générale de l’Indo-Chine*, Gagnepain (1943: 310) described *T. yersinii* A.Chev. (the original epithet “yersini” in the protologue should be considered as an orthographical error of “yersinii” because it may be named after A. Yersin, 1863–1943; Art. 60.12 & 60C.1[b]). The collectors’ numbers of the syntypes were not indicated in the protologue. The first author searched several herbaria and found that *Chevalier 38684* (P barcodes P02142599,



Fig. 2. Lectotype of *Camellia theifera* Griff. (Griffith s.n., TCD barcode TCD0017977). Image scanned by Ms J. Stone (TCD).

P05278730 & P05278764), 38705 (P barcode P05312519), 38842 (P barcodes P02274496, P02274497, P02274498 & P04511724), *Poilane 7744* (P barcode P04511404) and 16693 (K, P barcode P04500223, VNM barcode VNM00003825) all bore the handwriting “*Thea yersinii* A.Chev.”. So these are all syntypes of *T. yersinii*. However, the first author found that the syntypes represented three different taxa: Assam tea (*Chevalier 38684*, 38705 & 38842), *C. corallina* (Gagnep.) Sealy (*Poilane 7744*) and *C. pubicosta* Merr. (*Poilane 16693*). Nevertheless, no one has so far lectotypified the name *T. yersinii*. The characters recorded in its protologue match those of *Chevalier 38684*, 38705 and 38842. The sheet P02142599 of *Chevalier 38684* at P is designated below as the lectotype since it bears Gagnepain’s drawing. Therefore, *T. yersinii* is a synonym of Assam tea and *Poilane 7744* and 16693 are excluded from this name.

Sealy (1958: 131) placed *C. gracilipes* Merr. in sect. *Thea* “as a matter of convenience”. However, this treatment is not supported by Chang (1981), Chang & Bartholomew (1984), Ming (2000) and the first author. Our nuclear DNA investigation (in prep.) does not suggest that a clade is formed by *C. gracilipes* and sect. *Thea*. Although *C. gracilipes* is distributed in northern Vietnam, the first author did not find any record of its usage on the specimens examined (*Ban 4767* [HN, PE]; *Tagane & al. V3721* [FU]; *Tsang 27106* [E barcode E00681071, IBSC, K, SYS], 27151 [E barcode E00681073, IBSC, K, P barcode P04511530, SYS], 27275 [A barcode 00024749, E barcode E00284418, IBSC, K barcodes K000704327 & K000704328, KUN, P barcode P04511528, SYS] & 29576 [C, E barcode E00681072, IBSC, K, P barcode P04511529, SYS]) or in the literature available (Sealy, 1949, 1958; Chang, 1981; Chang & Bartholomew, 1984; Ming, 2000; Nguyễn, 2003).

Sealy (1958), Chang (1981) and Chang & Bartholomew (1984) recognized that *C. pubicosta* was a member of sect. *Thea*, a treatment with which Ming (2000) and the first author disagree. Our nuclear DNA analysis (in prep.) shows that *C. pubicosta* and sect. *Thea* do not form a clade. *Camellia pubicosta* naturally occurs in Vietnam (Sealy, 1958; Ming, 2000; also see Appendix 2) and the first author collected specimens in the forest of Vinh Phuc (Zhao & al. 107(1) & 107 (2) [TCD], see Appendix 2); however, during the field, herbarium and literature investigations, the first author found that local people did not use this species or plant it as a beverage or medicine source, nor did he find any information on its usage recorded on the specimens examined (see Appendix 2) or in the literature available (Merrill, 1942; Sealy, 1958; Chang, 1981; Chang & Bartholomew, 1984; Hô, 1991; Ming, 2000; Nguyễn, 2003; Gao & al., 2005).

