



NOTE

Synopsis of *Camphora* (Cinnamomeae, Lauraceae) of Taiwan, with two new combinations and one new synonym

Kuo-Fang CHUNG*, Chia-Lun HSIEH

Research Museum and Herbarium (HAST), Biodiversity Research Center, Academia Sinica, Taipei 115201, Taiwan.
*Corresponding author's email: bochung@gate.sinica.edu.tw

(Manuscript received 22 April 2023; Accepted 27 July 2023; Online published 6 September 2023)

ABSTRACT: *Cinnamomum kanahirae* (*Cinnamomum* sect. *Camphora*) is an ecologically and economically important tree species endemic to Taiwan best known as the sole host plant of the highly valued medicinal mushroom ‘niu-chang-chih’ (*Taiwanofungus camphoratus*). Although *C. kanahirae* had been synonymized under *C. micranthum*, studies of fruit morphology, essential oil contents, allozyme profiles, and plastome phylogenomics have demonstrated that the two species are different. However, in a recent study that transferred all species of *Cinnamomum* sect. *Camphora* to the restored genus *Camphora* based on phylogenetics and macro- and micromorphology, *C. kanahirae* was regarded as conspecific with *C. micranthum* and thus was treated as a synonym of *Camphora micrantha*. Additionally, *C. camphora* var. *nominale*, an ecologically and genetically distinct variety long recognized in Taiwan, was also synonymized under *Camphora officinarum*. On the other hand, *Machilus philippinensis* was thought to be *Cinnamomum philippinense* and thus erroneously transferred to *Camphora* (i.e., *Camphora philippinensis*). To rectify these taxonomic oversights, two new combinations *Camphora kanahirae* **comb. nov.** and *Camphora officinarum* var. *nominale* **comb. nov.** are proposed and *Camphora philippinensis* is treated as a **syn. nov.** of *Machilus philippinensis* for effective conservation and sustainable utilization of these valuable tree species in Taiwan.

KEY WORDS: *Cinnamomum* sect. *Camphora*, stout camphor tree, Catalogue of Life in Taiwan (TaiCOL).

INTRODUCTION

Cinnamomum kanahirae Hayata, commonly known as the stout camphor tree, is an endemic and one of the largest broadleaved forest trees in Taiwan (Liao, 1996), with trunks reaching up to 700 cm in diameter and towering over 30 m tall (Chang, 1988). Surveys for camphor production conducted between 1918 and 1922 (Uka, 1927) reported that *C. kanahirae*, along with three congeners, *C. camphora* (L.) J.Presl, *C. camphora* var. *nominale* Hayata, and *C. micranthum* (Hayata) Hayata, once dominated the montane forests of 200–2,000 m in elevation throughout the island (Lin, 1993; Lin *et al.*, 1997). Although stout camphor tree in fact does not contain camphor (Fujita, 1952, 1967), its aromatic and decay-resistance wood has been sought after for making premium furniture and sculptures (Hung *et al.*, 2017). Additionally, *C. kanahirae* is the sole host plant of ‘niu-chang-chih’ (牛樟芝) [or stout camphor medicinal mushroom/stout camphor fungus; *Taiwanofungus camphoratus* (M.Zang & C.H.Su) Sheng H.Wu, Z.H.Yu, Y.C.Dai & C.H.Su (Wu *et al.*, 2004; Wu *et al.*, 2012)]. As a precious medicinal mushroom renowned for its rich bioactive compounds and potent medicinal values including anti-cancer properties, ‘niu-chang-chih’ naturally only grows on the inner walls of old tree trunk cavities of stout camphor (Geethangili and Tzeng, 2011; Wu *et al.*, 2012; Lu *et al.*, 2014; Lee *et al.*, 2019).

Although *Cinnamomum kanahirae* had escaped from exploitation during early camphor industry and remained

abundant by the end of the World War II, unrestricted logging in the 1980s and recent poaching for cultivating niu-chang-chih have nearly decimated its wild populations (Lin, 1993; Lin *et al.*, 1997; Hung *et al.*, 2017; Wu *et al.*, 2017). To promote sustainable utilization and conservation of *C. kanahirae*, researchers in Taiwan have extensively studied its taxonomy (Lin, 1993; Liao, 1996; Ju, 2006), ecology (Huang *et al.*, 1997; Tsai *et al.*, 2020), population genetics and phylogeography (Lin *et al.*, 1997; Kuo *et al.*, 2010; Liao *et al.*, 2010), physiology (Kuo *et al.*, 2004), silviculture (Kao and Huang, 1993; Chang *et al.*, 1997; Kao *et al.*, 1997a; Kao *et al.*, 1997b; Chang *et al.*, 2002; Chen and Chang, 2009), plant pathology (Chang, 1992; Chang and Chern, 1997), phytochemistry (Fujita, 1952, 1960, 1967; Leu *et al.*, 2014; Cheng *et al.*, 2015), and genomics (Wu *et al.*, 2016; Wu *et al.*, 2017; Chaw *et al.*, 2019).

Despite its ecological and economic importance, the nomenclature and classification of stout camphor have been subjects of dispute. “*Cinnamomum Kanahirai* Hayata” was named after “R. Kanahira” (金平亮三), a renowned Japanese botanist and forester (Yeh, 2018) who collected the type specimen (Hayata, 1913). While the character 金 can be pronounced and spelled either as ‘kana’ or ‘kane’ in Japanese, 金平 himself spelled his last name as Kanehira (e.g., Kanehira, 1917, 1936), not Kanahira. Consequently, while Hayata (1913)’s original spelling ‘*kanahirai*’ was adopted by Kanehira (1917, 1936) as well as other earlier authors (Hayata, 1915; Fujita, 1952; Li, 1963; Li, 1975; Li *et al.*, 1982), various

**Table 1.** Morphological and chemical comparison between *Camphora kanahirae* and *Camphora micrantha*.

	<i>Camphora kanahirae</i>	<i>Camphora micrantha</i>
Leaf morphology	Broadly ovate, ovate to elliptic, 10–15 cm long, 4–7.5 cm wide, usually short acute at the apex, acute to obtuse-rounded at the base.	Oblong to broadly elliptic, 9–15 cm long, 4–5 cm wide, usually short acuminate at the apex, acute to obtuse at the base.
Fruit morphology	Compressed obconic globose, 1–1.3 cm long, cm across.	Ellipsoid, 0.8–1.8 cm long, 0.6–1.2 cm across.
Seed morphology	Globose, rounded at the both sides.	Ellipsoid, acute on one side.
Essential oil ¹	Leaf: linalool, sesamin, sabinene, terpinen-4-ol Stem: terpinen-4-ol (main), safrole Root: safrole (main), sabinene, terpinen-4-ol	Leaf: decylaldehyde (main), linalool (trace) Stem: pentadecylaldehyde , safrole, linalool (trace) Root: safrole (main)

