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Liang Chen
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The Tea Plant Genome

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Liang Chen • Jie-Dan Chen
Editors

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Editors
Liang Chen
Tea Research Institute
Chinese Academy of Agricultural Sciences
Hangzhou, China

Jie-Dan Chen
Tea Research Institute
Chinese Academy of Agricultural Sciences
Hangzhou, China

ISSN 2662-3188 ISSN 2662-3196 (electronic)
Concepts and Strategies in Plant Sciences
ISBN 978-981-97-0679-2 ISBN 978-981-97-0680-8 (eBook)
https://doi.org/10.1007/978-981-97-0680-8

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The tea plant, *Camellia sinensis* (L.) O. Kuntze, originated in the southwestern part of China. Tea is the largest non-alcohol healthy beverage next to water in the world. According to the Annual Bulletin Statistics of International Tea Committee (2023), the tea plant has been cultivated in more than 50 countries with 5.32 million ha of plantation and 6.48 million tonnes of made tea in 2022. It is a very important cash crop for family income and social welfare in many countries, such as China, India, Sri Lanka, Turkey, Viet Nam, Kenya, Malawi, Japan, etc., and scientific research in tea plant is booming.

The tea plant is cross-pollinated, largely self-incompatible, with high heterozygosity, and a very large genome (~3.0 Gb), which has greatly hindered research and breeding in this crop. In recent years, modern genetic and genomic tools have contributed to the development of significant valuable resources for tea genetic improvement. Consequently, a book providing comprehensive and updated information on tea plant genomics and molecular breeding approaches is needed to fill a gap in the current literature on the tea plant. The chapter authors are top and highly reputed researchers in the field.

This book, *The Tea Plant Genome*, includes 20 chapters that cover the most relevant and hot topics in tea plant genetics and genomics. A first set of chapters includes its global economic and health importance, the botany and taxonomy, and main quality and functional components. A second group of chapters deals with genetics and breeding and includes genetic resources, commercial breeding, genetic transformation techniques, as well as the use of marker assisted-selection (QTL, GWAS). This is followed by a set of chapters on omics, including genomics, transcriptomics, metabolomics, proteomics, organelle genome, small RNA and DNA methylation. Two chapters are devoted to biotic and abiotic stresses, followed by two others focused on the SNP array and databases for molecular design breeding. Finally, a chapter deals with future perspectives in the omics era for tea breeding.

We hope that this book will be useful not only to the world tea community to enhance the understanding of tea genetics and omics, promote the progress of global tea breeding, and help us breed more desirable new tea cultivars to meet the demands

of different markets and consumers in the increasing world market, but also as a reference for other woody perennial species.

The publication of the book is partially supported by the National Natural Sciences Foundation of China, the China Agriculture Research System (CARS-019) of MOF and MARA, etc.

We would like to express sincere thanks to Professor Chittaranjan Kole, Chairman of Professor Chittaranjan Kole Foundation for Science & Society, President of International Climate Resilient Crop Genomics Consortium, President of International Phytomedomics & Nutriomics Consortium, and President of Genome India International, for his critical guidance. We would like to thank Drs Zhao-Tang Ding, Qing-Sheng Li, Hui-Ling Liang, Chun-Lei Ma, Ze-Jiang Pan, Jie Qiu, Bin-Mei Sun, Lu Wang, Ming-Le Wang, Peng-Jie Wang, Tian-Li Wang, Wei-Wei Wen, En-Hua Xia, Zhi-Qiang Xia, Yong-Quan Xu, Shi-Xiong Yang, Zi-Yin Yang, Meng Ye, Chuan Yue, Liang-Sheng Zhang, Qun-Feng Zhang, Qun-Jie Zhang, Wei Zhang, Xing-Tan Zhang, Zhao-Liang Zhang, Zheng-Qun Zhang, Chao Zheng, Xin-Qiang Zheng, etc., for their constructive peer reviews and revisions. The editors want to express special acknowledgment to Ms Amanda Laverick for her professional language editing.

Hangzhou, China Liang Chen
Hangzhou, China Jie-Dan Chen

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Editors and Contributors

About the Editors

Liang Chen is a world-renowned professor in the Tea Research Institute of the Chinese Academy of Agricultural Sciences (TRICAAS) located at Hangzhou, China. He has extensive research experience in tea germplasm, genetics, breeding, and genomics. He received his Ph.D. in Tea Science from Zhejiang University, China, and had postdoctoral research from Cornell University, USA. He visited Ehime University in Japan, University of Florence in Italy, and Wageningen University and Research in the Netherlands as senior visiting professor. He has been appointed three times as Honorary Scientist and Advisor of the Rural Development Administration of the Republic of Korea. He has been the curator of the world's largest collection of tea genetic resources, National Tea Germplasm Repository at Hangzhou for 20 years and bred 3 dozens of national released and plant variety protection covered tea cultivars for the tea industry.

Jie-Dan Chen is an associate professor of tea genomics, genetics, and databases in the Tea Research Institute of the Chinese Academy of Agricultural Sciences (TRICAAS) located at Hangzhou, China. He has constructed a comprehensive database of genomic variations for molecular breeding in tea plants (TeaGVD).

Contributors

Jie-Dan Chen Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Liang Chen Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Xiu-Ling Deng Institute of Agro-Bioengineering, Guizhou University, Guiyang, China

Zhao-Tang Ding Tea Research Institute, Shandong Academy of Agricultural Sciences, Jinan, China

Sezai Ercisli Department of Horticulture, Faculty of Agriculture, Ataturk University, Erzurum, Turkey

Zhi-Lu Fu Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Da-Wei Gao National Key Laboratory for Germplasm Innovation and Utilization of Horticultural Crops; Key Laboratory of Horticultural Plant Biology, MOE; College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan, China

Yu-Qiong Guo Anxi College of Tea Science, Fujian Agriculture and Forestry University, Quanzhou, China

College of Horticulture, Fujian Agriculture and Forestry University, Fuzhou, China

Xin-Yuan Hao Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Jian-Yan Huang Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Rong Huang Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Takashi Ikka Faculty of Agriculture, Shizuoka University, Shizuoka, Japan

Xin-Xin Jia National Key Laboratory for Germplasm Innovation and Utilization of Horticultural Crops; Key Laboratory of Horticultural Plant Biology, MOE; College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan, China

Samson M. Kamunya Tea Research Institute, Kenya Agricultural & Livestock Research Organization, Kericho, Kenya

Wei-Long Kong National Key Laboratory for Tropical Crop Breeding, Shenzhen Branch; Guangdong Laboratory for Lingnan Modern Agriculture; Genome Analysis Laboratory of the Ministry of Agriculture and Rural Affairs, Agricultural Genomics Institute at Shenzhen, Chinese Academy of Agricultural Sciences, Shenzhen, China

Chun-Fang Li College of Tea Science and Tea Culture, Zhejiang A&F University, Hangzhou, China

Fang Li Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Zhi Lin Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Hai-Peng Lv Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Jian-Qiang Ma Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Abdelkader Bassiony Mahmoud Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Qian-Xi Mi Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Doo-Gyung Moon Research Institute of Climate Change and Agriculture, National Institute of Horticultural and Herbal Science, Rural Development Administration, Jeju, Republic of Korea

Su-Zhen Niu The Key Laboratory of Plant Resources Conservation and Germplasm Innovation in Mountainous Region (Ministry of Education), Institute of Agro-Bioengineering, Guizhou University, Guiyang, China

Chang-Jian Pan Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Wen-Jun Qian College of Horticulture, Qingdao Agricultural University, Qingdao, China

Da-He Qiao Tea Research Institute, Guizhou Academy of Agricultural Sciences, Guiyang, China

Mahasen A. B. Ranatunga Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka

Heng-Ze Ren Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Yu-Jia Ren National Key Laboratory for Germplasm Innovation and Utilization of Horticultural Crops; Key Laboratory of Horticultural Plant Biology, MOE; College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan, China

Satoshi Yamaguchi Tamagawa University, Tokyo, Japan

Yan Shen Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Jiang Shi Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Jiao-Jiao Shi Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Sa-Sa Song College of Tea Science and Tea Culture, Zhejiang A&F University, Hangzhou, China

Yu Tao College of Tea Science and Tea Culture, Zhejiang A&F University, Hangzhou, China

Cai-Yun Tian College of Horticulture, Fujian Agriculture and Forestry University, Fuzhou, China

Wei Tong State Key Laboratory of Tea Plant Biology and Utilization, Anhui Agricultural University, Hefei, China

Huan Wang College of Horticulture, Qingdao Agricultural University, Qingdao, China

Jia-Tong Wang Westlake University, Hangzhou, China

Shuang-Shuang Wang Tea Research Institute, Shandong Academy of Agricultural Sciences, Jinan, China

Yanli Wang State Key Laboratory of Tea Plant Biology and Utilization, Anhui Agricultural University, Hefei, China

Yi-Han Wang Institute of Agro-Bioengineering, Guizhou University, Guiyang, Guizhou Province, China

Department of Tea Studies (Guizhou Duyun Maojian Tea College), Guizhou Vocational College of Economics and Business, Duyun, Guizhou Province, China

Yu Wang College of Horticulture, Qingdao Agricultural University, Qingdao, China

Xin-Chao Wang Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Zhi-Hua Wang Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Kang Wei Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Wei-Wei Wen National Key Laboratory for Germplasm Innovation and Utilization of Horticultural Crops; Key Laboratory of Horticultural Plant Biology, MOE; College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan, China

Qiong Wu State Key Laboratory of Tea Plant Biology and Utilization, Anhui Agricultural University, Hefei, China

Tea Research Institute, Anhui Academy of Agricultural Sciences, Huangshan, China

Enhua Xia State Key Laboratory of Tea Plant Biology and Utilization, Anhui Agricultural University, Hefei, China

Xiu-Xiu Xu Tea Research Institute, Shandong Academy of Agricultural Sciences, Jinan, China

Hiroto Yamashita Faculty of Agriculture, Shizuoka University, Shizuoka, Japan

Kang-Ni Yan Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Gao-Zhong Yang Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Xu-Lin Yang Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Ying Yang Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Qiu-Shuang You Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Jia-Xuan Yue College of Horticulture, Qingdao Agricultural University, Qingdao, China

Cheng Zhang College of Horticulture, Fujian Agriculture and Forestry University, Fuzhou, China

Shu-Ning Zhang Faculty of Agriculture, Shizuoka University, Shizuoka, Japan

Shu-Ran Zhang Tea Research Institute, Chinese Academy of Agricultural Sciences, Hangzhou, China