Huang & al. (2014) reported the complete chloroplast genome of *C. pubicosta* and found that this species was closely related to *C. sinensis* and “may be classified into sect. *Thea*”. The fresh leaf material of *C. pubicosta* that they (Huang & al., 2014) used was collected in the “International *Camellia* Species Garden (Jinhua, Zhejiang, China)” in May 2011 without any voucher specimen cited. Meanwhile, they stated that “... *C. pubicosta* [was] native to Laos” (Huang & al., 2014: 11) and the plant materials were identified based on the taxonomic treatment in *Flora of China* (Ming & Bartholomew, 2007). The

original reference in Huang & al. (2014) is “Min TL, Bruce B: *Flora of China*. Beijing, China: Science Press; 2010” and is full of errors. The correct citation is given in the Literature Cited below. However, this *C. pubicosta* they (Huang & al., 2014) used has several problems. Firstly, *C. pubicosta* has not been found in Laos based on the first author’s investigations of specimens (from 44 herbaria, see Acknowledgements and Appendix 2) and literature (Merrill, 1942; Sealy, 1958; Chang, 1981; Chang & Bartholomew, 1984; Ming, 2000; Gao & al., 2005; Newman & al., 2007); secondly, no record of *C. pubicosta* can be found in the *Flora of China* (Ming & Bartholomew, 2007); and finally, the International *Camellia* Species Garden at Jinhua, Zhejiang, China may not have living material of *C. pubicosta* (Gao & al., 2005: 223; the first author’s correspondence with Prof. Jiyan Li on 17 May 2017). Therefore, we doubt the credibility of the material of *C. pubicosta* used in Huang & al. (2014) and believe that this species is not a member of sect. *Thea*.

A recently published species of sect. *Thea*, *C. tenuistipa* Orel & al., is another synonym of Assam tea, whose type was collected in Vietnam (Orel & Curry, 2015: 263).

Apart from the published data discussed above for the identity of *T. cochinchinensis*, the first author examined *Camellia* collections from 44 herbaria (see Acknowledgements), especially those specimens collected in Vietnam. Specimens of Assam tea collected from north of and around Huế in Vietnam are listed in Appendix 1. As a natural taxon, the morphological characters of Assam tea vary in its areas of distribution. For example, in the northern Vietnamese provinces of Lao Cai and Lai Chau, especially along the Sino-Vietnamese border, some specimens (*Hiep & al. HAL 10438*, *Pételot 4249* & *Poilane 17010* in Appendix 1) have a pedicel that is gradually swollen towards the top and/or a 3–4-lobed style. These character states might imply that Assam tea has introgressed with its neighbour *C. taliensis* (W.W.Sm.) Melch., a species of sect. *Thea* occurring in southern and southwestern Yunnan, China (Zhao & al., 2014) (Assam tea usually has a slender pedicel and a 3-lobed style whereas *C. taliensis* generally has a stout pedicel that is gradually swollen towards the top and a 5-lobed style). This morphological variation does not challenge the circumscription of Assam tea, on the contrary, it suggests that this taxon is naturally distributed in northern Vietnam, has natural geographical boundaries and may undergo gene exchange with a phylogenetically closely related species.

Since no original material of *T. cochinchinensis* is extant, a single specimen with mature flowers collected from northern Vietnam, *Poilane 25282* (P barcode P04511587), is designated below as the neotype (Art. 9.13).

■ PRIORITY OF THE NAMES

Camellia theifera, *T. cochinchinensis* and *T. viridis* var. *assamica* all represent plants of *Camellia* whose leaves can produce drinkable beverage (Loureiro, 1790; Griffith, 1838; Choisy, 1855). On the one hand, *C. theifera* and *T. viridis* var. *assamica* were reported as endemic to Assam (Griffith, 1838; Choisy, 1855) and their syntypes were collected there. These

two taxa share the same character states (see description below) and we think that they represent the same taxon (Assam tea) based on our analyses of their protologues and type materials. On the other hand, *T. cochinchinensis* was reported to be both indigenous to and cultivated in northern Vietnam (Loureiro, 1790). According to our analysis above, the only taxon that matches this information in sect. *Thea* of *Camellia* is Assam tea. Therefore, we conclude that *C. theifera*, *T. cochinchinensis* and *T. viridis* var. *assamica* are heterotypic synonyms of the same taxon.