¹Chemical compositions of each part of the tree were summarized from (Fujita, 1952, 1960, 1967), Hsieh *et al.* (2005), and Wu *et al.* (2017). The major characteristics and differences of the essential oil between the two species were marked in bold.

spelling appeared, including ‘*kanehirai*’ (Liu, 1960; Chang, 1970, 1976; Liao, 1988), ‘*kanehira*’ (Liu and Ou, 1969), and ‘*kanahirae*’ (Liao, 1995, 1996; Yang *et al.*, 1997; Li *et al.*, 2008; Chung and Hsu, 2016). The last specific epithet ‘*kanehirae*’ is also adopted both by IPNI (International Plant Name Index; <https://www.ipni.org/>; accessed 11 June 2023) and Tropicos (<https://tropicos.org/home>; accessed 11 June 2023), two of the most searched plant name databases. Because Hayata (1913) specifically cited “leg. R. Kanahira”, the epithet ‘*kanahirai*’ is not a typographical error and is to be retained according to Art. 60.1 of the *Code* (Turland *et al.*, 2018). However, as the name Kanahira ends with *-a*, the termination of the specific epithet *-i* should be changed to *-e* according to Art. 60.8(a) of the *Code* (Turland *et al.*, 2018). Therefore, the correct species epithet of stout camphor should be ‘*kanahirae*’, which is used in this article unless otherwise discussed.

Although Kanehira (1917) initially recognized *Cinnamomum kanahirae* and *C. micranthum* as two different species in his “Formosan Trees”, the former was synonymized under the latter in ‘Formosan Trees Indigenous to the Island (Revised)’ for their similar gross morphology (Kanehira, 1936). As a highly influential work, Kanehira (1936)’s treatment had been followed widely (Liu, 1960; Li, 1963; Liu and Ou, 1969; Chang, 1970; Li, 1975; Chang, 1976; Liao, 1988). However, older-generation foresters in Taiwan had long recognized the differences between the two species (Uka, 1927; Fujita, 1952), as demonstrated by Lin (1993) based on fruit morphology, constitution of essential oils (Table 1), and allozyme profiles. While a majority of taxonomic works in Taiwan subsequent to Lin (1993) recognized *C. kanahirae* and *C. micranthum* as two separate species (Liao, 1996; Yang *et al.*, 1997; Chung and Hsu, 2016), Lin (1993)’s work was overlooked in the Flora of China (Li *et al.*, 2008), which not only treated *C. kanahirae* as a synonym of *C. micranthum* but further expanded the latter species by including *C. xanthophyllum* H.W.Li of southeastern China (Li *et al.*, 1982). Nevertheless, recent plastome phylogenomic studies further showed that *C. kanahirae* and *C. micranthum* differ not only in their plastome sequences (Wu *et al.*, 2017) but are not even sister group (Song *et al.*, 2020; Fig. 1).

On the other hand, phylogenetic (Huang *et al.*, 2016; Rohde *et al.*, 2017; Yang *et al.*, 2022) and phylogenomic (Song *et al.*, 2020; Liu *et al.*, 2021) studies all revealed that the traditionally-defined *Cinnamomum* Schaeff. (i.e., *Cinnamomum* s.l.) is diphyletic, with *Cinnamomum* sect. *Camphora* Meisner (e.g., *C. camphora*, *C. camphora* var. *nominale*, *C. kanahirae*, and *C. micranthum*) sister to the East Asian-Eastern North American disjunct *Sassafras* J.Presl (Chung *et al.*, 2010; Chung *et al.*, 2011) and *Cinnamomum* sect. *Cinnamomum* (\equiv *Cinnamomum* s.str.) sister to the African *Kuloa* Trofimov & Rohwer (Trofimov and Rohwer, 2020). Because the generic type of *Cinnamomum* (i.e., *C. verum* J.Presl) is phylogenetically nested within sect. *Cinnamomum* (Fig. 1), the generic status of *Camphora* Fabr. was reserected (Yang *et al.*, 2022). It should be noted that, while *Camphora* Fabr. is a *nom. rej.* under the *nom. cons.* *Cinnamomum* Schaeff. (Stafleu and Voss, 1975), the former’s generic status is to be restored according to Art. 14.6 of the *Code* (Turland *et al.*, 2018). It should also be noted, however, while our plastome phylogenomic analysis also supports the diphyly of *Cinnamomum* s.l., the generic placements of several species appear to be problematic (Fig. 1). Specifically, *Camphora officinarum* Nees [\equiv *Cinnamomum camphora* (L.) J.Presl], which is the type of *Camphora*, is not monophyletic, with samples placed both in *Camphora* and *Cinnamomum* s.str. (Fig. 1). Additionally, plastome phylogenomic analysis places *Camphora chartophylla* (H.W.Li) Y.Yang, Bing Liu & Zhi Yang, *Camphora mollifolia* (H.W.Li) Y.Yang, Bing Liu & Zhi Yang, and *Camphora tenuipiles* (Kosterm.) Y.Yang, Bing Liu & Zhi Yang all in *Cinnamomum* s.str. (Fig. 1) instead of *Camphora*. The polyphyly of *Camphora officinarum* and conflicts between our plastome tree (Fig. 1) and Yang *et al.* (2022)’s treatment could have resulted from species misidentification (Chandrasekara *et al.*, 2021) and/or hybridization and introgression that appear to be prevalent in *Cinnamomum* s.l. (e.g., Rohwer *et al.*, 2019; Wu *et al.*, 2020). Further investigations are needed to resolve these issues.