Xiao-Liang Zhang National Key Laboratory for Germplasm Innovation and Utilization of Horticultural Crops; Key Laboratory of Horticultural Plant Biology, MOE; College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan, China

Xing-Tan Zhang National Key Laboratory for Tropical Crop Breeding, Shenzhen Branch; Guangdong Laboratory for Lingnan Modern Agriculture; Genome Analysis Laboratory of the Ministry of Agriculture and Rural Affairs, Agricultural Genomics Institute at Shenzhen, Chinese Academy of Agricultural Sciences, Shenzhen, China

Dong-Wei Zhao Department of Forestry, College of Forestry, Central South University of Forestry and Technology, Changsha, China

Lin Zhao Tea Research Institute of the Chinese Academy of Agricultural Sciences, Hangzhou, China

Cheng-Zhe Zhou College of Horticulture, Fujian Agriculture and Forestry University, Fuzhou, China

Chen Zhu Guangdong Provincial Key Laboratory of Applied Botany and Key Laboratory of South China Agricultural Plant Molecular Analysis and Genetic Improvement, Guangzhou, China

South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, China

Chapter 2
Botany and Taxonomy of Tea (*Camellia sinensis*, Theaceae) and Its Relatives

Dong-Wei Zhao

2.1 Introduction

Tea, *Camellia sinensis* (L.) Kuntze (Theaceae), is a beverage source which is enjoyed globally. Tea has been used and recorded by the Chinese for at least two millennia (Fang 1998; Lu et al. 2016). The currently widely accepted scientific name of tea, *C. sinensis*, was initially proposed by Linnaeus (1753) when he established the genus *Thea* L. for *Thea sinensis* L. The genus was, however, subsequently transferred to *Camellia* L. (Sweet 1818), and tea received its binomial name as a combination (Art. 6.10 of the Shenzhen Code, hereafter ICN, Turland et al. 2018).

Camellia sinensis is native to subtropical China (Zhao et al. 2017a). Though it has been collected and planted for a relatively long time, the plants of tea have not evolved clearly morphological characters by which we can distinguish the wild individuals from the cultivated. Therefore, it is sometimes difficult to identify a wild plant with confidence in the forests because its leaf buds and young leaves may be regularly collected by local people as what happened for the cultivated plants (Zhao 2022). The same phenomenon is also applicable to some of its relatives, the taxa of *Camellia* sect. *Thea* (L.) Griff. (tea plants).

Griffith (1854), rather than Dyer (1874), first treated *Thea* as a name at the sectional rank, *C.* sect. *Thea* (Zhao et al. 2017a; Zhao 2022). The circumscriptions of sect. *Thea* had been revised substantially until Sealy's (1958) monograph of

Reviewed by
Wei Zhang, Shandong University, China
Shi-Xiong Yang, Kunming Institute of Botany, Chinese Academy of Sciences, China

D.-W. Zhao (✉)
Department of Forestry, College of Forestry, Central South University of Forestry and Technology, Changsha, China
e-mail: zhaodw@csuft.edu.cn

L. Chen, J.-D. Chen (eds.), *The Tea Plant Genome*, Concepts and Strategies in Plant Sciences, https://doi.org/10.1007/978-981-97-0680-8_2

Table 2.1 Taxonomies of tea plants, *Camellia* sect. *Thea*

Reference	Taxonomic treatment
Chang (1981a, b, 1984, 1998)	ser. *Gymnogynae*: *C. costata*, *C. dehungensis*, *C. gymnogyna*, *C. jingyunshanica*, *C. leptophylla*, *C. parvisepaloides*, *C. yungkiangensis*; ser. *Pentastylae*: *C. atrothea*, *C. crassicolumna*, *C. crispula*, *C. irrawadiensis*, *C. makuanica*, *C. pentastyla*, *C. rotundata*, *C. taliensis*; ser. *Quinquelocularis*: *C. grandibracteata*, *C. kwangnanica*, *C. kwangsiensis*, *C. nanchuanica*, *C. remotiserrata*, *C. tachangensis*; ser. *Sinenses*: *C. angustifolia*, *C. arborescens*, *C. assamica*, *C. assamica* var. *kucha*, *C. assamica* var. *polyneura*, *C. fangchengensis*, *C. multisepala*, *C. parvisepala*, *C. ptilophylla*, *C. pubescens*, *C. pubicosta*, *C. purpurea*, *C. sinensis*, *C. sinensis* var. *pubilimba*, *C. sinensis* var. *waldenae*
Ming (1992, 2000), Ming and Bartholomew (2007)	*C. costata*, *C. crassicolumna*, *C. crassicolumna* var. *multiplex*, *C. fangchengensis*, *C. grandibracteata*, *C. gymnogyna*, *C. kwangsiensis*, *C. kwangsiensis* var. *kwangnanica*, *C. leptophylla*, *C. ptilophylla*, *C. sealyana*, *C. sinensis*, *C. sinensis* var. *assamica*, *C. sinensis* var. *dehungensis*, *C. sinensis* var. *pubilimba*, *C. tachangensis*, *C. tachangensis* var. *remotiserrata*, *C. taliensis*
Chen et al. (2000)	*C. crassicolumna*, *C. gymnogyna*, *C. sinensis*, *C. sinensis* var. *assamica*, *C. sinensis* var. *pubilimba*, *C. tachangensis*, *C. taliensis*

Camellia and then greatly enlarged with new taxa described from China (Yang 2021). Chang (1981a, b, 1984, 1998) eventually revised the taxonomy of tea plants to include four series, 32 species, and four varieties. By contrast, Ming (1992, 2000) rejected the rank of series and proposed 12 species and six varieties in sect. *Thea*. Besides, Du et al. (1990) suggested only two species and three varieties in the section, which the new names were, unfortunately, invalidly published under Art. 39.1 of the ICN. Subsequently, Chen et al. (2000) supplied a simplified taxonomy of sect. *Thea* to contain five species and two varieties. A summary of these taxonomies is listed in Table 2.1 where the authorship of each name is absent to reduce the redundancy.

Increasingly, plant taxonomy relies on reproducible and informative genomic data, from phylogenetics based on several DNA regions (Zhao et al. 2023) to phylogenomics using complete plastid (Yan et al. 2021) and nuclear genome information (Yu et al. 2018). However, a robust phylogenetic tree of sect. *Thea* has yet to be achieved. This paper aims to provide an up-to-date taxonomy of sect. *Thea* with a simplified description, natural geographic distribution, and nomenclatural and taxonomic notes provided for each taxon and discuss the progress and difficulties of phylogenetic classification of tea and its relatives.

2.2 Materials and Methods

Specimens or their images conserved in the following herbaria (acronyms based on Thiers 2023) were examined: A, ABD, BK, BKF, BM, C, CMUB, CSFI, DLU, E, FU, G, GXFI, GXMI, HITBC, HN, HNL, HNNU, HNU, IBK, IBSC, K, KKU,

KUN, L, LINN, MBK, MICH, MO, NSW, NY, P, PE, PHH, QBG, SGN, SING, SYS, TAI, TCD, US, VFM, VNF, VNM, and VNMN. Collections cited are indicated by the collector's name and relevant collection number which are printed in italic. The single barcode on the specimen sheet is provided following the herbarium acronym. Examined specimens are indicated by the exclamation mark (!). The protologue of each name was read and the nomenclatural status of the name was judged based on the ICN. Information on taxonomic literature was searched using Taxonomic Literature II online (https://www.sil.si.edu/DigitalCollections/tl-2/), and author's abbreviations were verified on the IPNI (https://www.ipni.org/). The single correct name for each living taxa studied was recognized based on the ICN. Accepted names of taxa are printed in bold italics. Homotypic and heterotypic synonyms are indicated by the identity sign (≡) and equality sign (=), respectively. Synonyms are listed in chronological order based on the year of publication and then provided alphabetically if published in the same year. New synonym identified in the research is labeled as "**syn. nov.**" The type of a name at the sectional rank is cited as a species under Art. 10.1 of the ICN, whereas the type (holotype, lectotype, or neotype) of the specific or infraspecific name is indicated as a single specimen or an illustration (Art. 8.1 of the ICN). All photos in this chapter were taken by the author.

2.3 Taxonomy

2.3.1 Camellia *Sect.* Thea

Camellia L. sect. ***Thea*** (L.) Griff., Not. Pl. Asiat. 4: 553. 1854—Type: *Camellia sinensis* (L.) Kuntze.

= *Camellia* sect. *Glaberrima* Hung T. Chang, Taxon. Gen. Camellia, 126. 1981—Type: *C. glaberrima* Hung T. Chang.

= *Camellia* sect. *Longissima* Hung T. Chang, Taxon. Gen. Camellia, 124. 1981, excl. *C. gracilipes* Merr. ex Sealy, **syn. nov.**—Type: *C. longissima* Hung T. Chang & S. Ye Liang.

Shrubs or trees, evergreen; trunk smooth, yellowish or brownish gray; leaves alternate, petiolate, coriaceous, margin serrulate; flowers axillary, clearly pedicellate; bracteoles 2–4, caducous; sepals persistent; petals white; stamens numerous, glabrous; style 1, apically usually 3–5-lobed; capsule oblate, globose to 3–5-coccal, seeds brown or fuscous, glabrous. Usually 2n = 30.

Distribution. China, India, Laos, Myanmar, Thailand, and Vietnam.

Notes. The monophyly of sect. *Thea* is supported by the analyses using morphological approaches (Ming 2000) and nuclear DNA markers (Zhao et al. 2023) but denied in the phylogenomic investigations with complete plastid genomes (Huang et al. 2014; Yan et al. 2021). The maternally inherited plastid DNA of *Camellia* (Kaundun and Matsumoto 2011) seems to undergo a distinct evolutionary history partially correlated with geographic distributions (Yu et al. 2017; Yan et al. 2021),

so the result from biparentally inherited nuclear DNA (Zhao et al. 2023) was adopted here for the phylogenetic taxonomy of sect. *Thea*.

Zhao et al. (2023) suggested that *C. longissima* was nested in the monophyletic group consisting of tea plants; therefore, the species is included in sect. *Thea*. Accordingly, *C.* sect. *Longissima*, whose type is *C. longissima*, is treated as a new heterotypic synonym of sect. *Thea* above. The molecular phylogenetic analysis (Zhao et al. 2023) implies that the length of the pedicel, a character valued by Chang (1981b, 1998) and Ming (2000) and used as a diagnostic character at the sectional rank, becomes less influential in the taxonomy of *Camellia*.