However, only one correct name can be used to represent a taxon of living plant below the rank of genus (Art. 11.1) and its nomenclature is based on the priority of publication (Principle III) in the same rank (Art. 11.2). Clearly, *T. cochinchinensis* has priority over *C. theifera* and *C. assamica* in the rank of species. But, we prefer to recognize Assam tea as a variety of *C. sinensis* here because of their morphological and molecular

(Su & al., 2009; Yang & al. 2016) similarities. Tea and Assam tea have the same character states of flower and fruit, only differing from each other in habit, leaf size and the shape of the leaf apex—*C. sinensis* is usually a shorter shrub and has smaller leaves than Assam tea, and its leaf apex is acute or shortly attenuate with a rounded tip. By contrast, Assam tea is generally a tall tree, has large leaves and its leaf apex is attenuate or acuminate (see description below and Fig. 3). We think that these differences and those of geographical distributions (Sealy, 1958; Ming, 2000) are sufficient to warrant separation of Assam tea from *C. sinensis* at varietal level. Therefore, *Thea viridis* var. *assamica*, the basionym of *C. sinensis* var. *assamica*, has priority and the latter remains correct for Assam tea at the rank of variety (Art. 11.2 & 11.4) and *C. theifera* and *T. cochinchinensis* are herein treated as its earlier published synonyms.