Regardless, *Camphora* and *Cinnamomum* s.str. defined by Yang *et al.* (2022) appear to be distinguishable also in terms of their macro- and micromorphological features (Gang *et al.*, 2021; Yang *et al.*, 2022). Specifically, *Camphora* is recognized by its alternate and

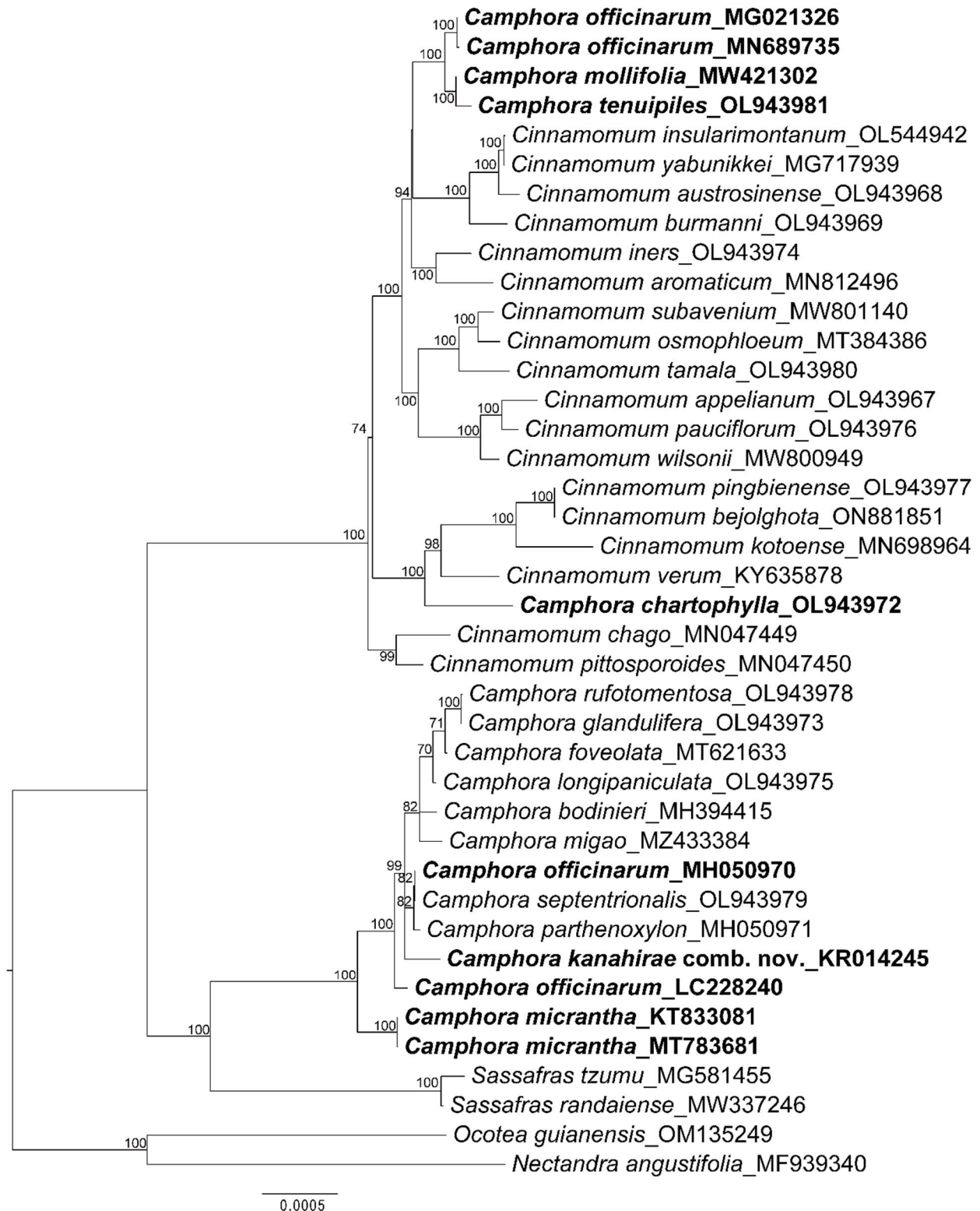


Fig. 1. Maximum likelihood phylogram of 40 plastomes of tribe Cinnamomeae. NCBI accession numbers are shown after the scientific names. The plastome configuration of each sequence was manually adjusted in Geneious Prime v.2022.1.1 (Kearse et al., 2012) and aligned using MAFFT v.1.5.0 (Kato and Standley, 2013) under Geneious. The maximum likelihood phylogeny tree was generated by RAxML v.4.0 (Stamatakis, 2014) under Geneious with 500 rapid bootstrapping replicates and GTRGAMMA substitution model. The resulting tree was visualized using FigTree v.1.4.4 (<http://tree.bio.ed.ac.uk/software/figtree/>).



pinnately veined leaves, presence of domatia in the axils of lateral and middle veins, perulate terminal buds, and epidermis with regularly-shaped cells and straight anticlinal cell walls and smooth periclinal cell walls. In contrast, *Cinnamomum* s.str. is characterized by its opposite/subopposite and tripliveined leaves, absence of domatia, scale-less buds, and epidermis with irregularly-shaped cells and sinuous anticlinal cell walls and reticulate periclinal cell walls (Gang *et al.*, 2021). However, Yang *et al.* (2022) overlooked the extensive literature that established the distinctness (Table 1) and specific status of *Cinnamomum kanahirae* (Fujita, 1952; Lin, 1993; Ju, 2006; Wu *et al.*, 2017; Song *et al.*, 2020) and treated *C. kanahirae* as a synonym of *Camphora micrantha* (Hayata) Y. Yang, Bing Liu & Zhi Yang. Because *C. micranthum* is listed as “Least Concerned (LC)” in The red list of vascular plants of Taiwan, 2017 (Editorial Committee of the Red List of Taiwan Plants, 2017), Yang *et al.* (2022)’s taxonomic treatment jeopardizes the conservation and sustainable utilization of a precious endemic tree species of Taiwan. Additionally, *C. camphora* var. *nominale*, an ecologically and genetically distinct variety that has long been recognized in Taiwan (Kanehira, 1917, 1936; Liu, 1960; Li, 1963; Liao, 1988, 1995, 1996; Ju, 2006; Editorial Committee of the Red List of Taiwan Plants, 2017), was synonymized under *Camphora officinarum* Nees (Yang *et al.*, 2022). Moreover, apparently unaware of Ju *et al.* (2006)’s work that had confirmed the generic placement of *Machilus philippinensis* Merr., Yang *et al.* (2022) followed earlier treatments (Chang, 1975, 1976) that placed the species in *Cinnamomum* [i.e., *C. philippinense* (Merr.) C.E. Chang] and transferred the species as *Camphora philippinensis* (Merr.) Y. Yang, Bing Liu & Zhi Yang. To rectify these taxonomic oversights that affect the conservation effort of Taiwan (Mace, 2004; Ely *et al.*, 2017; Stanton *et al.*, 2019) and particularly sustainable utilization of the stout camphor tree and niu-chang-chi, we propose two new combinations and one new synonym. A taxonomic key and a synopsis of *Camphora* of Taiwan are also provided. The proposed nomenclatural changes are also needed for Catalogue of Life in Taiwan (TaiCoL; <https://taicol.tw/>), the national database that maintains the most complete authoritative list of Taiwan’s species based on the most updated taxonomic literature (e.g., Lin and Chung, 2017).

