

# A taxonomic revision of the small mangrove genus *Campstostemon* (*Malvaceae*)

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**Abstract.** The true mangrove genus *Campstostemon* (*Malvaceae*) is becoming increasingly rare. This genus can be found in the Philippines, Borneo, Sulawesi, Maluku, Papua New Guinea, and Australia. Confusion remains over the taxonomic status of *Campstostemon aruensis*, endemic to Aru Islands, Indonesia. Therefore, a taxonomic revision is presented. Morphological characteristics, distribution maps, an identification key, and photographs of the species are provided. Based on type and type-locality specimens from the Aru Islands, *C. aruensis* is found to morphologically match *C. schultzii*. *Campstostemon aruensis* is a synonym of *C. schultzii*. Therefore, *Campstostemon* consists of two species, *C. philippinensis* (from the Philippines, Borneo, and Sulawesi), and *C. schultzii* (from Maluku, Indonesian Papua, Papua New Guinea, and northern Australia). *Campstostemon philippinensis* and *C. schultzii* are found in different geographic areas and do not share the same island.

**Key words:** Aru Islands, Australia, *Campstostemon aruensis*, Malesia, synonymy

## Introduction

The genus *Campstostemon* Mast. (*Malvaceae*) belongs to true mangrove species that are becoming increasingly rare. *Campstostemon* is distributed in the Philippines, Borneo, Sulawesi, Maluku, Papua New Guinea, and Australia. *Campstostemon* is easily recognized from its trees- or shrubs-like habit, roots spreading horizontally

along the surface of the soil, and it may bear knobbly pneumatophores, elliptic to obovate leaves, flowers with cup-shaped epicalyx, a bell-shaped or campanulate calyx, petals imbricate with white color, 5–20 stamens, fused into a tube at the base, a sessile ovary, a fruit capsule with densely woolly seeds, and leaves, flowers and fruits usually covered by densely spread scales.

*Campstostemon* is derived from the Greek *kamptos* (curved) and *stemon* (stamen), referring to the stamens, which are curved in shape (Hamilton-Brown 2016). *Campstostemon* was first described by Maxwell Tylden Masters, a British botanist (1833–1907) (Britten 1907), in 1872 (Hooker 1876; Troll 1933). The type species of *Campstostemon* is *C. schultzii* Mast. (Hooker 1876), based on *Schultz 511*, collected from Port Darwin, northern Australia (Troll 1933; JSTOR 2022) and stored in K (Herbweb 2022a; JSTOR 2022).

Subsequently, in 1885, Sebastian Vidal published *Cumingia* S.Vidal, in ‘*Phanerogamae Cumingianae Philippinarum*’ with the only species being *Cumingia philippinensis* S.Vidal and claimed that *Cumingia* is very similar to *Campstostemon* (Troll 1933). Based on the close relationship between *Campstostemon* and *Cumingia*, Beccari (1886–1890), then concluded that *Cumingia* should be abandoned and *Cumingia philippinensis* was transferred to *Campstostemon philippinensis* (S.Vidal) Becc. Additionally, Beccari (1886–1890) published the third *Campstostemon* species collected from the Aru Islands, Maluku, Indonesia as *C. aruensis* Becc. Therefore, there were

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three species of *Campstostemon sensu* Beccari, namely *C. aruensis* which is endemic to the Aru Islands, Indonesia, *C. philippinensis* from the Philippines, Sulawesi, and Borneo, and *C. schultzii* from Australia and Papua New Guinea (Beccari 1886–1890).

Reinier Cornelis Bakhuizen van den Brink stated that *C. aruensis* was a synonym of *C. schultzii* without leaving any notes on his publication (Bakhuizen v. d. Brink 1924). Therefore, only *C. philippinensis* and *C. schultzii* were accepted as *Campstostemon sensu* Reinier Cornelis Bakhuizen van den Brink (Woodroffe & Grindrod 1991; Giesen et al. 2007). According to POWO (2022), there are three accepted species of *Campstostemon*, namely *C. aruensis*, *C. philippinensis*, and *C. schultzii* based on the publication of R. Govaerts in 1999: ‘World Checklist of Seed Plants 3(1, 2a and 2b)’, in line with ALA (2022), COL (2022), Dahdouh-Guebas (2022), EOL (2022), GBIF (2022a), iNaturalist (2022a), Mindat (2022), Tropicos (2022), WFO (2022), and WP (2022).