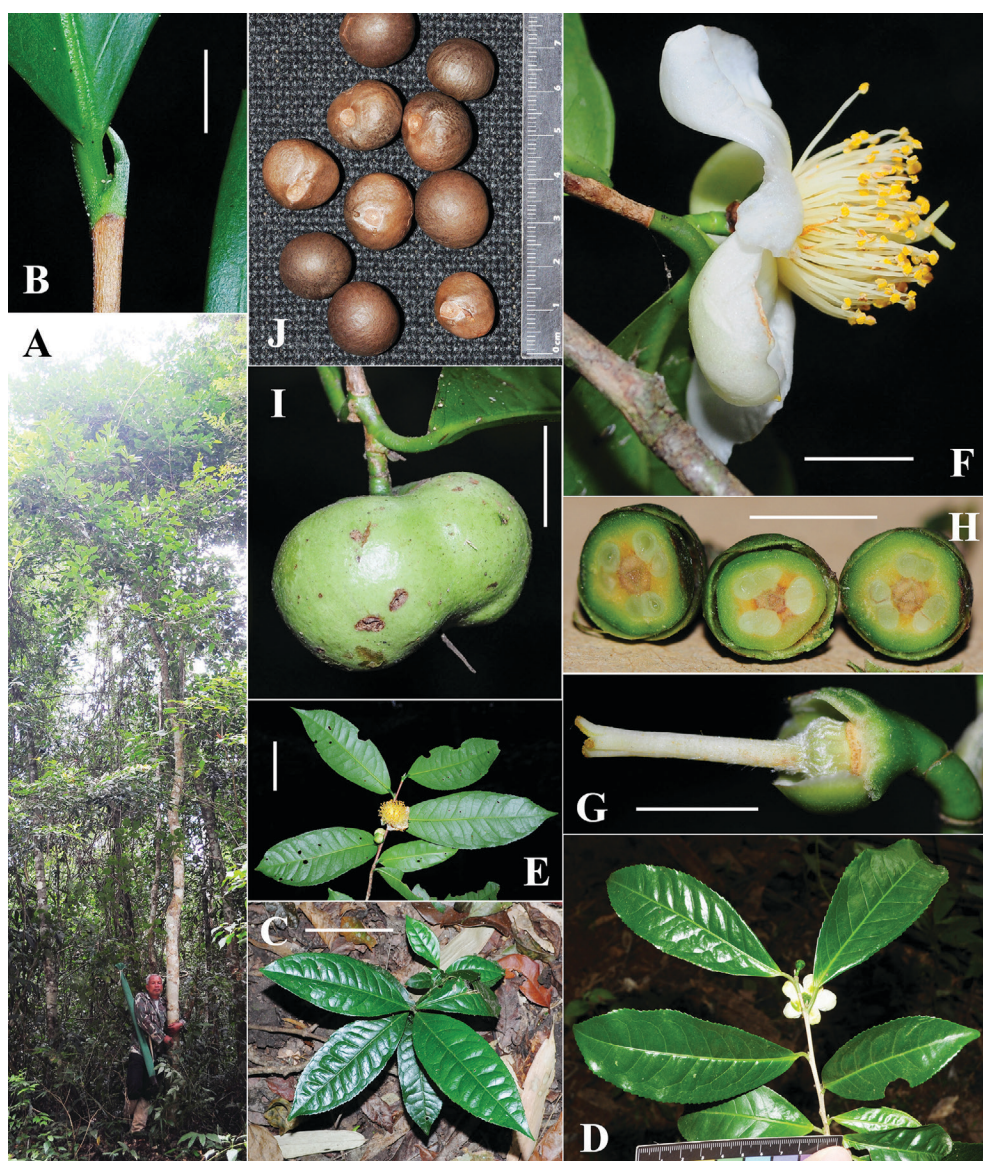


Fig. 3. *Camellia sinensis* (L.) Kuntze var. *assamica* (Choisy) Kitam. **A**, Habit; **B**, Terminal bud; **C**, Seedlings; **D & E**, Branchlets with flowers; **F**, Flower; **G**, A flower without petals, androgynium and one and half sepals; **H**, Transections of immature fruits; **I**, Fruit; **J**, Seeds. — The bars represent 5 mm (in B), 10 cm (in C), 5 cm (in E), 1 cm (in F), 5 mm (in G), 5 mm (in H) and 1 cm (in I). The minimum graduation of the ruler in D and J indicates 1 mm. Photos: D.W. Zhao.

■ TAXONOMIC TREATMENT AND DESCRIPTION

Camellia sinensis (L.) Kuntze var. *assamica* (Choisy) Kitam. in Acta Phytotax. Geobot. 14: 59. 1950 $\equiv$ *Thea viridis* L. var. *assamica* Choisy in Mém. Soc. Phys. Genève 14: 156. 1855 $\equiv$ *T. chinensis* Sims var. *assamica* (Choisy) Pierre, Fl. Forest. Cochinch.: t. 114, D¹, D². 1887 $\equiv$ *C. assamica* (Choisy) Hung T. Chang in Fl. Reipubl. Popul. Sin. 49(3): 133. 1998 – **Lectotype (designated here)**: INDIA. Assam: Chundoo, *Masters s.n.* (K!). — Fig. 1.

= *Thea cochinchinensis* Lour., Fl. Cochinch. 1: 338. 1790, **syn. nov.** – **Neotype (designated here)**: VIETNAM. Yên Bái [Yen Bai]: Bao Ha, 21 Feb 1936, *Poilane 25282* (P barcode P04511587!). — An image of the neotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p04511587>

= *Camellia theifera* Griff. in Trans. Agric. Soc. India. 5: t. C. 1838 – **Lectotype (designated here)**: INDIA. Upper Assam, *Griffith s.n.* (TCD barcode TCD0017977!). — Fig. 2.

= *Thea yersinii* A. Chev. ex Gagnep. in Lecomte Fl. Indo-Chine, Suppl. 1 [ed. H. Humbert]: 310. 1943 (“*Thea yersinii*”), excl. *Poilane 7744 & 16693*, **syn. nov.** – **Lectotype (designated here)**: VIETNAM. [Khanh Hoa]: Massif du Hòn bà, province de Nhatrang, 1000–1500 m, 12 Sep 1918, *Chevalier 38684* (P barcode P02142599!). — An image of the lectotype is available at <https://science.mnhn.fr/institution/mnhn/collection/p/item/p02142599>

= *Camellia tenuistipa* Orel, Curry & Luu in Orel & Curry, Pursuit Hidden Camellias Vietnam China: 263. 2015, **syn. nov.** – Holotype: VIETNAM. Gia Lai: Kon Ka Kinh National Park, 22 Jan 2011, *Luu & Nguyen KKK 221* (NSW barcode NSW901734 [digital image!]).