Molecular dating analysis indicated that the plants of sect. *Thea* had generally diversified during the Miocene (Zhao et al. 2023). Though the geographic diversification center may be difficult to infer due to continental drift and climate change, current surveys reveal that all taxa of sect. *Thea* occur in China (Zhao 2022) and Guangdong, Guangxi, Guizhou, and Yunnan harbor the most taxa in sect. *Thea*, which could suggest that southern and south-western China is a diversity hotspot for tea plants.

Key to taxa of *Camellia* sect. *Thea*

• 1. Pedicel (1.7–)2–4 cm long… *C. longissima*
1. Pedicel 0.5–1.5(−2) cm long… 2
2. Ovary hairy… 3
2. Ovary glabrous… 10
3. Sepals hairy outside… 4
3. Sepals glabrous outside… 7
4. Flower 3.5–5.5 in diam… *C. crispula* var. *crispula*
4. Flower 2–3.5 in diam… 5
5. Leaf blade 5.5–12.5 cm wide, base obtuse to rounded… *C. fangchengensis*
5. Leaf blade 2–7.5 cm wide, base cuneate… 6
6. Leaf blade 5–12 cm long, abaxially glabrescent; sepals sericeous inside… *C. sinensis* var. *pubilimba*
6. Leaf blade 6.5–25 cm long, abaxially pubescent; sepals glabrous inside… *C. ptilophyll*
7. New branchlets glabrous; flower 3–5.5 cm in diam., style apically (3–)5-lobed… 8
7. New branchlets pubescent; flower 2.5–3.5 cm in diam., style apically 3-lobed… 9
8. Pericarp 1.5–4 mm thick… *C. taliensis*
8. Pericarp 4–8 mm thick… *C. crispula* var. *multiplex*
9. Leaf blade 5–12 × 2–5 cm, leaf apex acute, shortly attenuate or rounded… *C. sinensis* var. *sinensis*
9. Leaf blade 8–29 cm × 3.5–10 cm, leaf apex attenuate or acuminate… *C. sinensis* var. *assamica*
10. Sepals hairy outside… *C. kwangsiensis* var. *kwangnanica*
10. Sepals glabrous outside… 11
11. Style apically 4–5-lobed… 12
11. Style apically 3-lobed… 14
12. Pericarp 4–8 mm thick… 13
12. Pericarp 1–2 mm thick… 15

13. New branchlets puberulous to pubescent; leaf blade abaxially puberulous... *C. kwangsiensis* var. *kwangsiensis*
13. New branchlets glabrous; leaf blade abaxially glabrous… 14
14. Leaf buds usually glabrous; leaf margin serrate… *C. tachangensis* var. *tachangensis*
14. Leaf buds pubescent; leaf margin usually sparsely serrate… *C. tachangensis* var. *remotiserrata*
15. Leaf buds glabrous or puberulous… 16
15. Leaf buds pubescent… 17
16. Leaf blade abaxially glabrous; pedicel 5–20 mm long… *C. costata*
16. Leaf blade abaxially glabrous or sparsely puberulous; pedicel 3–7 mm long… *C. sinensis* f. *formosensis*
17. Sepals glabrous inside… *C. leptophylla*
17. Sepals sericeous inside… 18
18. Sepals 3–5 × 4–8 mm… *C. gymnogyna*
18. Sepals 2.5–3.5 × 3–4 mm… *C. sinensis* var. *dehungensis*

Camellia costata Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 94. 1981—Holotype: China. Guangxi: Zhaoping, Nanrong, 850 m, 18 October 1965, *S.Y. Liang 6505169* (SYS; isotypes: GXMI 009609!, GXMI 050191!, GXMI 050192!, PE 00026330!, PE 01432818!).

= *Camellia kwangtungensis* Hung T. Chang, Taxon. Gen. Camellia 127. 1981—Holotype: China. Guangdong: Yangshan, Xilu, 1100 m, 23 November 1958, *P.X. Tan 60382* (IBSC 0003507!; isotypes: IBK 00190477!, KUN 1205989!, PE 01432087!, SYS 00094871!).

= *Camellia yungkiangensis* Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 95. 1981—Holotype: China. Guangxi: Rongjiang, Yueliangshan, 25°39′30″N, 108°14′20″E, 970 m, 10 August 1965, *C.P. Tsien et al. 51745* (PE 00024359!; isotypes: PE 00702501!, KUN 1205990!).

= *Camellia danzaiensis* Hung T. Chang & K.M. Lan, Bull. Bot. Res., Harbin 9(4): 59. 1989—Holotype: China. Guizhou: Danzhai, Longquan, 800 m, 10 July 1982, *Guizhou Agric. Coll. For. Exp. III-132* (GACP; isotype: SYS 00095014!).

New branchlets glabrous, leaf buds glabrous or puberulous at apex. Leaf blade elliptic, oblong to lanceolate, 5.5–17 × 2–5 cm, glabrous. Flower 2.5–4 cm in diameter. Pedicel 5–20 mm long, glabrous. Sepals 3–5 × 4–7 mm, outside glabrous or puberulous at apex, inside sericeous. Ovary glabrous. Style apically 3-lobed, glabrous. Capsule ca. 2 cm in diameter; pericarp ca. 1 mm thick. Fl. October to November, fr. July to September (Fig. 2.1).

Distribution. China: Guangdong, Guangxi, Guizhou.

Notes. Ming (1992) treated *C. danzaiensis*, *C. kwangtungensis*, and *C. yungkiangensis* as the heterotypic synonyms of *C. costata*. *Camellia danzaiensis* is clearly conspecific with *C. yungkiangensis*, and their plants usually bear shorter leaves and longer pedicels. By contrast, *C. costata* seems to have longer leaves and shorter pedicels (Fig. 2.1). However, the significance of the divergence between them requires more data to explore, especially additional collections and molecular phylogenetic analysis, before a further taxonomic revision is made. The situation is also

Fig. 2.1 *Camellia costata* in Guangxi. (**a**) Habit, (**b**) & (**c**) branches, (**d**) a flower without petals, androecium, and one and a half sepals. The bars indicate 5 cm (in **b**), 3 cm (in **c**), and 5 mm (in **d**)

true for *C. kwangtungensis*, a species with very few available specimens for research. Therefore, Ming's (1992, 2000) circumscription of *C. costata* is provisionally accepted here.

Camellia costata is distinguished from *C. sinensis* by its usually glabrous leaf bud and ovary, whereas the latter is generally hairy on these parts. Chemical analysis revealed that the leaves of *C. costata* collected from the natural populations at Zhaoping, Guangxi, contained 0.2–0.42% caffeine and 23.4–28.7% tea polyphenols (Li et al. 2019), suggesting a special germplasm resource of tea plants with low caffeine and high polyphenol.

Camellia crispula Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 94. 1981—Holotype: China. Yunnan: Jinping, Yongping, 2000 m, 12 May 1956, *Sino-USSR Exp. 1344* (KUN 1205994!; isotypes: PE 00024305!, PE 00026331!, PE 00026337!, PE 00026338!, PE 00702766!).

= *Camellia atrothea* Hung T. Chang & H.S. Wang, Acta Sci. Nat. Univ. Sunyatseni 23(1): 5. 1984—Lectotype (designated by Jiang et al. 2023: 112): China. Yunnan: Pingbian, Yuping, 1900 m, 7 November 1982, *B.H. Chen & Y.J. Yang A21002* (SYS 00095178).

= *Camellia haaniensis* Hung T. Chang & F.L. Yu, Acta Sci. Nat. Univ. Sunyatseni 23(1): 7. 1984—Holotype: China. Yunnan: Jinping, Hanitian, 2220 m, *B.H. Chen A22005* (SYS).

= *Camellia makuanica* Hung T. Chang & Y.J. Tan, Acta Sci. Nat. Univ. Sunyatseni 23(1): 6. 1984—Holotype: China. Yunnan: Maguan, Gulinqing, 1720 m, 17 October 1982, *Y.J. Tan & S.C. Ma A17003* (SYS).

= *Camellia purpurea* Hung T. Chang & B.H. Chen, Acta Sci. Nat. Univ. Sunyatseni 23(1): 9. 1984—Holotype: China. Yunnan: Pingbian, Yuping, 1500 m, 8 November 1982, *B.H. Chen et al. A21003* (SYS 00095186!).

= *Camellia rotundata* Hung T. Chang & F.L. Yu, Acta Sci. Nat. Univ. Sunyatseni 23(1): 6. 1984—Holotype: China. Yunnan: Honghe, Langdi, 1850 m, 5 November 1982, *Y.J. Tan et al. A24001* (SYS 00095184!).

= *Camellia crassicolumna* Hung T. Chang var. *shangbaensis* F.C. Zhang, Acta Bot. Yunnan. 19(4): 437. 1997—Holotype: China. Yunnan: Zhenyuan, Qianjiazhai, Shangba, 2100–2450 m, 13 November 1996, *F.C. Zhang* et al. *01* (Yunnan Agricultural University; isotype: KUN 1205991!)

Camellia crispula var. ***crispula***

New branchlets and leaf buds puberulous. Leaf blade elliptic to oblong, 6.5–17 × 2–6.5 cm, abaxially glabrous or puberulous, adaxially glabrous. Flower 3.5–5.5 cm in diameter. Pedicel 5–15 mm long. Sepals 5–8 × 6–12 mm, outside puberulous or pubescent, inside sericeous. Ovary densely pubescent. Style apically (3–)5-lobed, pubescent. Fruit 3–7 cm in diameter; pericarp 4–8 mm thick. Fl. October to December, fr. June to November (Fig. 2.2).

Distribution. China: Yunnan.

Notes. Jiang et al. (2023) revealed the incorrect description of *C. crassicolumna* Hung T. Chang in its protologue (Chang 1981a) and reinstated *C. crispula* to represent those tea plants with hairy leaf buds, sepals, ovaries, and styles and relatively larger flowers and fruits. Previously recognized synonyms of *C. crassicolumna* by Ming (1992, 2000), including *C. atrothea*, *C. crassicolumna* var. *shangbaensis*, *C. haaniensis*, *C. makuanica*, *C. purpurea*, and *C. rotundata*, were transferred into the synonymy of *C. crispula* accordingly because of morphological similarity (Jiang et al. 2023). Therefore, the samples named *C. crassicolumna* in the published research between 1981 and 2023 should be considered as *C. crispula*.