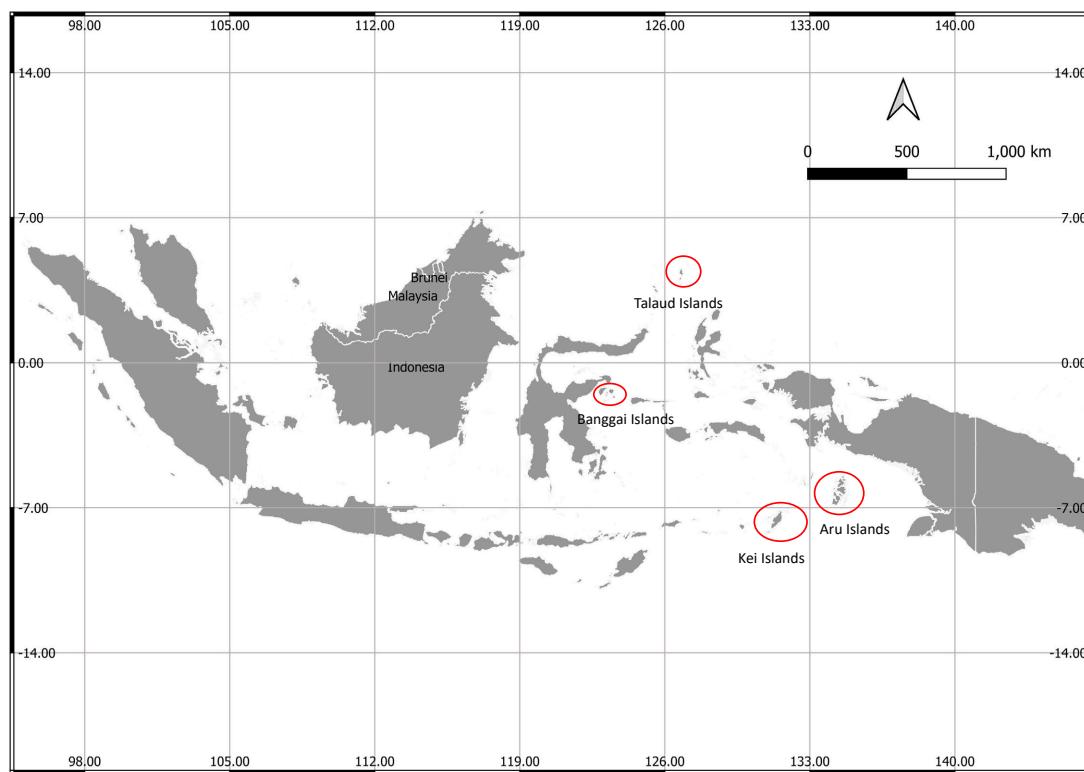
Based on BO specimens, *C. philippinensis* and *C. schultzii* are obviously distinguished. *Campstostemon philippinensis* has an obovate leaf shape and five stamens, while *C. schultzii* has an elliptic leaf shape and 20 stamens. However, *C. aruensis* is very similar to *C. schultzii* and it is hard to distinguish them from one another. During the flora exploration in several *Campstostemon*’s distribution areas in Indonesia, such as in Talaud and the Banggai Islands in Sulawesi, the Aru and Tual Islands in Maluku, including the type-locality of *C. aruensis* on the Maikor Island, the Aru Islands, better herbarium specimens were collected. A taxonomic revision, therefore, was made. Morphological characteristics, distribution maps, an identification key, and photographs of the species were provided.

## Materials and methods

The distribution of *Campstostemon* in Indonesia was investigated by carrying out flora explorations in different regions, including in the Talaud Islands of North Sulawesi in 2016, the Banggai Islands of Central Sulawesi in 2019, the Kei Islands of Maluku in 2021, and the Aru Islands of Maluku in 2022 (Fig. 1). The method of *Campstostemon* collection prescribed by Rugayah et al. (2004) and the processing of herbarium specimens by Djarwaningsih et al. (2002) was followed. Supporting data were recorded and photographs of the fresh specimens were taken. All specimens were stored in BO.