Description (glossary follows Ming & Bartholomew, 2007, and Beentje, 2012). — Trees or shrubs up to 20 m tall, evergreen. Trunk smooth, yellowish or brownish grey, new branchlets puberulous or pubescent, terminal buds pubescent or puberulous. Leaves alternate, petiolate, petiole 2–9 mm long, puberulous; leaf blade elliptic, oblong or obovate, 8–29 cm $\times$ 3.5–10 cm, coriaceous, abaxially yellowish green, puberulous, especially along midrib, adaxially dark or yellowish green, shiny, midrib abaxially elevated and adaxially slightly raised or flat, secondary veins brochidodromous, 7–15 on each side of midrib, abaxially slightly elevated and adaxially slightly impressed or flat, base cuneate or attenuate, margin serrulate, apex attenuate or acuminate. Flowers axillary, solitary or up to 4 in a cluster, pedicellate, 2–3.5 cm in diam. Pedicel 4–14 mm long, slender or gradually swollen towards the top, bracteoles 2–3, alternate, caducous. Sepals 5, persistent, sub-orbicular or broadly ovate, 3–4.5 mm $\times$ 3–5 mm, outside glabrous, inside sericeous, margin ciliate. Petals 5–7 in 1–2 whorls, white or outer 1–3 petals with a tinge of green at apex, obovate, elliptic or rounded, 1–2.5 cm $\times$ 1–2 cm, glabrous on both surfaces. Stamens numerous in 3–5 whorls, 7–16 mm long, filaments pale yellow, glabrous, outer filaments basally adnate to petals for 1–3 mm. Ovary oblate or globose, sericeous; ovules 2–4 per carpel; style

6–15 mm long, glabrous or basally sparsely sericeous and gradually becoming glabrous upwards, apically (2–)3(–4)-lobed for 1–3 mm. Capsule oblate, bi-coccal or globose, 17–45 mm in diam., 12–20 mm in height, 1–3-loculed with 1–2 seeds per locule; pericarp 0.5–1.5 mm thick. Seeds brown or fuscous, globose, hemispherical or polyhedral, 1.2–2 cm in diam., glabrous. Flower Sep–Jan, fruit Feb–Dec (Fig. 3).

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Appendix 1. Examined specimens of *Camellia sinensis* (L.) Kuntze var. *assamica* (Choisy) Kitam. from north of and around Hué in Vietnam.

Information is listed as follows: **province (or unknown but in northern Vietnam):** date of collecting (if available), *collector* and *collector number* (herbarium code and/or sheet number or barcode), and/or notes or some identifications (under *Thea*) on the specimens, and/or comments made by the first author (indicated with *).