Camellia crispula occurs in southeastern and central Yunnan (Jiang et al. 2023). Local people collect the leaves from both wild and planted shrubs. Tang et al. (2010) reported that a cultivar of *C. crispula* named "Jinchang dashucha" contained 0.06% caffeine and 32.42% tea polyphenol. Ning et al. (2023) analyzed 21 samples of the species and revealed that the contents of caffeine and tea polyphenols were 0.03–3.00% and 15.45–23.25%, respectively, suggesting a wide range of chemical variation within the species.

Camellia crispula var. ***multiplex*** (Hung T. Chang & Y.J. Tang) S.X. Yang, Phytotaxa 595: 113. 2023 ≡ *Camellia multiplex* Hung T. Chang & Y.J. Tang, Acta Sci. Nat. Univ. Sunyatseni 23(1): 7. 1984—Holotype: China. Yunnan: Wenshan, Xiaojie, Laojunshan, 2210 m, 20 October 1982, *Y.J. Tan et al. A16003* (SYS 00095168!).

Fig. 2.2 *Camellia crispula* var. *crispula* in Yunnan. (**a**) Habit, (**b**) & (**c**) branches, (**d**) a new branchlet with immature leaves, (**e**) immature fruits, (**f**) transversely dissected immature fruits. The bars represent 3 cm (in **b**), 5 cm (in **c**), and 1 cm (in **d** & **e**)

New branchlets, pedicel and outside of the sepals glabrous. Fl. October, fr. June.

Distribution. China: Guangxi, Guizhou, Yunnan.

Notes. Jiang et al. (2023) transferred Ming's (1992) *C. crassicolumna* var. *multiplex* (Hung T. Chang & Y.J. Tang) T.L. Ming to be a variety of *C. crispula*. Yang et al. (2021) added a new record of the variety in Guangxi. A misidentified cultivar

named "Daba dashucha" with glabrous sepals should be this taxon and was reported to contain 0.07% caffeine and 29.01% tea polyphenols (Tang et al. 2010).

Camellia fangchengensis S. Ye Liang & Y.C. Zhong, Acta Sci. Nat. Univ. Sunyatseni 20(3): 118. 1981—Holotype: China. Guangxi: Fangcheng, Huashi, 320 m, 3 December 1980, *Y.C. Zhong 80120* (GXFI; isotype: KUN 1206002!).

New branchlets and leaf buds densely pubescent. Leaf blade elliptic, 13–29 × 5.5–12.5 cm, abaxially pubescent, adaxially glabrous, base obtuse to rounded. Flower 2–3.5 cm in diameter. Pedicel 5–10 mm long, pubescent. Sepals 2.5–3.5 × 4–5 mm, outside pubescent, inside glabrous. Petals outside pubescent to glabrous. Ovary densely pubescent. Style apically 3-lobed, glabrous or basally pubescent. Fruit ca. 2 cm in diameter; pericarp ca. 0.5 mm thick. Fl. December to January, fr. June to December (Fig. 2.3).

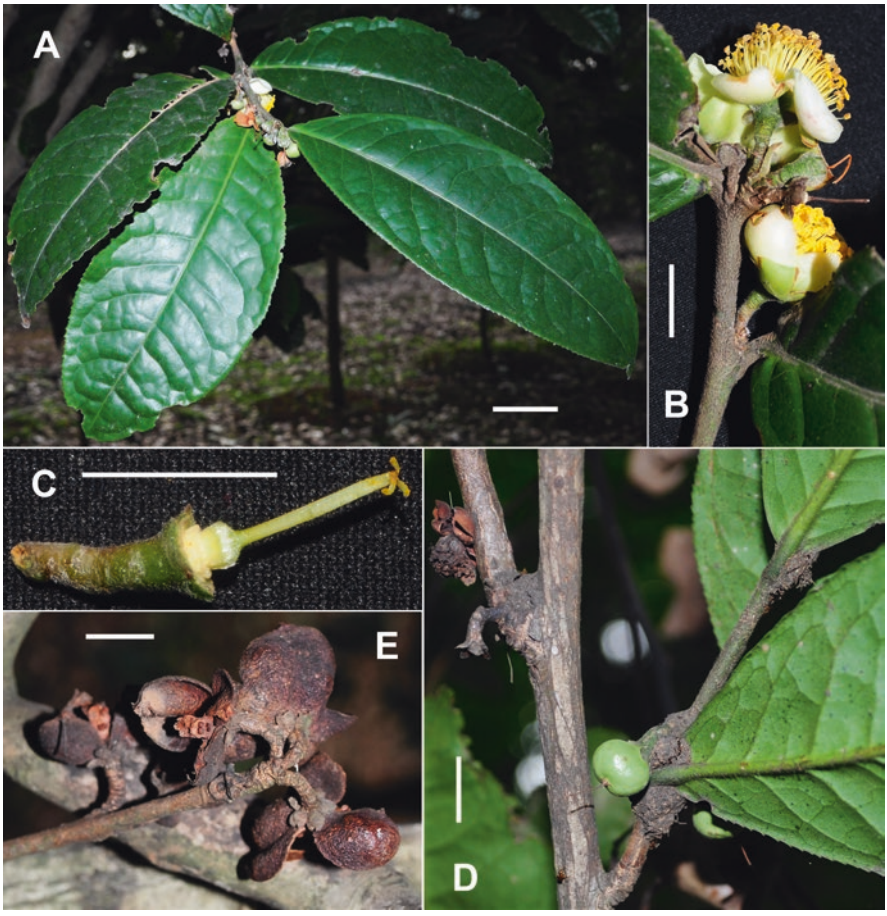

Fig. 2.3 *Camellia fangchengensis* in Guangxi (planted). (**a**) & (**b**) Branchlets with flowers, (**c**) a pedicel and a gynoecium, (**d**) branches with immature fruits, (**e**) mature fruits without seeds. The bars represent 3 cm (in **a**), 1 cm (in **b**–**e**)

Distribution. China: Guangxi.

Notes. Zhao et al. (2023) suggested that *C. fangchengensis* was sister to *C. sinensis*. The flowers and fruits of the former are similar to those of *C. sinensis* var. *pubilimba* Hung T. Chang. *Camellia fangchengensis* can be, however, differentiated from the latter by its more densely pubescent branchlets and usually larger leaves. Chen et al. (1996) reported that two samples of *C. fangchengensis* collected in the spring contained 2.91% and 3.8% caffeine, and 24.84% and 33.17% tea polyphenols, which were suggested to be suitable to produce black tea. Meng et al. (2018) revealed that the leaves of *C. fangchengensis* were rich in potent antioxidants and recommended it as a valuable beverage source.

Camellia gymnogyna Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 94. 1981—Holotype: China. Guangxi: Lingyun, 1400 m, 9 December 1957, *C.C. Chang 11123* (IBSC 0003498!, image: https://www.cvh.ac.cn/spms/detail.php?id=c7656128; isotype: IBK 00118547!).

= *Camellia glaberrima* Hung T. Chang, Taxon. Gen. Camellia 126. 1981—Holotype: China. Yunnan: Pingbian, Jiangshe, 1360 m, 11 March 1954, *P.Y. Mao 3330* (KUN 1206019!; isotypes: IBSC 0003496!, KUN 1206020!, PE 00024306!).

New branchlets glabrescent, leaf buds pubescent. Leaf blade elliptic, 8–18 × 4–6.5 cm, glabrous on both surfaces, base cuneate. Flower 3.5–4.5 cm in diameter. Pedicel 7–15 mm long, glabrous. Sepals 3–5 × 4–8 mm, outside glabrous, inside sericeous. Petals outside glabrous, inside sericeous or glabrous. Ovary glabrous. Style apically 3-lobed, glabrous. Fruit 3–4 cm in diameter; pericarp 0.5–2 mm thick. Fl. October to December, fr. June to October (Fig. 2.4).

Distribution. China: Guangdong, Guangxi, Guizhou, Yunnan.

Notes. Ming (1992, 2000) treated the type of *C.* sect. *Glaberrima*, *C. glaberrima*, as a heterotypic synonym of *C. gymnogyna*, which made sect. *Glaberrima* a synonym of sect. *Thea*. Chang (1981b) valued the basally connate filaments of *C. glaberrima* so much so that he proposed sect. *Glaberrima* to include the species and *C. kwangtungensis*. However, the filaments of *Camellia* species are, more or less, connate at the base and adnate to the petals. Molecular phylogenetic analysis did not support that the filament tube could become a diagnostic character at the sectional rank of *Camellia* and suggested that *C. gymnogyna* was closely related with *C. tachangensis* F.C. Zhang (Zhao et al. 2023).

Camellia gymnogyna has larger flower and fruit which can be distinguished from other tea plants that bear similar glabrous ovary and apically three-lobed style, such as *C. costata* and *C. leptophylla* S. Ye Liang ex Hung T. Chang. Populations of *C. gymnogyna* in Guizhou were reported harboring a higher genetic diversity than those of *C. tachangensis* (He et al. 2023). Samples of *C. gymnogyna* from Dayaoshan in Guangxi was reported to contain 0.051–0.202% caffeine, 0.582–0.910% theacrine, and 1.437–3.972% theobromine (Teng et al. 2020).

Camellia kwangsiensis Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 89. 1981—Holotype: China. Guangxi: Tianlin, Lengjiaping, 28 July 1956, *Y.K. Li 560* (IBSC 0003505!, image: https://www.cvh.ac.cn/spms/detail.php?id=c76564e3; isotype: PE 00026332!).