TAXONOMIC TREATMENT

Camphora Fabr., Enum. 218 (1759); Yang *et al.*, Ecol. Evol. 12(10)-e9378: 7 (2022). — **TYPE:** *Camphora officinarum* Nees.

Key to *Camphora* of Taiwan (Liao, 1996)

- 1a. Leaves 10–15 cm long, green beneath when fresh 2
- 1b. Leaves 5–10 cm long, slightly gray beneath when fresh 3
- 2a. Fruit obconic-globes, 1.2–1.3 cm long, 1.2–1.5 cm across; seeds globose, rounded on both sides 1. *Camphora kanahirae*

- 2b. Fruit ellipsoid, 1.4–1.6 cm long, 1–1.2 cm across; seeds ellipsoid, acute on both sides 2. *Camphora micrantha*
- 3a. Bark of trunk without knobs, deeply furrowed; seeds 6–7.1 mm across 3a. *Camphora officinarum*
- 3b. Bark of trunk often with knobs, somewhat smooth and lustrous; seeds 4.2–5.4 mm across . 3b. *Camphora officinarum* var. *nominale*

Synopsis of *Camphora* of Taiwan

1. *Camphora kanahirae* (Hayata) K.F. Chung & C.L. Hsieh, **comb. nov.** 牛樟

Cinnamomum kanahirae (*kanahirai*) Hayata, Icon. Pl. Formosan. 3: 159. 1913; Hayata, Icon. Pl. Formosan. 5: 157. 1915 (*kanahirai*); Kanehira, Formosan Trees 424. 1917 (*kanahirai*); Fujita, Bot. Mag. (Tokyo) 65: 246. 1952 (*kanahirai*); Liao in Fl. Taiwan 2nd ed. 2: 443. 1996 (*kanehirae*); Yang *et al.* in Manual Taiwan Vasc. Pl. 2: 133. 1997 (*kanehirae*); Chung & Hsu, Ill. Fl. Taiwan 1: 75. 2016 (*kanehirae*).—**TYPE:** TAIWAN (‘FORMOSA’). Miaoli County: Nanzhuang (‘Nanshōshichō’), Kali-zenzan, ad 4000 ped. alt., Oct. 1912, leg. R. Kanehira s.n. [holotype TI-02456 (image!)].—*Cinnamomum micranthum* f. *kanahirae* (Hayata) S.S. Ying, Coloured Ill. Fl. Taiwan 1: 309. 1985 (*kanehirae*); Ying, Mem. Coll. Agric. Natl. Taiwan Univ. 25: 108. 1985 (*kanehirae*).

2. *Camphora micrantha* (Hayata) Y. Yang, Bing Liu & Zhi Yang in Yang *et al.*, Ecol. Evol. 12(10)-e9378: 9. 2022, *pro parte.* 冇樟

Machilus micrantha Hayata, Icon. Pl. Formosan. 2: 130. 1912.—**TYPE:** TAIWAN (‘FORMOSA’). New Taipei City (‘Taihoku’). Sanxia (‘Sankakuyū’), ‘Taihyō’, Juni. 1912, leg. R. Kanehira s.n. [holotype TI-02537 (image!)].—*Cinnamomum micranthum* (Hayata) Hayata, Icon. Pl. Formosan. 3: 160. 1913; Hayata, Icon. Pl. Formosan. 5: 158. 1915; Kanehira, Formosan Trees 426. 1917; Kanehira, Formosan Trees rev. ed. 203. 1936, *pro parte*; Fujita, Bot. Mag. (Tokyo) 65: 246. 1952; Liu, Ill. Native Introd. Lign. Plants Taiwan 1: 102. 1960, *pro parte*; Li, Woody Fl. Taiwan 203. 1963, *pro parte*; Liu & Ou, Quart. J. Chin. Forest. 2(3): 5. 1969, *pro parte*; Chang, Bull. Taiwan Prov. Pingtung Inst. Agric. 11: 52. 1970, *pro parte*; Li, Acta Phytotax. Sin. 13(4): 42. 1975, *pro parte*; Chang in Fl. Taiwan 2: 416. 1976, *pro parte*; Li *et al.* in Fl. Reipubl. Popul. Sin. 31: 180. 1982, *pro parte*; Ying, Coloured Ill. Fl. Taiwan 1: 307. 1985, *pro parte*; Ying, Mem. Coll. Agric. Natl. Taiwan Univ. 25: 108. 1985, *pro parte*; Liu *et al.*, Trees Taiwan 136. 1988, *pro parte*; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 35. 1988, *pro parte*; Liu *et al.*, Trees Taiwan rev. ed. 104. 1994, *pro parte*; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 2nd ed. 41. 1995; Liao in Fl. Taiwan 2nd ed. 2: 445. 1996; Yang *et al.* in Manual Taiwan Vasc. Pl. 2: 133. 1997; Lu *et al.*, Trees Taiwan 1: 68. 2000, *pro parte*; Li *et al.* in Fl. China 7: 174. 2008, *pro parte*; Chung & Hsu, Ill. Fl. Taiwan 1: 75. 2016.

3. *Camphora officinarum* Nees in Wallich, Pl. Asiat. Rar. 2: 72. 1831.—**TYPE:** JAPAN. [lectotype LINN 518.7 (image!), designated by Kostermans (1978: 18)]; Yang *et al.*, Ecol. Evol. 12(10)-e9378: 9. 2022, *pro parte.*

樟樹

Laurus camphora L., Sp. Pl. Linnaeus 1: 369. 1753.—*Cinnamomum camphora* (L.) J. Presl in Berchtold & Presl, Prir. Rostlin 2: 47. 1824–1825; Li *et al.* in Fl. Reipubl. Popul. Sin. 31: 182. 1982, *pro parte*; Ying, Coloured Ill. Fl. Taiwan 1: 107. 1985; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 19. 1988; Liu *et al.*, Trees Taiwan rev. ed. 108. 1994, *pro parte*; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 2nd ed. 25. 1995; Liao in Fl. Taiwan 2nd ed. 2: 440. 1996; Yang *et al.* in Manual Taiwan Vasc. Pl. 2: 132. 1997, *pro parte*; Lu *et al.*, Trees Taiwan 1: 66. 2000, *pro parte*; Chung & Hsu, Ill. Fl. Taiwan 1: 74. 2016, *pro parte*.—*Cinnamomum camphora* (L.) Siebold, Verh. Batav. Genootsch. Kunst. 23. 1830, *nom. illeg.*; Kanehira, Formosan Trees rev. ed. 201. 1936; Fujita, Bot. Mag. (Tokyo) 65: 245. 1952; Liu, Ill. Native Introd. Lign. Plants Taiwan 1: 100. 1960; Li, Woody Fl.