Cao Bang: 16 May 1999, *Phuong 1599* (HN); 17 May 1999, *Phuong 1643* (HN). **Ha Giang:** 13 Sep 2000, *Harder & al. DKH 5566* (HN, HNU No. 019011). **Hanoi:** *Pételot s.n.* (P barcode P04500207), *Thea sinensis*; 1909, *d'Alleizette s.n.* (P barcode P04500205), cultivated, *Thea chinensis* Seem. var. *assamica* Pierre; 29 Oct 1918, *Chevalier 37814* (P barcode P05278738), *Thea tonkinensis* Pitard. **Hoa Binh:** 1 Sep 1926, *Poillane 13083* (K, P barcodes P04500203 & P04511599, VNM barcode VNM00003732), *Thea chinensis* L. var. *assamica* Pierre; 20 Jun 1999, *Phuong 1978* (HN); 24 Jun 1999, *Phuong 2182* (HN); 5 Oct 2000, *Phuong 3610* (HN). **Lao Cai:** *Poillane s.n.* (P barcode P04511835, VNM barcodes VNM00003748 & VNM00003749), *Thea chinensis* L. var. *assamica* Pierre; 4 Aug 1926, *Poillane 12823* (VNM barcode VNM00003731), *Thea sinensis* L.; 17 Nov 1929, *Poillane 17010* (P barcode P04511836, PE barcode 01513487), *Thea chinensis* L. var. *assamica* Pierre, pedicel gradually swollen towards the top*; 22 Dec 1929, *Poillane 17223* (P barcode P04511598), *Thea chinensis* L. var. *assamica* Pierre; 11 Jan 1931, *Poillane 18828* (K, P barcode P04511578, VNM barcode VNM00003754), *Thea chinensis* L. var. *coantonensis* Pierre; Sep 1942, *Pételot s.n.* (P barcode P06614761) & *7918* (P barcode P06614766); 19 Jul 2004, *Atha & al. DA 4942* (HN). **Lai Chau:** Sep 1931, *Pételot 4249* (P barcode P04511595), *Thea chinensis* L. var. *bohea* Pierre, pedicel gradually swollen towards the top*; 6 Dec 1938, *Poillane 27033* (P barcode P04511577, PE barcode 01513488, SING barcode SING 0204915), *Thea chinensis* L. var. *cantonensis* Pierre; 7 Dec 2006, *Hiep & al. HAL 10438* (HN, P barcode P05108752), pedicel gradually swollen towards the top, style 3–4-lobed*. **Nam Dinh:** 21 Nov 1913, *Chevalier 29008* (P barcode P05278768). **Nghe An:** 18 Dec 2002, *Binh & Cuong VN 1027* (HN). **Ninh Binh:** 2 Sep 1926, *Poillane 13114* (P barcodes P05108760 & P06838097). **Phu Tho:** *Eberhardt 4432* (P barcodes P04511600 & P04511601), *Thea sinensis* var. *assamica*; Oct 1917, *Gilbert 37709* (P barcode P05108716); Dec 1917, *Gilbert 37708* (P barcode P05278774), *Thea bohea* L.; May 1918, *Gilbert 37707* (P barcode P05278773), *Thea bohea* L.; Jun 1918, *Gilbert 37482* (P barcode P05248034, VNM barcode VNM00003740), cultivated, *Thea chinensis* L.; Jun 1918, *Gilbert 37540* (P barcode P05286388, VNM barcode VNM00003741), *Thea chinensis*; Nov 1918, *Chevalier 39717* (VNM barcodes VNM00003737, VNM00003738 & VNM00003739), cultivated, *Thea sinensis* L.; 1920, *Chevalier 41094* (P barcodes P05108717, P06615051 & P06615052); 11 Apr 1924, *Pasquier 62* (P barcode P06615042); 23 Jan 1961, *Loc 3075* (HNU); Nov 2011, *Hoc 18* (VNF No. BC-TV001237); 12 Jun 2012, *VMBN 2065* (VNMN). **Quang Ninh:** 8 May 1918, *Chevalier 37894* (P barcodes P05286385 & P05286386, VNM barcode VNM00003762), *Thea viridis* L.; 23 Jun–31 Aug 1939, *Tsang 29277* (C, E barcode E00681070, K, SING barcode SING 0204890). **Quang Tri:** 10 Mar 1936, *Poillane 25310* (P barcode P06615011). **Son La:** Nov 2003, *Phuong 7050* (HN). **Thai Nguyen:** 22 Oct 2004, *Phuong 9441* (HN). **Thanh Hoa:** 11 Sep 1920, *Poillane 1821* (K, P barcodes P04511594 & P04511596, VNM barcode VNM00003750), *Thea chinensis* L. var. *bohea* Pierre. **Thua Thien Hue:** *Eberhardt 2570* (P barcode P04511592), *Thea chinensis* L. var. *cantonensis* Pierre; *Eberhardt 3303* (P barcode P04511664), *Thea chinensis* L. var.?: 18 Feb 1919, *Chevalier 40734* (P barcode P06615035); May–Jul 1927, *Clemens 4379* (BM, P barcode P04511597), cultivated, *Thea chinensis* L. var. *bohea* Pierre; 10 Sep 1938, *Poillane 27747* (P barcodes P04511663 & P04511663, PE barcode 01513489; SING barcode SING 0204914), *Thea chinensis* L. var. *assamica* Pierre. **Vinh Phuc:** 23 Jun 2000, *Phuong 2645* (HN); 18 Nov 2015, *Zhao & al. 105(l)* (TCD). **Yen Bai:** 21 Feb 1936, *Poillane 25282* (P barcode P04511587, VNM barcode VNM00003756), cultivated, *Thea sinensis* L. var. *cantonensis* Pierre. **Unknown (Tonkin):** Dec 1874, *Pierre 479* (P barcode P04511631); May 1917, *Chevalier 37306* (P barcode P05248030), cultivated, *Thea sasanqua*; Jun 1918, *Chevalier 38071* (P barcode P05312446); Jun 1918, *Chevalier 38072* (P barcode P05248035, VNM barcode VNM00003757), *Thea chinensis* L. var. *cantonensis* Pierre; Oct 1960, *Halle 113* (P barcode P04964510), *Thea sinensis*.