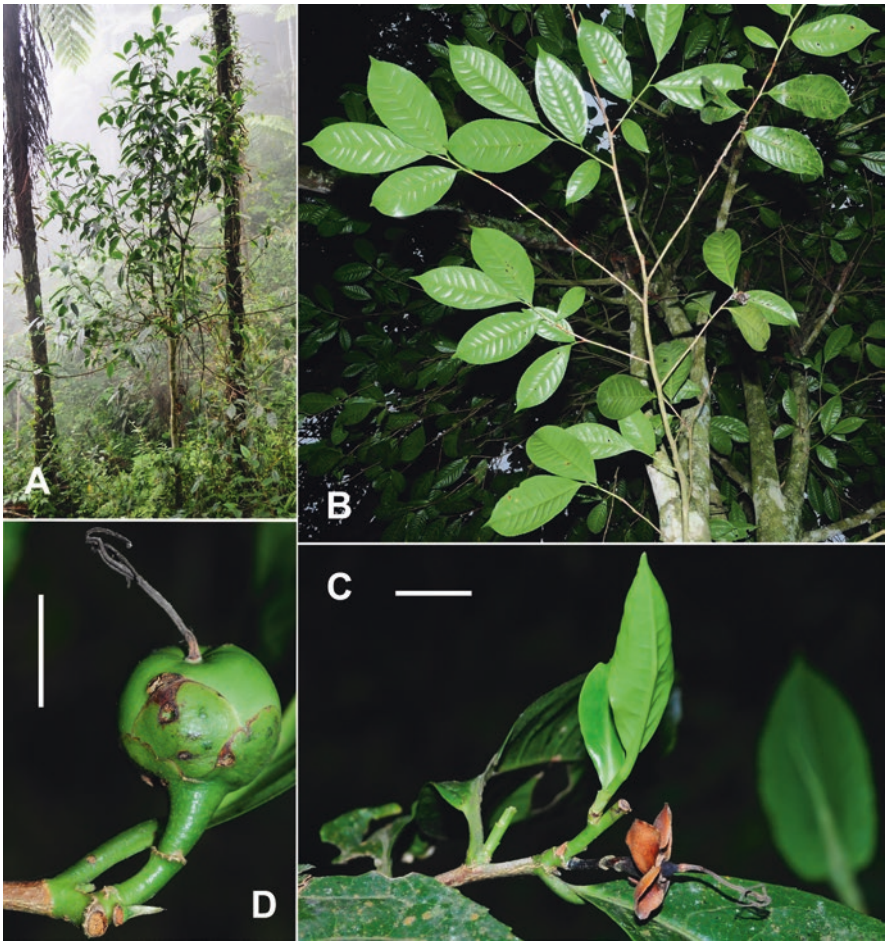

Fig. 2.4 *Camellia gymnogyna* in Yunnan. (**a**) Habit, (**b**) & (**c**) branches, (**d**) an immature fruit. The bars indicate 1 cm (in **c** & **d**)

Camellia kwangsiensis var. *kwangsiensis*

New branchlets and leaf buds puberulous to pubescent. Leaf blade elliptic, 6–16 × 3–7 cm, abaxially puberulous, adaxially glabrous, base cuneate. Pedicel 7–11 mm long, glabrous. Sepals 5–8 × 4–9 mm, outside glabrous, inside sericeous. Petals glabrous. Ovary glabrous. Style apically 5-lobed, glabrous. Fruit 4–6 cm in diameter; pericarp 5–8 mm thick. Fl. September to November, fr. May to September (Fig. 2.5).

Distribution. China: Guangxi, Yunnan.

Notes. *Camellia kwangsiensis* is distinguished from *C. tachangensis* by its hairy new branchlets, leaf buds, and abaxial surface of the leaf blade, whereas the latter is glabrous on those parts. Chen et al. (1996) reported that the sample of *C.*

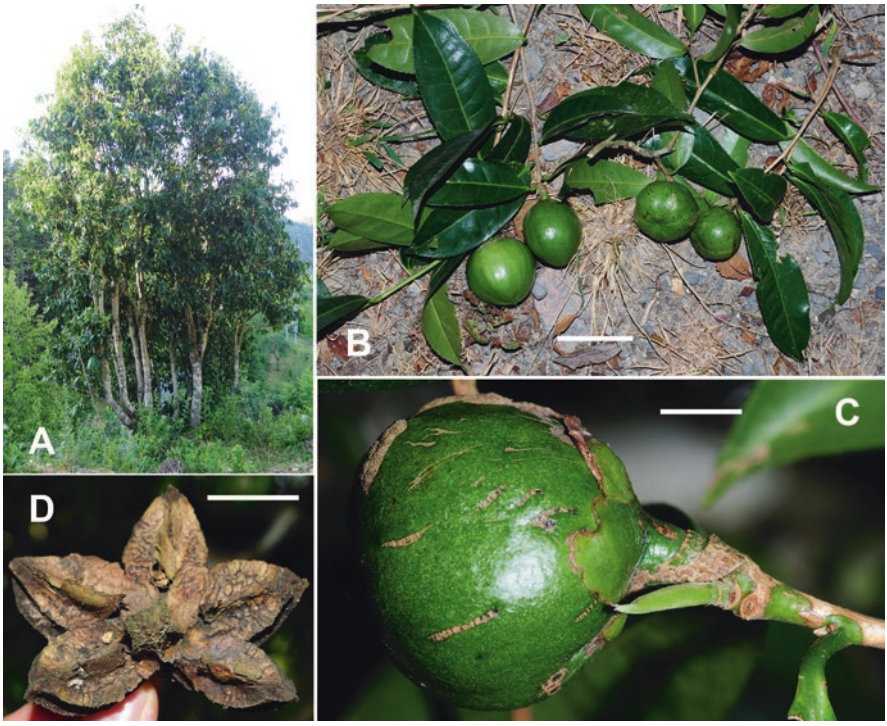

Fig. 2.5 *Camellia kwangsiensis* var. *kwangsiensis* in Yunnan. (**a**) Habit, (**b**) & (**c**) branches with immature fruits, (**d**) a capsule without seeds. The bars represent 5 cm (in **b**), 1 cm (in **c**), and 2 cm (in **d**)

kwangsiensis collected from Napo, Guangxi, contained 2.06% caffeine and 18.97% tea polyphenols, which were suitable for producing both green and black tea.

Camellia kwangsiensis var. ***kwangnanica*** (Hung T. Chang & B.H. Chen) T.L. Ming, Acta Bot. Yunnan. 14: 118. 1992 ≡ *Camellia kwangnanica* Hung T. Chang & B.H. Chen, Acta Sci. Nat. Univ. Sunyatseni 23 (1): 4. 1984—Holotype: China. Yunnan: Guangnan, Heizhiguo, 1790 m, 27 October 1982, *B.H. Chen et al. A20002* (SYS 00095169!).

= *Camellia crassicolumna* Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 91. 1981—Holotype: China. Yunnan: Xichou, November 1943, *C.P. Tsien 644* (PE 00024303!, image: https://www.cvh.ac.cn/spms/detail.php?id=075759dd; isotypes: IBK!).

Sepals outside pubescent or puberulous, inside sericeous. Petals pubescent or puberulous on both surfaces. Fl. October to November, fr. June to November.

Distribution. China: Guangxi, Yunnan.

Notes. Jiang et al. (2023) found that the type of *C. crassicolumna*, *C.P. Tsien 644*, bore a glabrous ovary, thus treated it as a heterotypic synonym of *C. kwangsiensis* var. *kwangnanica*. As mentioned above, previous research involving

C. crassicolumna generally indicate *C. crispula* rather than *C. kwangsiensis* var. *kwangnanica*.

Camellia leptophylla S. Ye Liang ex Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 95. 1981—Holotype: China. Guangxi: Longzhou, *S.Y. Liang 56* (SYS).

New branchlets and leaf buds pubescent. Leaf blade elliptic, 7–15 × 3–6 cm, abaxially glabrescent, adaxially glabrous, base cuneate. Pedicel ca. 5 mm long, glabrescent. Sepals 3–4 × 4–5 mm, glabrous on both surfaces. Ovary glabrous. Style apically 3-lobed, glabrous. Fruit ca. 3 cm in diameter; pericarp ca. 1 mm thick. Fl. November to December, fr. September to December.

Distribution. China: Guangxi.

Notes. Further collection of *C. leptophylla*, especially those with mature flowers and fruits, is needed to describe its morphology in detail.

Camellia longissima Hung T. Chang & S. Ye Liang in Hung T. Chang, Taxon. Gen. Camellia 124. 1981—Holotype: China. Guangxi: Longzhou, 440 m, 4 October 1956, *Z.J. Li 3273* (IBSC 0003519!; isotype: IBK 00118623!).

New branchlets and leaf buds glabrous. Leaf blade obovate to elliptic, 7–20 × 3–9 cm, both surfaces glabrous, base cuneate. Flower ca. 2.5 cm in diameter. Pedicel 1.7–4 cm long, glabrous. Sepals 2.5–5 × 3–6 mm, outside glabrous, inside sericeous. Petals outside glabrous, inside sericeous, glabrescent, or glabrous. Ovary glabrous. Style apically 3-lobed, glabrous. Fruit not seen. Fl. November to December.

Distribution. China: Guangxi.

Notes. Molecular phylogenetic analysis supported that *C. longissima* and other tea plants consisted of a monophyletic group, and the species was closely related with *C. taliensis* (W.W. Sm.) Melch. (Zhao et al. 2023). *Camellia longissima* bears a long pedicel, which was valued by Chang (1981b) and Ming (2000) as a diagnostic character at the sectional rank. However, the length of the pedicel may vary in tea plants. For instance, *C. sinensis* usually bears a pedicel less than 1 cm long; occasionally, under cultivation it can produce a more than 2-cm-long pedicel. Though bearing a relatively long pedicel, neither *C.* sect. *Longipedicellata* Hung T. Chang nor sect. *Longissima* was suggested to be monophyletic in the molecular phylogenetic analysis (Zhao et al. 2023).

Camellia longissima was endemic to Longzhou, Guangxi. I have not seen a specimen of its natural plant collected in recent 30 years, nor have I found or heard its occurrence in the wild. Regardless of its potential value in tea breeding, conservation and propagation should be the top priority of *C. longissima* to avoid extinction.

Camellia ptilophylla Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 98. 1981—Lectotype (designated by Zhao et al. 2019: 299): China. Guangdong: Longmen, Nankunshan, 6 Dec 1978, *P. Zeng 4011* (SYS 00094851!; isolectotypes: SYS 00091372!, SYS 00091373!, SYS 00094850!, SYS 00094852!).

= *Camellia pubescens* Hung T. Chang & C.X. Ye, Acta Sci. Nat. Univ. Sunyatseni 26(1): 18. 1987—Holotype: China. Hunan: Rucheng, 270 m, 25 January 1986, *H.T. Chang et al. 460* (consisting of five sheets: SYS 00094853!, SYS 00094854!, SYS 00094855!, SYS 00094856! and SYS 00094857!).