Taiwan 206. 1963; Liu & Ou, Quart. J. Chin. Forest. 2(3): 2. 1969, *pro parte*; Chang, Bull. Taiwan Prov. Pingtung Inst. Agric. 11: 51. 1970, *pro parte*; Li, Acta Phytotax. Sin. 13(4): 43. 1975; Chang in Fl. Taiwan 2: 413. 1976, *pro parte*.—*Cinnamomum camphora* (L.) Nees & Eberm., Pl. Asiat. Rar. 2: 430. 1831, *nom. illeg.*; Matsumura & Hayata, J. Coll. Sci. Imp. Univ. Tokyo. 22: 349. 1906; Hayata, J. Coll. Sci. Imp. Univ. Tokyo. 25: 189. 1908; Kanehira, Formosan Trees 420. 1917; Ying, Coloured Ill. Fl. Taiwan 1: 305. 1985; Liu *et al.*, Trees Taiwan 133. 1988, *pro parte*.

3b. *Camphora officinarum* var. *nominale* (Hayata)

K.F.Chung & C.L.Hsieh, *comb. nov.* 栲樟

Cinnamomum camphora var. *nominale* Hayata in Matsumura & Hayata, J. Coll. Sci. Imp. Univ. Tokyo. 22: 349. 1906; Kanehira, Formosan Trees 421. 1917; Kanehira, Formosan Trees rev. ed. 202. 1936; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 24. 1988; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 2nd 26. 1995; Liao in Fl. Taiwan 2nd ed. 2: 440. 1996.—**TYPE**: The original type [Taiwan ('FORMOSA'). HengChuen ('Kōshūn'), anno 1905, leg. T. Kawakami *s.n.*] was not found. Neotype designated by Yang *et al.* (2022: 9): TAIWAN ('FORMOSA'). Pingtung County: HengChuen ('Kōshūn'), Kenting National Park ('Kuaru'), 30 May 1912, B. Hayata *s.n.* [TI-02459 (image!), isoneotypes TI-02460 (image!), TI-02461 (image!), TI-02462 (image!)]—*Cinnamomum nominale* (Hayata) Hayata, Icon. Pl. Formosan. 3: 160. 1913; Fujita, Bot. Mag. (Tokyo) 65: 245. 1952; Liu, Ill. Native Introd. Lign. Plants Taiwan 1: 130. 1960; Li, Woody Fl. Taiwan 206. 1963; Li, Acta Phytotax. Sin. 13(4): 43. 1975.

Species excluded:

Machilus philippinensis Merr., Philipp. J. Sci. 1(Suppl. 1): 56. 1906; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 118. 1988; Liao, Taxon. Rev. Fam. Lauraceae Taiwan 2nd 123. 1995; Liao in Fl. Taiwan 2nd ed. 2: 481. 1996; Yang *et al.* in Manual Taiwan Vasc. Pl. 2: 141. 1997; Ju *et al.*, Quart. J. Chin. Forest. 39(2): 171. 2006; Chung & Hsu, Ill. Fl. Taiwan 1: 98. 2016.—**TYPE**: PHILIPPINES. Province of Bataan, Lamao River, Mt. Mariveles, March 1905, R. Meyer 2793 [lectotype US-00516627 (image!), designated by Yang *et al.* (2022: 10), isolectotypes NY-00355328 (image!), NY-00355329 (image!)]—*Cinnamomum philippinense* (Merr.) C.E.Chang, Sci. Developm. 3(11): 64. 1975; Chang in Fl. Taiwan 2: 417. 1976; Li *et al.* in Fl. Reipubl. Popul. Sin. 31: 168. 1982; Liu *et al.*, Trees Taiwan 137. 1988; Liu *et al.*, Trees Taiwan rev. ed. 110. 1994; Li *et al.* in Fl. China 7: 170. 2008.—*Camphora philippinensis* (Merr.) Y.Yang, Bing Liu & Zhi Yang in Yang *et al.*, Ecol. Evol. 12(10)-e9378: 10. 2022, *syn. nov.*

Cinnamomum acuminatissimum Hayata, Icon. Pl. Formosan. 3: 157. 1913; Hayata, Icon. Pl. Formosan. 5: 153. 1915; Kanehira, Formosan Trees 419. 1917; Ying, Coloured Ill. Fl. Taiwan 1: 303. 1985; Ying, Mem. Coll. Agric. Natl. Taiwan Univ. 25: 160. 1985.—**TYPE**: TAIWAN ('FORMOSA'). 'Taishō', 26 March 1910, leg. R. Furukawa *s.n.* [holotype TI-02537 (image!), isotypes L-0035683 (image!), L-0035684 (image!)]—*Machilus acuminatissima* (Hayata) Kanehira, Formosan Trees rev. ed. 219. 1936.—*Persea acuminatissima* (Hayata) Kostermans, Reinwardtia 6(2): 191. 1962; Li, Woody Fl. Taiwan 224. 1963; Chang, Bull. Taiwan Prov. Pingtung Inst. Agric. 11: 42. 1970. *Cinnamomum caudatifolium* Hayata, Icon. Pl. Formosan. 5: 155. 1915; Kanehira, Formosan Trees 423. 1917.—**TYPE**: TAIWAN ('FORMOSA'). Chiayi County. Mt. Arisan: intre Karapin et Funkiko, prope Suisharyō, 27 Mart. 1914, leg. B. Hayata *s.n.* [holotype TI-02450 (image!)]

ACKNOWLEDGMENTS

The authors thank Wei-Chun Chao, Szuwei Tsai, Sheng-Hwa Wu, and Chih-Kai Yang for providing references and Po-Hsun Huang for bringing us attention for the correct spelling of *Cinnamomum kanahirae*. This work was supported by the 2023 research grant "Operation and Promotion of Catalogue of Life in Taiwan Database-TaiCOL" (112 林發-08.1-保-05) of Bureau of Forestry, Council of Agriculture to K.-F. Chung.