Appendix 2. Examined specimens of *Camellia pubicosta* Merr.

Information is listed as follows: **COUNTRY, province:** date of collecting (if available), *collector* and *collector number* (herbarium code and/or sheet number or barcode, and/or notes about type status).

VIETNAM. Hanoi: 18 Oct 1887, *Balansa 3183* (P barcodes P04500222 & P05312525); Nov 1887, *Balansa 3861* (K, P barcodes P04500222, P04511359 & P04511360); Jun 1918, *Chevalier 37872* (P barcodes P05278755, P05278756 & P05278758, VNM barcode VNM00003828); 1 Jun 1918, *Fleury 37816* (P barcode P05278765); 29 Oct 1918, *Chevalier 37815* (P barcodes P05286438, P05286439, P05286440, P05312501, P05312502 & P05312504, VNM barcode VNM00003826); 19 Nov 1924, *Pételot 1727* (A barcode 00024753, holotype); 28 Aug 1940, *Pételot 2285* (HNU) & *2598* (A barcode 00024752, paratype); 5 Nov 1940, *Pételot 6655* (VNM barcodes VNM00003813 & VNM00003814). **Nghe An:** 11 Aug 1929, *Poillane 16693* (K, P barcode P04500223, VNM barcode VNM00003825, syntypes of *Thea yersinii*); 22 Dec 1962, *Lan B.268* (HN, IBSC barcode 0256478, VFM); 17 Jul 1998, *Ninh C605* (HNU). **Phu Tho:** Nov 1930, *Pasquier s.n.* (P barcode P04511793); 3 Jul 2003, *Phuong 6490* (HN). **Vinh Phuc:** Nov 1930, *Pételot 3837* (P barcode P04500226, VNM barcode VNM00003827), 7 Feb 1965, *Sino-Vietnam Exp. 1943* (KUN barcode 0695860, PE barcode 01679142); 13 Oct 1975, *Ve 15090* (HN); 31 May 1977, *Phuong 181* (HN); 13 Oct 1995, *Rosmann 95690* (P barcode P05247463); 19 Nov 1998, *Ninh 9886 & 98117* (HNU); 18 Oct 1998, *Qin & al. 108* (HITBC No. 088385); 24 Oct 2001, *Phuong 4540* (HN); 31 Oct 2004, *Li & al. 604* (HN); 18 Nov 2015, *Zhao & al. 107(l) & 107(2)* (TCD).