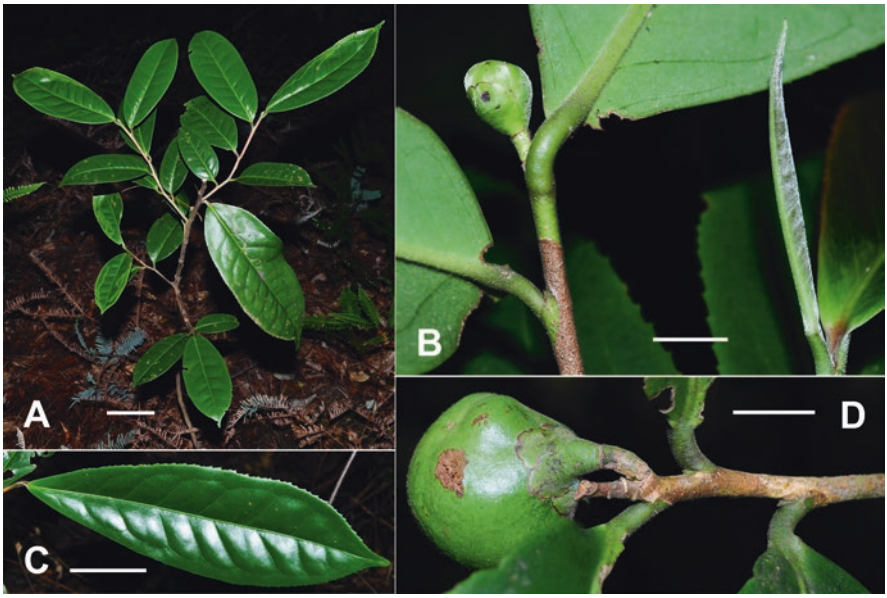

Fig. 2.6 *Camellia ptilophylla* in Hunan. (**a**) A sapling, (**b**) branchlets with a flower bud and a leaf bud, (**c**) a leaf, (**d**) a branchlet with an immature fruit. The bars indicate 5 cm (in **a** & **c**) and 1 cm (in **b** & **d**)

New branchlets and leaf buds densely pubescent. Leaf blade elliptic to oblong, 6.5–25 × 3–7.5 cm, abaxially pubescent, adaxially glabrous, base cuneate. Flower 2.5–3 cm in diameter. Pedicel ca. 1 cm long, pubescent. Sepals 3–7 × 3.5–7 mm, outside pubescent, inside glabrous. Petals outside pubescent to puberulous, inside glabrous. Ovary densely pubescent. Style apically 3-lobed, glabrous or basally pubescent. Fruit 2–3.5 cm in diameter; pericarp ca. 1 mm thick. Fl. November to January, fr. September to December (Fig. 2.6).

Distribution. China: Guangdong, Hunan.

Notes. Ming (1992) treated *C. pubescens* as a heterotypic synonym of *C. ptilophylla*. Zhao et al. (2023) found that *C. pubescens* formed a clade with *C. fangchengensis* and *C. sinensis*. Chang et al. (1988) analyzed the sample of *C. ptilophylla* collected from Longmen, Guangdong, and found that it contained 4.70% theobromine and 33.26% tea polyphenols, while caffeine was absent. With 22 trees investigated, Ye et al. (1997) revealed that all samples of *C. ptilophylla* contained 0.57–6.84% theobromine; four of them contained 3.02–4.94% caffeine, while caffeine was absent in the remaining 18 trees. Li et al. (1998) suggested that the samples of *C. pubescens* collected from Rucheng, Hunan, contained 3.44% caffeine, 0.35% theobromine, and 34.38–40.16% tea polyphenols.

Camellia sinensis (L.) Kuntze, Um die Erde: 500. 1881 ≡ *Thea sinensis* L., Sp. Pl. 1: 515. 1753. ≡ *Thea bohea* L., Sp. Pl., ed. 2. 1: 734. 1762—Lectotype

(designated by Bartholomew in Jarvis et al. 1993: 93): "Tsja" in Kaempfer, Amoen. Exot. Fasc.: 606, f. 1–2. 1712.

= *Camellia arborescens* Hung T. Chang & F.L. Yu, Acta Sci. Nat. Univ. Sunyatseni 29(2): 86. 1990—Holotype: China. Yunnan: Weixin, *F.L. Yu & P.S. Wang A35004* (SYS).

= *Camellia longlingensis* F.C. Zhang, G.B. Chen & M.D. Tang, Acta Bot. Yunnan. 12(1): 33. 1990—Holotype: China. Yunnan: Longling, Daba, 1850 m, 19 November 1987, *F.C. Zhang et al. 87* (Yunnan Agricultural University; isotype: KUN 1206051!).

Camellia sinensis var. ***sinensis***

Shrubs, new branchlets and leaf buds pubescent. Leaf blade elliptic, 5–12 × 2–5 cm, abaxially glabrescent, adaxially glabrous, base cuneate, apex acute, shortly attenuate or rounded. Flower 2.5–3.5 cm in diameter. Pedicel usually 5–15 mm long, glabrous. Sepals 2.5–4 × 3–5 mm, outside glabrous, inside sericeous. Petals glabrous. Ovary pubescent. Style apically 3-lobed, glabrous or basally pubescent. Fruit 1.5–3.5 cm in diameter; pericarp ca. 1 mm thick. Fl. September to January, fr. July to February (Fig. 2.7).

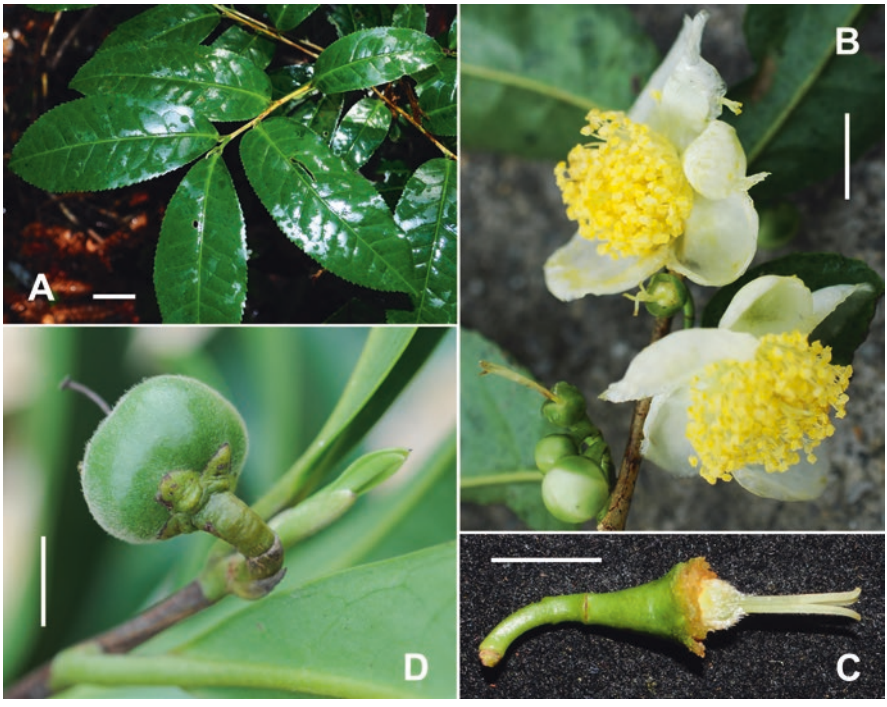

Fig. 2.7 *Camellia sinensis* var. *sinensis*. (**a**) Branchlets (in Guangxi), (**b**) flowers (in Hunan, planted), (**c**) a pedicel and a gynoecium (in Guangxi), (**d**) an immature fruit (in Guangdong). The bars represent 2 cm (in **a**), 1 cm (in **b** & **d**), and 5 mm (in **c**)

Distribution. China: Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hong Kong, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Sichuan, Taiwan, Tibet, Yunnan, Zhejiang.

Notes. The lectotype of the basionym of *C. sinensis* is a drawing, which was overlooked by Ming (2000). This plant is native to subtropical China. Thanks to its wide cultivation over about two millennia (Fang 1998), it is usually difficult to determine whether a plant of tea is wild or cultivated in the field (Zhao 2022).

Camellia sinensis f. ***formosensis*** (Masam. & Suzuki) Kitam., Acta Phytotax. Geobot. 14: 59. 1950 ≡ *Thea formosensis* Masam. & Suzuki, Taiwan Zyumoku Benran. 262. 1937—Neotype (designated by Su et al. 2009: 481): China. Taiwan: Nantou, Yuchi, 8 November 1935, *S. Suzuki s.n.* (TAI 218078, image: https://tai2.ntu.edu.tw/species/351%20003%2011%202/218078).

Leaf buds glabrous or sparsely puberulous. Leaf blade abaxially glabrous or sparsely puberulous. Pedicel 3–7 mm long. Sepals glabrous outside, ovary glabrous. Fl. September to January, fr. June to November.

Distribution. China: Fujian, Taiwan.

Notes. Su et al. (2009) treated the plant as a species even though their molecular phylogenetic analysis suggested that *C. sinensis* f. *formosensis* nested in the clade of *C. sinensis*. The plant is merely different from tea by the indumenta of the leaf buds, sepals and ovary as described above.

Camellia sinensis var. ***assamica*** (Hook.) Steenis, Fl. Scholen Indon.: 280. 1949 ≡ *Thea assamica* Royle ex Hook., Kew Gardens. 28. 1847—Neotype (designated by Mabberley 2021: 1354): India. Assam, *W. Griffith s.n.* (K 000939670!, image: http://specimens.kew.org/herbarium/K000939670).

= *Thea cochinchinensis* Lour., Fl. Cochinch. 1: 338. 1790—Neotype (designated by Zhao et al. 2017a: 1453): Vietnam. Yen Bai: Bao Ha, 21 February 1936, *Poilane 25282* (P 04511587!, image: https://science.mnhn.fr/institution/mnhn/collection/p/item/p04511587).

= *Camellia theifera* Griff. in Trans. Agric. Soc. India. 5: t. C. 1838 —Lectotype (designated by Zhao et al. 2017a: 1453): India. Upper Assam, *W. Griffith s.n.* (TCD 0017977!).

= *Thea yersinii* A. Chev. ex Gagnep. in Lecomte Fl. Indo-Chine, Suppl. 1 [ed. H. Humbert]: 310. 1943 ("*Thea yersini*"), excl. *Poilane 7744* & *16693*—Lectotype (designated by Zhao et al. 2017a: 1453): Vietnam. Khanh Hoa: Massif du Hòn bà, province de Nhatrang, 1000–1500 m, 12 September 1918, *A. Chevalier 38684* (P 02142599!, image: https://science.mnhn.fr/institution/mnhn/collection/p/item/p02142599).

= *Camellia multisepala* Hung T. Chang & Y.J. Tan, Acta Sci. Nat. Univ. Sunyatseni 23(1): 11. 1984—Holotype: China. Yunnan: Mengla, Xiangming, cultivated, 1050 m, 3 December 1982, *Y.J. Tan et al. A31002* (SYS 00095167!).