LITERATURE CITED

- Chandrasekara, C.H.W.M.R.B., Naranpanawa, D.N.U., Bandusekara, B.S., Pushpakumara, D.K.N.G., Wijesundera, D.S.A., Bandaranayake, P.C.G. 2021 Universal barcoding regions, *rbcl*, *matK* and *trnH-psbA* do not discriminate *Cinnamomum* species in Sri Lanka. *PLoS ONE* 16(2): e0245592.
- Chang, C.-E. 1970 The Lauraceae of Taiwan (1). *Bull. Taiwan Prov. Pingtung Inst. Agric.* 11: 35–59.
- Chang, C.-E. 1975 Notes on the Lauraceae of Asia. *Sci. Developm.* 3(11): 64–69.
- Chang, C.-E. 1976 Lauraceae. In: Li, H.-L. *et al.* (eds.), *Flora of Taiwan* 2: 406–468. Epoch Publishing Co., Taipei, Taiwan.
- Chang, C.-J. 1988 The stout camphor tree. *Sinorama* 23(12): 44–47.
- Chang, S.-H., Chen, F.-H., Tsay, J.-Y., Wu, C.-C., Chang, C., Ho, C.-K. 1997 Somatic embryogenesis and plant regeneration from immature embryo cultures of *Cinnamomum kanehirae*. *Taiwan J. Forest Sci.* 30(3): 157–171.
- Chang, S.-H., Ho, C.-K., Tsay, J.-Y. 2002 *In vitro* culture of *Cinnamomum kanehirae* Hay. *Taiwan J. Forest Sci.* 17(4): 491–501.
- Chang, T.-T. 1992 Two new diseases on *Cinnamomum kanehirai* cuttings. *Bull. Taiwan Forest. Res. Inst. New Ser.* 7(3): 231–236.
- Chang, T.-T., Chern, L.-L. 1997 Anthranose and brown root rot of *Cinnamomum kanehirae*. *Taiwan J. Forest Sci.* 12(3): 373–378.
- Chaw, S.-M., Liu, Y.-C., Wu, Y.-W., Wang, H.-Y., Lin, C.-Y.I., Wu, C.-S., Ke, H.-M., Chang, L.-Y., Hsu, C.-Y., Yang, H.-T., Sudianto, E., Hsu, M.-H., Wu, K.-P., Wang, L.-N., Leebens-Mack, J.H., Tsai, I.J. 2019 Stout camphor tree genome fills gaps in understanding of flowering plant genome evolution. *Nat. Plants* 5(1): 63–73.
- Chen, Y.-C., Chang, C. 2009 Plant regeneration through somatic embryogenesis from young leaves of *Cinnamomum kanehirae* Hayata. *Taiwan J. Forest Sci.* 24(2): 117–125.
- Cheng, S.-S., Lin, C.-Y., Yang, C.-K., Chen, Y.-J., Chung, M.-J., Chang, S.-T. 2015 Chemical polymorphism and composition of leaf essential oils of *Cinnamomum kanehirae* using gas chromatography/mass spectrometry, cluster analysis, and principal component analysis. *J. Wood. Chem. Technol.* 35(3): 207–219.
- Chung, K.-F., van der Werff, H., Peng, C.-I. 2010 Observations on the floral morphology of *Sassafras randaiense* (Lauraceae). *Ann. Missouri Bot. Gard.* 97(1): 1–10.
- Chung, K.-F., Lin, T.-T., Tsai, Y.-S., Lin, S.-T., Peng, C.-I. 2011 Isolation and characterization of microsatellite loci in