Original descriptions (Hooker 1876; Beccari 1886–1890; Troll 1933) from holotypes of related species were consulted and compared. A comprehensive study was conducted by examining all specimens of related species directly in BO, scanned images of herbarium specimens from K and L, as well as online portals including Australasian Virtual Herbarium or AVH, e-ReColNat, Global Biodiversity Information Facility or GBIF, Integrated Digitized Biocollections or iDigBio, JSTOR, and MNHN Vascular Plant (P) (Damayanto & Irsyam 2022). Furthermore, an identification key and descriptions of the species including the photographs were provided. Distribution maps were produced by the Quantum GIS software. Herbaria abbreviations followed the guidelines by Thiers (2023).

Scales of leaves were observed with a scanning electron microscope (SEM) in the Zoology Characterization Laboratory, National Research and Innovation Agency through E- Layanan Sains for SEM. A sample of abaxial leaves ( $1 \times 1$  cm) was mounted on a stub using carbon tape and coated with gold using a coater model IB-2 (Giko



**Figure 1.** The locations of fieldwork in several areas of Indonesia.

Engineering, Japan). The samples were observed in Jeol JSM-IT200 SEM at  $\times 300$  magnifications.

### Taxonomy treatments

***Campstostemon*** Mast., Hooker's Icon. Pl. 12: 18. 1872; Phan. Cuming. Philipp.: 211. 1885.

Type species: *Campstostemon schultzii* Mast.

Generic synonym: *Cumingia* S.Vidal, Phan. Cuming. Philipp.: 211. 1885. Type species: *Cumingia philippinensis* S.Vidal.

**Description.** Trees or shrubs. Roots spread horizontally along the surface of the soil and may bear knobbly pneumatophores. Leaves obovate to elliptic. Part of leaves, flowers, and fruits usually covered by densely spread scales. Flowers cluster up to 7 (or 8)-flowered, umbel; cup-shaped epicalyx; calyx campanulate; petals 5 lobes, imbricate, white; stamens 5–20, fused into a tube at the base; ovary sessile. Fruits capsule, dehiscent, contains densely woolly seeds.

**Habitat and ecology.** *Campstostemon* is only found in mangrove habitats (a true mangrove) (Giesen et al. 2007; Azizah 2021) in open rocky shores, on sandy beaches within the tidal range, inner edges of the mangrove forest, often reaching the margins and bordering the tidal streams (Giesen et al. 2007), tidal-stream edge (Djamaluddin 2018a), low intertidal region along tidal creeks (Middeljans 2014), and rarely in estuarine mangroves. *Loranthaceae* species, *Amyema mackayensis* (Blakely) Danser was reported to become a parasite on *Campstostemon* (Giesen et al. 2007).

**Distribution.** Can be found in the Philippines, Borneo, Sulawesi, on the Maluku Islands, Indonesian Papua, Papua New Guinea, and northern Australia (Troll 1933; Saenger 1998; Giesen et al. 2007; Herison & Romdania 2020).

**Uses.** Potentially used as firewood (Numbere 2020), poles of rafts (Baishya et al. 2020), pulp for paper production (Herison & Romdania 2020), home interior materials, household utensils (Giesen et al. 2007), carvings, and inlays (Noor et al. 2006).

**Notes.** Flowers appear from April to October. It is probably pollinated by wind or insects (Giesen et al. 2007). Seed is probably dispersed by wind and/or water. As is typical for *Malvaceae*, it has dense woolly seeds.

### Key to the *Campstostemon* species

1 Leaves obovate, both surfaces covered by scales and constantly persistent with age; flowers with only 5 stamens ..... *C. philippinensis*

Leaves broadly to narrowly elliptic, abaxial surface covered by scales, adaxial surface glabrous or sometimes covered by scattered scales becoming glabrous when mature; flowers with 20 stamens ..... *C. schultzii*