= *Camellia polyneura* Hung T. Chang & Y.J. Tan, Acta Sci. Nat. Univ. Sunyatseni 23(1): 10. 1984—Holotype: China. Yunnan: Luchun, Qimaba, in tea garden, 1400 m, 18 November 1982, *Y.J. Tan et al. A26001* (SYS 00090671!).

= *Camellia sinensis* var. *kucha* Hung T. Chang & Ping S. Wang, Acta Sci. Nat. Univ. Sunyatseni 23(1): 10. 1984—Holotype: China. Yunnan: Jinping, Tongchang, 1371 m, 11 November 1982, *B.H. Chen et al. A22003* (SYS 00095188!).

= *Camellia tenuistipa* Orel, Curry & Luu in Orel & Curry, Pursuit Hidden Camellias Vietnam China: 263. 2015—Holotype: Vietnam. Gia Lai: Kon Ka Kinh National Park, 22 January 2011, *Luu & Nguyen KKK 221* (NSW 901734, image!).

Trees, leaf blade 8–29 cm × 3.5–10 cm, leaf apex attenuate or acuminate. Sepals glabrous outside, ovary pubescent. Fl. September to January, fr. July to December.

Distribution. China: Guangxi, Hainan, Yunnan. India: Upper Assam. Laos: Champasak, Khammouan, Oudomxay, Xiangkhouang. Myanmar: Kachin, Sagaing. Thailand: Chiang Mai, Chiang Rai, Loei, Mae Hong Son, Nan, Phayao, Phitsanulok. Vietnam: Cao Bang, Dak Lak, Gia Lai, Ha Giang, Hanoi, Hoa Binh, Khanh Hoa, Kon Tum, Lai Chau, Lam Dong, Lao Cai, Nghe An, Ninh Binh, Phu Tho, Quang Ninh, Thai Nguyen, Thua Tien Hue, Vinh Phuc.

Notes. Zhao (2022) summarized the nomenclatural issues of *C. sinensis* var. *assamica* (Assam tea) discussed by Zhao et al. (2017a) and Mabberley (2021) and listed the natural distribution localities in tropical China and Indochina. Assam tea can be distinguished from tea by its larger leaf blade and attenuate or acuminate leaf apex. Both are the most widely cultivated tea plants in the world.

Camellia sinensis var. ***dehungensis*** (Hung T. Chang & B.H. Chen) T.L. Ming, Acta Bot. Yunnan. 14: 128. 1992 ≡ *Camellia dehungensis* Hung T. Chang & B.H. Chen, Acta Sci. Nat. Univ. Sunyatseni 23(1): 8. 1984—Holotype: China. Yunnan: Mengla, Yiwu, Manluo, at tea garden, 1430 m, 4 December 1982, *Y.J. Tan & S.C. Ma A31005* (SYS 00095177!).

Leaf bud pubescent. Sepal glabrous outside, ovary glabrous. Fl. October to December, fr. August to December.

Distribution. China: Yunnan.

Notes. The plant is different from *C. sinensis* f. *formosensis* and *C. sinensis* var. *assamica* by its pubescent leaf buds and glabrous ovary, respectively. By contrast, *C. sinensis* f. *formosensis* usually bears glabrous leaf buds and Assam tea has a pubescent ovary.

Camellia sinensis var. ***pubilimba*** Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 98. 1981—Holotype: China. Guangxi: Lingyun, *Guangxi Forestry Institute 4209* (GXFI, image!).

= *Camellia sinensis* var. *dulcamara* Q.U. Le & D.L. Nguyen, J. New Biol. Rep. 9(1): 46. 2020—Holotype: Vietnam. Bac Kan: Na Ri, 22°14′41”N, 106°1′9″ E, 400–500 m, 20 February 2018, *Le Ung TN20012018* (VNM).

Young branchlet and leaf bud pubescent, leaf base cuneate, sepal pubescent outside, ovary pubescent. Fl. September to November, fr. June to November (Fig. 2.8).

Distribution. China: Guangdong, Guangxi, Hainan, Yunnan. Vietnam: Bac Kan.

Notes. Nguyen et al. (2022) treated *C. sinensis* var. *dulcamara* as a new heterotypic synonym of *C. sinensis* var. *pubilimba*. The variety bears a pubescent sepal on the outside surface by which it can be easily distinguished from tea and Assam tea.

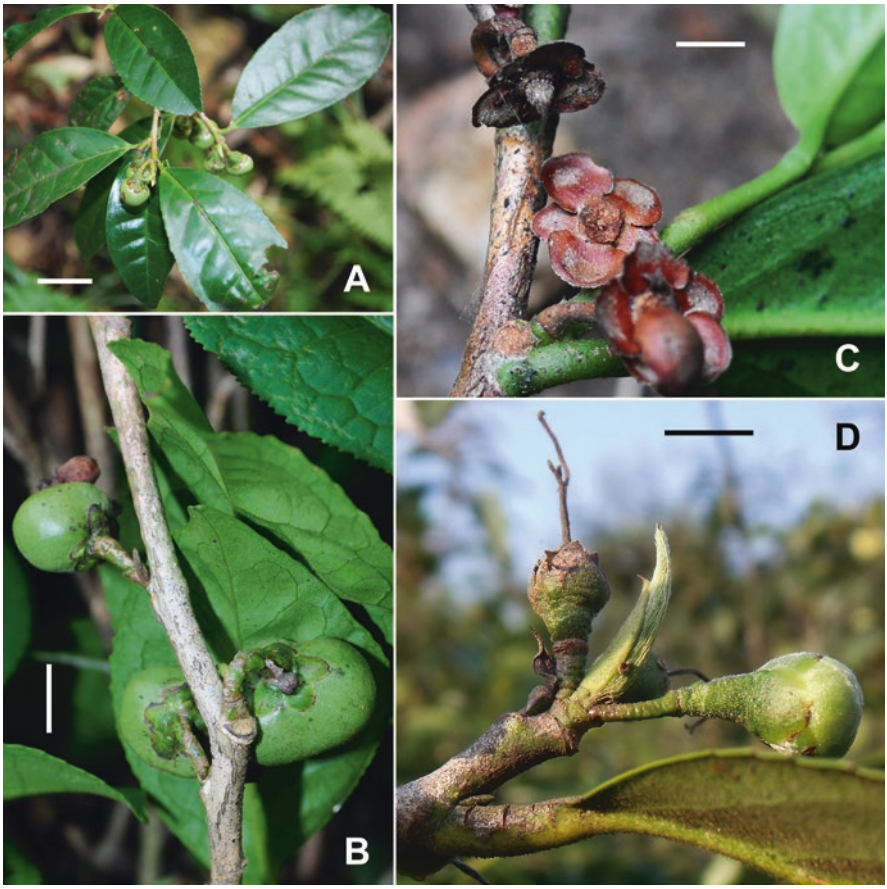

Fig. 2.8 *Camellia sinensis* var. *pubilimba*. (**a**) & (**b**) Branches with immature fruits (in Guangxi, planted), (**c**) a branchlet with dry sepals (in Guangdong), (**d**) tip of a branchlet, showing the indumenta of the leaf, buds, pedicels, and sepals (in Guangdong, planted). The bars represent 2 cm (in **a**), 1 cm (in **b**), 5 mm (in **c** & **d**)

The type of the taxon was collected from the local cultivar of tea plant named "Lingyun Baihao" in Guangxi, which is suitable for producing green tea.

Camellia tachangensis F.C. Zhang, Acta Bot. Yunnan. 2(3): 341. 1980—Holotype: China. Yunnan: Shizong, Dachang, 19 August 1979, *F.C. Zhang & Y.W. Guo 5* (Yunnan Agricultural University; isotype: KUN 1206056!).

= *Camellia quinquelocularis* Hung T. Chang & S. Ye Liang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 90. 1981—Holotype: China. Guangxi: Longlin, Jinzhongshan, 1700 m, 23 October 1957, *Nanzhidi 4680* (IBSC 0003555!).

= *Camellia tetracocca* Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 90. 1981—Holotype: China. Guizhou: Pu'an, *Guizhou Agricultural Products Procurement Bureau 2* (PE 01432821!).

Camellia tachangensis var. ***tachangensis***

New branchlets glabrous, leaf buds usually glabrous. Leaf blade elliptic, 8–15 × 3–6.5 cm, glabrous on both surfaces, base cuneate, margin serrate. Flower 3.5–5.5 cm in diameter. Pedicel 8–14 mm long, glabrous. Sepals 3.5–5 × 4–7 mm, outside glabrous, inside sericeous. Petals glabrous. Ovary glabrous. Style apically (4–)5-lobed, glabrous. Fruit 3–5 cm in diameter; pericarp 1–2 mm thick. Fl. August to December, fr. March to October.

Distribution. China: Guangxi, Guizhou, Yunnan.

Notes. He et al. (2023) found that the genetic diversity of *C. tachangensis* was lower than that of *C. gymnogyna* in Guizhou. Hao et al. (2019) suggested *C. tachangensis* formed a clade with *C. gymnogyna* and *C. taliensis* based on phylogenetic analysis using complete plastid genome. By contrast, Zhao et al. (2023) reported that *C. tachangensis* and *C. gymnogyna* shaped a monophyletic group and they were sister to other taxa of sect. *Thea* according to the analysis using nuclear DNA regions and more samples.

Camellia tachangensis var. ***remotiserrata*** (Hung T. Chang et al.) T.L. Ming, Fl. Yunnan. 8: 276. 1997 ≡ *Camellia remotiserrata* Hung T. Chang, H.S. Wang & P.S. Wang, Acta Sci. Nat. Univ. Sunyatseni 29(2): 87. 1990—Holotype: China. Yunnan: Weixin, Jiucheng, 1170 m, 11 October 1983, *F.L. Yu et al. A35005* (SYS 00095185!).

= *Camellia gymnogynoides* Hung T. Chang & B.H. Chen, Acta Sci. Nat. Univ. Sunyatseni 29(2): 86. 1990—Holotype: China. Yunnan: Yanjin, 980 m, *B.H. Chen & H.S. Wang 38006* (SYS).

= *Camellia jinyunshanica* Hung T. Chang & J.H. Xiong, Acta Sci. Nat. Univ. Sunyatseni 29(2): 85. 1990—Holotype: China. Chongqing: Jinyunshan, 12 September 1982, *J.H. Xiong 3497* (SYS 00094866!).

= *Camellia nanchuanica* Hung T. Chang & J.H. Xiong, Acta Sci. Nat. Univ. Sunyatseni 29(2): 85. 1990—Holotype: China. Chongqing: Nanchuan, 1300 m, *J.H. Xiong S-34116* (SYS).