- Sassafras randaiense* (Lauraceae). Amer. J. Bot. **98**(11): e326–e329.
- Chung, S.-W., Hsu, T.-C.** 2016 Illustrated Flora of Taiwan, Vol. 1. Owls Publishing Co., Taipei, Taiwan. 408 pp.
- Editorial Committee of the Red List of Taiwan Plants** 2017 The Red List of Vascular Plants of Taiwan, 2017. Endemic Species Research Institute, Forestry Bureau, Council of Agriculture, Executive Yuan and Taiwan Society of Plant Systematics, Nantou, Taiwan. 187 pp.
- Ely, C.V., Bordignon, S.A.D., Trevisan, R., Boldrini, I.I.** 2017 Implications of poor taxonomy in conservation. J. Nat. Conserv. **36**: 10–13.
- Fujita, Y.** 1952 *Cinnamomum camphora* Sieb. and its allied species. Their inter-relationship considered from the viewpoints of species characteristics, chemical constitutions, geographical distributions and evolution. Bot. Mag. (Tokyo) **65**(771–772): 245–250.
- Fujita, Y.** 1960 Classification of the plants viewed from the constituents of essential oils (I). *Cinnamomum micranthum* Hay. and *C. kanahirai* Hay. Acta Phytotax. Geobot. **18**(5–6): 178–179.
- Fujita, Y.** 1967 Classification and phylogeny of the genus *Cinnamomum* viewed from the constituents of essential oils. Bot. Mag. (Tokyo) **80**(948–949): 261–271.
- Gang, Z., Liu, B., Rohwer, J.G., Ferguson, D.K., Yang, Y.** 2021 Leaf epidermal micromorphology defining the clades in *Cinnamomum* (Lauraceae). PhytoKeys **182**: 125–148.
- Geethangili, M., Tzeng, Y.-M.** 2011 Review of pharmacological effects of *Antrodia camphorata* and its bioactive compounds. Evid.-Based. Compl. Alt. **2011**: e212641.
- Hayata, B.** 1913 Icones Plantarum Formosanarum, Vol. 3. Bureau of Productive Industries, Government of Formosa, Taihoku. 222 pp.
- Hayata, B.** 1915 Icones plantarum formosanarum, vol. 5. Bureau of Productive Industries, Government of Formosa, Taihoku. 358 pp.
- Hsieh, T.-J., Lu, L.-H., Su, C.-C.** 2005 NMR spectroscopic, mass spectroscopic, X-ray crystallographic, and theoretical studies of molecular mechanics of natural products: farformolide B and sesamin. Biophys. Chem. **114**(1): 13–20.
- Huang, J.-F., Li, L., Conran, J.G., Li, J.** 2016 Phylogenetic utility of LEAFY gene in *Cinnamomum* (Lauraceae): Gene duplication and polymerase chain reaction-mediated recombination. J. Syst. Evol. **54**(3): 238–249.
- Huang, S.-G., Ho, K.-Y., Wu, K.-W., Sen, Y.-C., Lieu, W.-Y.** 1997 Survey on the composition and structure of natural *Cinnamomum kanehirae* forests. Taiwan J. Forest Sci. **11**(4): 349–360.
- Hung, K.-H., Lin, C.-H., Ju, L.-P.** 2017 Tracking the geographical origin of timber by DNA fingerprinting: a study of the endangered species *Cinnamomum kanehirae* in Taiwan. Holzforschung **71**(11): 853–862.
- Ju, L.-P.** 2006 Study on the Population Genetic of *Cinnamomum kanehirae*, *Cinnamomum micranthum* and *Cinnamomum camphora* and Phylogeny among Their Related Species, Graduate Institute of Forestry Resource Conservation, National Taiwan University, Taipei, Taiwan.
- Ju, L.-P., Wang, Y.-N., Pan, F.-J., Yang, J.-C., Lu, S.-Y.** 2006 Molecular phylogeny of *Cinnamomum philippinense* based on chloroplast DNA sequences. Quart. J. Chin. Forest. **39**(2): 163–172.
- Kanehira, R.** 1917 Formosan Trees. Bureau of Productive Industries, Government of Formosa, Taihoku. 648 pp.
- Kanehira, R.** 1936. Formosan Trees Indigenous to the Island (revised). Department of Forestry, Government Research Institute, Formosa, Tokyo, Japan. 754 pp.
- Kao, Y.-P., Huang, S.-G.** 1993 Cutting propagation of *Cinnamomum kanehirae*. Bull. Taiwan Forest. Res. Inst. New Ser. **8**(4): 371–388.
- Kao, Y.-P., Huang, S.-G., Liu, I.-H.** 1997a Growth performance of 5-yr-old *Cinnamomum kanehirae* rooted cuttings after planting. Taiwan J. Forest Sci. **14**(1): 45–52.
- Kao, Y.-P., Liu, I.-H., Jeng, M.-R., Lin, P.-F., Tsai, J.-B.** 1997b Effects of planting spacing and clones on the production and quality of cuttings in a *Cinnamomum kanehirae* clonal orchard. Taiwan J. Forest Sci. **15**(2): 281–291.
- Katoh, K., Standley, D.M.** 2013 MAFFT Multiple Sequence Alignment Software Version 7: Improvements in performance and usability. Mol. Biol. Evol. **30**(4): 772–780.
- Kearse, M., Moir, R., Wilson, A., Stones-Havas, S., Cheung, M., Sturrock, S., Buxton, S., Cooper, A., Markowitz, S., Duran, C., Thierer, T., Ashton, B., Meintjes, P., Drummond, A.** 2012 Geneious Basic: An integrated and extendable desktop software platform for the organization and analysis of sequence data. Bioinformatics **28**(12): 1647–1649.
- Kostermans, A.J.G.H.** 1978 Lauraceae. In: Nasir, E. and S. I. Ali (eds.), Flora of West Pakistan, no. 118: 1–13. Botany Department, University of Karachi, Karachi, India.
- Kuo, D.-C., Lin, C.-C., Ho, K.-C., Cheng, Y.-P., Hwang, S.-Y., Lin, T.-P.** 2010 Two genetic divergence centers revealed by chloroplastic DNA variation in populations of *Cinnamomum kanehirae* Hay. Conserv. Genet. **11**(3): 803–812.
- Kuo, Y.-L., Chen, T.-J., Cheng, C.-T.** 2004 Growth and photosynthetic responses to light in rooted cuttings of *Cinnamomum kanehirae*. Taiwan J. Forest Sci. **19**(3): 215–224.
- Lee, I.-S., Kirschner, R., Chen, S.-T.** 2019 Medicinal mushroom *Taiwanofungus camphoratus*: A potential cure for cancer. Funct. Foods Health D. **9**(8): 508–520.
- Leu, Y.-L., Chung, Y.-M., Lai, J.-Y.** 2014 The chemical principles of the leaves of *Cinnamomum kanehirae* Hayata. Planta Med. **80**(16): 1451–1451.
- Li, H.-L.** 1963 Woody flora of Taiwan. Livingston Publishing Company, Narberth, U.S.A. 974 pp.
- Li, H.-W.** 1975 The relationship between plant classification and chemistry of essential oil in *Cinnamomum glanduliferum* (Wall.) Nees and its allies. Acta Phytotax. Sin. **13**(4): 36–50.
- Li, H.-W., Pai, P.-Y., Lee, S.-K., Wei, F.-N., Wei, Y.-T., Yang, Y.-C., Huang, P.-H., Tsui, H.-P., Shia, Z.-D., Li, J.-L.** 1982 Lauraceae. In: Li, H.-W. (ed.), Flora Reipublicae Popularis Sinicae **31**: 1–463. Science Press, Beijing, China.
- Li, X.-W., Li, J., van der Werff, H.** 2008 Lauraceae. In: Wu, Z.-Y. et al. (eds.), Flora of China **7**: 21–73. Science Press & Missouri Botanical Garden Press, Beijing, China & St. Louis, U.S.A.
- Liao, J.-C.** 1988 The taxonomic revisions of the family Lauraceae in Taiwan. Department of Forestry, National Taiwan University, Taipei, Taiwan. 185 pp.