Leaf buds pubescent. Leaf margin usually sparsely serrate. Style apically (3–)4–5-lobed. Fl. September to November, fr. July to September.

Distribution. China: Chongqing, Guizhou, Sichuan, Yunnan.

Notes. The variety can be distinguished from *C. gymnogyna* by its usually four to five-lobed style, whereas the latter bears an apically three-lobed style.

Camellia taliensis (W.W. Sm.) Melch. in Engler & Prantl, Nat. Pflanzenfam., ed. 2, 21: 131. 1925 ≡ *Thea taliensis* W.W. Sm., Notes Roy. Bot. Gard. Edinburgh 10: 73. 1917—Lectotype (first-step designated by Ming 2000: 119, second-step designated by Zhao et al. 2017b: 177): China. Yunnan: Ghi Shan east of Tali Lake, 25°48′N, 9000 ft., August 1914, *G. Forrest 13477* (E 00284542!, image: http://data.rbge.org.uk/herb/E00284542; isolectotypes: BM 000611997!, E 00284543!, K 000704280!, SYS 00091976!, SYS 00091977!).

= *Polyspora yunnanensis* Hu, Bull. Fan Mem. Inst. Biol. Bot. 8(3): 135. 1938—Lectotype (designated by Zhao et al. 2019: 299): China. Yunnan: Luxi, 1750 m, 6

February1934, *H.T. Tsai 56805* (PE 00716167!, image: https://www.cvh.ac.cn/spms/detail.php?id=f1dc1299).

= *Camellia irrawadiensis* P.K. Barua in Camellian 7(4): 18. 1956—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: K 000704313! & K 000704314!).

= *Camellia pentastyla* Hung T. Chang, Acta Sci. Nat. Univ. Sunyatseni 20(1): 92. 1981—Lectotype (designated by Zhao et al. 2018: 93): China. Yunnan: Fengqing, cultivated, 2050 m, 12 February 1963, *L.F. Xia & Z.H. Yang 28* (KUN 1206061!).

= *Camellia quinquebracteata* Hung T. Chang & C.X. Ye, Acta Sci. Nat. Univ. Sunyatseni 26(1): 20. 1987—Holotype: China. Yunnan: Lianghe, Dachang, 4 January 1983, *P. Zeng & Q.J. Xie 17055* (SYS; isotype: KUN 1206063!).

New branchlets glabrous, leaf buds glabrous or sparsely puberulous. Leaf blade elliptic to oblong, 7.5–15.5 × 3–6.5 cm, glabrous on both surfaces, base attenuate to obtuse. Flower 3–5 cm in diameter. Pedicel 8–15 mm long, glabrous. Sepals 4–6.5 × 5.5–9 mm, outside glabrous, inside sericeous. Petals glabrous. Ovary pubescent. Style apically (3–)5-lobed, basally sparsely pubescent and gradually becoming glabrous apically. Fruit 2.5–5 cm in diameter; pericarp 1.5–4 mm thick. Fl. October to February, fr. April to November (Fig. 2.9).

Distribution. China: Yunnan. Myanmar: Chin, Shan. Thailand: Chiang Mai, Kamphaeng Phet, Mae Hong Son, Nan, Phayao, Tak.

Notes. Zhao et al. (2014) analyzed the genetic diversity and population structure of *C. taliensis* in China and found a loss of genetic diversity of natural populations due to overexploitation and habitat fragmentation. Assam tea was usually planted together with *C. taliensis* in western Yunnan, which might have brought about new cultivars due to hybridization (Zhao and Yang 2012; Mao et al. 2021). Gao et al. (2008) revealed that the green tea of *C. taliensis* contained 2.32% caffeine. Local people usually produce black tea using the leaf buds of the species.

2.3.2 Species Excluded from Sect. Thea

Camellia flosculora Curry et al., a recently published species as a tea plant (Le et al. 2021), was excluded from sect. *Thea* but placed in sect. *Corallina* by Nguyen et al. (2022) because it bore persistent bracteoles and free styles.

Camellia grandibracteata Hung T. Chang & F.L. Yu was described based on a specimen collected from a tea garden in Yunnan (Chang 1984). Zhao and Yang (2012) amended its description based on the records of the original material and collections from the same tree on which the type was collected. They found that *C. grandibracteata* bore an apically 3–5-lobed style and might derive from hybridization between *C. taliensis* and *C. sinensis*. I have found some cultivated tea plants bearing similar diagnostic character states in Guizhou (e.g., *Zhao et al. 427*). No natural plant of *C. grandibracteata* has been collected or reported. Therefore, the

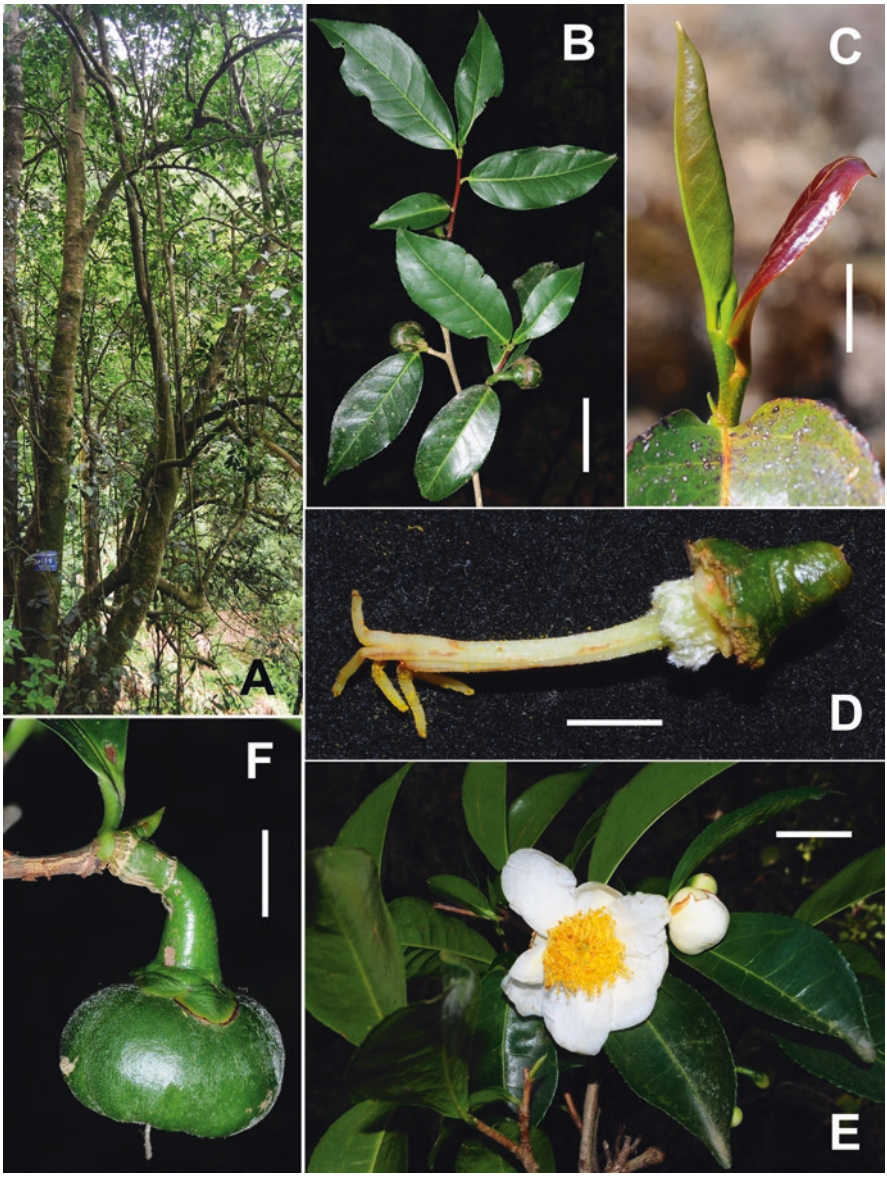

Fig. 2.9 *Camellia taliensis* in Yunnan. (**a**) Habit, (**b**) a branch with immature fruits, (**c**) a new branchlet with immature leaves, (**d**) a gynoecium and a part of pedicel, (**e**) branches with flowers, (**f**) an immature fruit. The bars indicate 4 cm (in **b**), 1 cm (in **c** & **f**), 5 mm (in **d**), 2 cm (in **e**)

taxon is excluded from the list of natural tea plants here. More data are needed to justify its relationship with the taxa of sect. *Thea*.

Camellia pubicosta Merr. was placed in sect. *Thea* by Sealy (1958), Chang (1981a, b), and Chang and Bartholomew (1984), whereas Ming (1999, 2000) treated the species as a member of sect. *Corallina* Sealy. Huang et al. (2014) suggested that the species had a close relationship with *C. sinensis* based on phylogenomic analysis using complete plastid genomes. However, Zhao et al. (2017a, 2023) argued that the material of *C. pubicosta* used in Huang et al. (2014) was misidentified, and *C. pubicosta* and sect. *Thea* was separately nested in two different main clades of the phylogenetic tree reconstructed by nuclear DNA regions. Morphologically, *C. pubicosta* has persistent bracteoles and distinct styles, which can be easily distinguished from species of sect. *Thea*.

Camellia sealyana T.L. Ming was placed in sect. *Thea* by Ming (1999, 2000). Zhao (2022) excluded the species from sect. *Thea* because of the abaxially punctate leaves and distinct styles. More materials of *C. sealyana* are needed to explore its phylogenetic position in *Camellia*.

2.4 Conclusions and Perspectives

Camellia sect. *Thea* includes 11 natural species and seven infraspecific taxa. All taxa occur in China. *Camellia sinensis* var. *assamica*, *C. sinensis* var. *pubilimba*, and *C. taliensis* are also distributed in Indochina. Since all tea plants can be used to produce beverages, they are vital germplasms for tea breeding.

Though I revised the systematics with the latest results of molecular phylogenetic analyses, the current taxonomy of sect. *Thea* remains largely based on morphological data. It is, however, hardly satisfactory when we consider the economic importance of these plants and the demands of a natural systematics for tea breeding and conservation. A robust phylogenetic tree with exhaustive sampling of sect. *Thea* has yet to be achieved. Sampling, rather than technology, is the main difficulty in this research. Meanwhile, the natural variation of each taxon of sect. *Thea* remains to be fully explored with more collection or investigations in the wild.

Acknowledgments I thank the staff of herbaria mentioned in the materials and methods section for making specimens or images available. The work is supported by the Scientific Research Foundation of the Central South University of Forestry and Technology (2019YJ023).

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