- Liao, J.-C. 1995 The Taxonomic Revisions of the Family Lauraceae in Taiwan (ed II). Department of Forestry, National Taiwan University, Taipei, Taiwan. 186 pp.
- Liao, J.-C. 1996 Lauraceae. In: Huang, T.-C. *et al.* (eds.), Flora of Taiwan, 2nd ed. 2: 433–499. Editorial Committee, Dept. Bot., NTU, Taipei, Taiwan.
- Liao, P.-C., Kuo, D.-C., Lin, C.-C., Ho, K.-C., Lin, T.-P., Hwang, S.-Y. 2010 Historical spatial range expansion and a very recent bottleneck of *Cinnamomum kanehirae* Hay. (Lauraceae) in Taiwan inferred from nuclear genes. BMC Evol. Biol. **10**(1): e124.
- Lin, C.-T., Chung, K.-F. 2017 Phylogenetic classification of seed plants of Taiwan. Bot. Stud. **58**: e52.
- Lin, T.-P. 1993 *Cinnamomum kanehirae* Hay. and *Cinnamomum micranthum* (Hay.) Hay. Bull. Taiwan Forest. Res. Inst. New Ser. **8**(1): 11–20.
- Lin, T.-P., Cheng, Y.-P., Huang, S.-G. 1997 Allozyme variation in four geographic areas of *Cinnamomum kanehirae*. J. Hered. **88**(5): 433–438.
- Liu, T.-S. 1960 Illustrations of Native and Introduced Ligneous Plants of Taiwan, Vol. 1. College of Agriculture, National Taiwan University, Taipei, Taiwan. 702 pp.
- Liu, Y.-C., Ou, C.-H. 1969 Revision of the Taiwan species of *Cinnamomum* (Lauraceae). Quart. J. Chin. Forest. **2**(3): 1–11.
- Liu, Z.-F., Ma, H., Ci, X.-Q., Li, L., Song, Y., Liu, B., Li, H.-W., Wang, S.-L., Qu, X.-J., Hu, J.-L., Zhang, X.-Y., Conran, J.G., Twyford, A.D., Yang, J.-B., Hollingsworth, P.M., Li, J. 2021 Can plastid genome sequencing be used for species identification in Lauraceae? Bot. J. Linn. Soc. **197**(1): 1–14.
- Lu, M.-Y.J., Fan, W.-L., Wang, W.-F., Chen, T.-C., Tang, Y.-C., Chu, F.-H., Chang, T.-T., Wang, S.-Y., Li, M.-Y., Chen, Y.-H., Lin, Z.-S., Yang, K.-J., Chen, S.-M., Teng, Y.-C., Lin, Y.-L., Shaw, J.-F., Wang, T.-F., Li, W.-H. 2014 Genomic and transcriptomic analyses of the medicinal fungus *Antrodia cinnamomea* for its metabolite biosynthesis and sexual development. Proc. Natl. Acad. Sci. U.S.A. **111**(44): E4743–E4752.
- Mace, G.M. 2004 The role of taxonomy in species conservation. Phil. Trans. R. Soc. Lond. B **359**(1444): 711–719.
- Rohde, R., Rudolph, B., Ruthe, K., Lorea-Hernandez, F.G., de Moraes, P.L.R., Li, J., Rohwer, J.G. 2017 Neither *Phoebe* nor *Cinnamomum* – the tetrasporangiate species of *Aiouea* (Lauraceae). Taxon **66**(5): 1085–1111.
- Rohwer, J.G., Trofimov, D., Mayland-Quellhorst, E., Albach, D. 2019 Incongruence of morphological determinations and DNA barcode sequences: a case study in *Cinnamomum* (Lauraceae). Willdenowia **49**(3): 383–400.
- Song, Y., Yu, W.-B., Tan, Y.-H., Jin, J.-J., Wang, B., Yang, J.-B., Liu, B., Corlett, R.T. 2020 Plastid phylogenomics improve phylogenetic resolution in the Lauraceae. J. Syst. Evol. **58**(4): 423–439.
- Stafleu, F.A., Voss, E.G. 1975 Synopsis of proposals on botanical nomenclature Leningrad 1975. Taxon **24**(1): 201–251.
- Stamatakis, A. 2014 RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies. Bioinformatics **30**(9): 1312–1313.
- Stanton, D.W.G., Frandsen, P., Waples, R.K., Heller, R., Russo, I.R.M., Orozco-terWengel, P.A., Pedersen, C.E.T., Siegmund, H.R., Bruford, M.W. 2019 More grist for the mill? Species delimitation in the genomic era and its implications for conservation. Conserv. Genet. **20**(1): 101–113.
- Trofimov, D., Rohwer, J.G. 2020 Towards a phylogenetic classification of the *Ocotea* complex (Lauraceae): an analysis with emphasis on the Old World taxa and description of the new genus *Kulooa*. Bot. J. Linn. Soc. **192**(3): 510–535.
- Tsai, C.-C., Hung, L.-F., Chung, J.-D., Kao, W.-Y., Kuo-Huang, L.-L. 2020 Regulation of tree crown phenology and fruit set of *Cinnamomum kanehirae* Hayata, an endangered evergreen tree in Taiwan. Taiwania **65**(1): 15–26.
- Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J., Smith, G.F. (eds.), 2018 International Code of Nomenclature for Algae, Fungi, and Plants (Shenzhen Code) Adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Koeltz Botanical Books, Glashütten, German. 254 pp.
- Uka, S. 1927 Report on the Survey of Taiwan Camphor Trees (In Japanese). Monopoly Bureau, Formosan Government, Taipei, Taiwan. 365 pp.
- Wu, C.-C., Ho, C.-K., Chang, S.-H. 2016 The complete chloroplast genome of *Cinnamomum kanehirae* Hayata (Lauraceae). Mitochondrial DNA A **27**(4): 2681–2682.
- Wu, C.-C., Chu, F.-H., Ho, C.-K., Sung, C.-H., Chang, S.-H. 2017 Comparative analysis of the complete chloroplast genomic sequence and chemical components of *Cinnamomum micranthum* and *Cinnamomum kanehirae*. Holzforschung **71**(3): 189–197.
- Wu, C.-C., Chang, S.-H., Tung, C.-W., Ho, C.-K., Gogorcena, Y., Chu, F.-H. 2020 Identification of hybridization and introgression between *Cinnamomum kanehirae* Hayata and *C. camphora* (L.) Presl using genotyping-by-sequencing. Sci. Rep. **10**(1): e15995.
- Wu, S.-H., Yu, Z.-H., Dai, Y.-C., Chen, C.-T., Su, C.-H., Chen, L.-C., Hsu, W.-C., Hwang, G.-Y. 2004 *Taiwanofungus*, a polypore new genus. Fung. Sci. **19**(3–4): 109–116.
- Wu, S.-H., Kirk, P.M., Redhead, S.A., Stalpers, J.A., Dai, Y.-C., Norvell, L.L., Yang, Z.-L., Ryvarden, L., Su, C.-H., Li, Y., Zhuang, W.-Y., Yao, Y.-J., Chen, C.-J., Chen, L.-C., Yu, Z.-H., Wang, X.-C. 2012 Resolution of the nomenclature for niu-chang-chih (*Taiwanofungus camphoratus*), an important medicinal polypore. Taxon **61**(6): 1305–1310.
- Yang, Y.-P., Liu, H.-Y., Lu, S.-Y. (eds.), 1997 Manual of Taiwan Vascular Plants, Vol. 2. The Council of Agriculture, The Executive Yuan, Taipei, Taiwan. 352 pp.
- Yang, Z., Liu, B., Yang, Y., Ferguson, D.K. 2022 Phylogeny and taxonomy of *Cinnamomum* (Lauraceae). Ecol. Evol. **12**(10): e9378.
- Yeh, E.-J. 2018 Formation of imperial Japanese tropical flora knowledge: the Kanehira Ryozo and Elmer Drew Merrill network. J. Geogr. Res. **68**: 115–132.