### Species descriptions

***Campstostemon philippinensis*** (Vidal) Becc., Malesia 3: 273. 1889. (Figs 2–3)

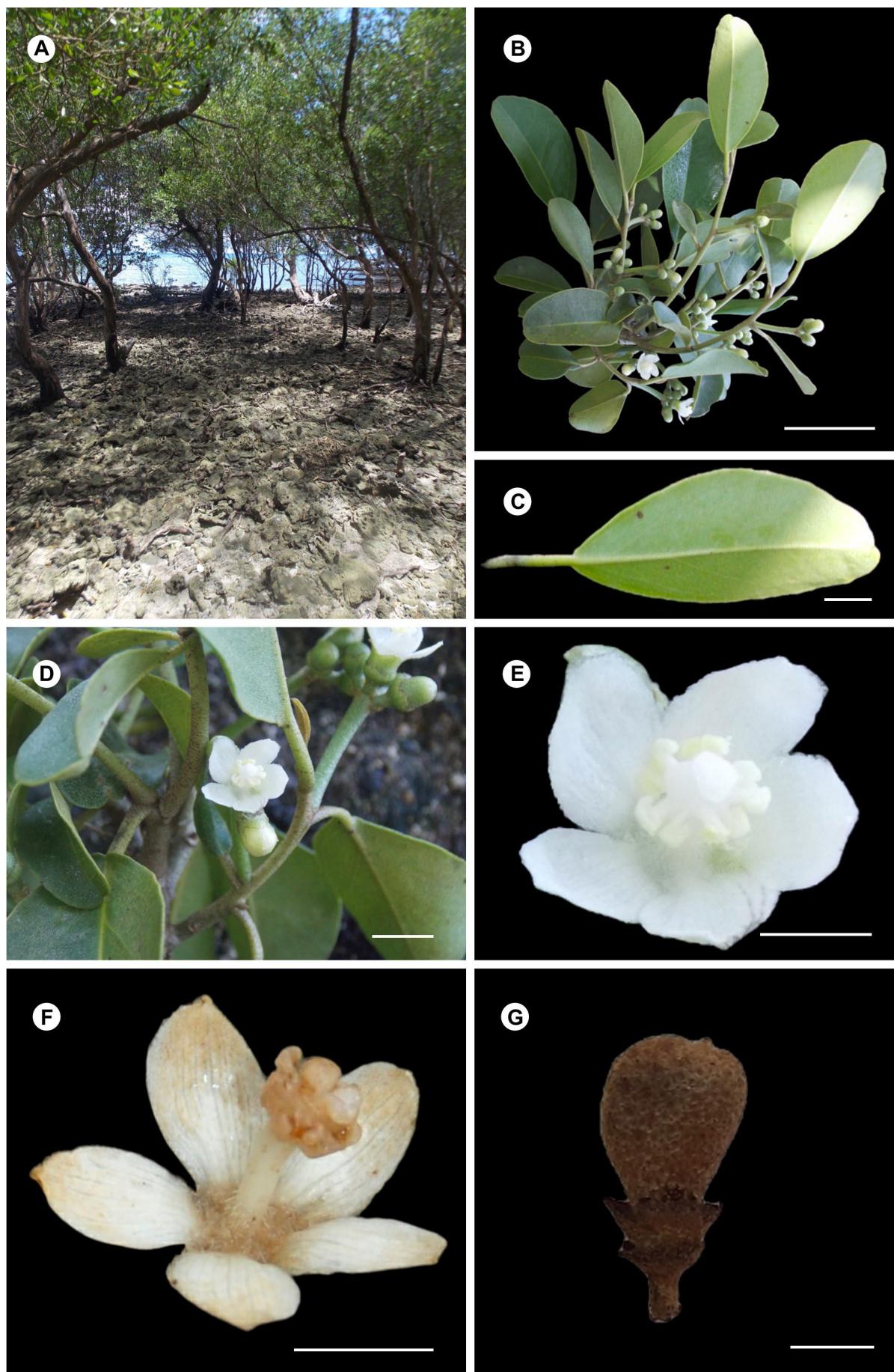
Basionym: *Cumingia philippinensis* S.Vidal, Phan. Cuming. Philipp.: 212–214, f. 1–17. 1885.

Type: the Philippines, Unisan, Pr. Tayabas, *S. Vidal* 1170 (K – syntype!, code K000671531, K000671532) (Fig 4) and 653 (MA – syntype!, code MA729045; L – syntype!, code L0012876).

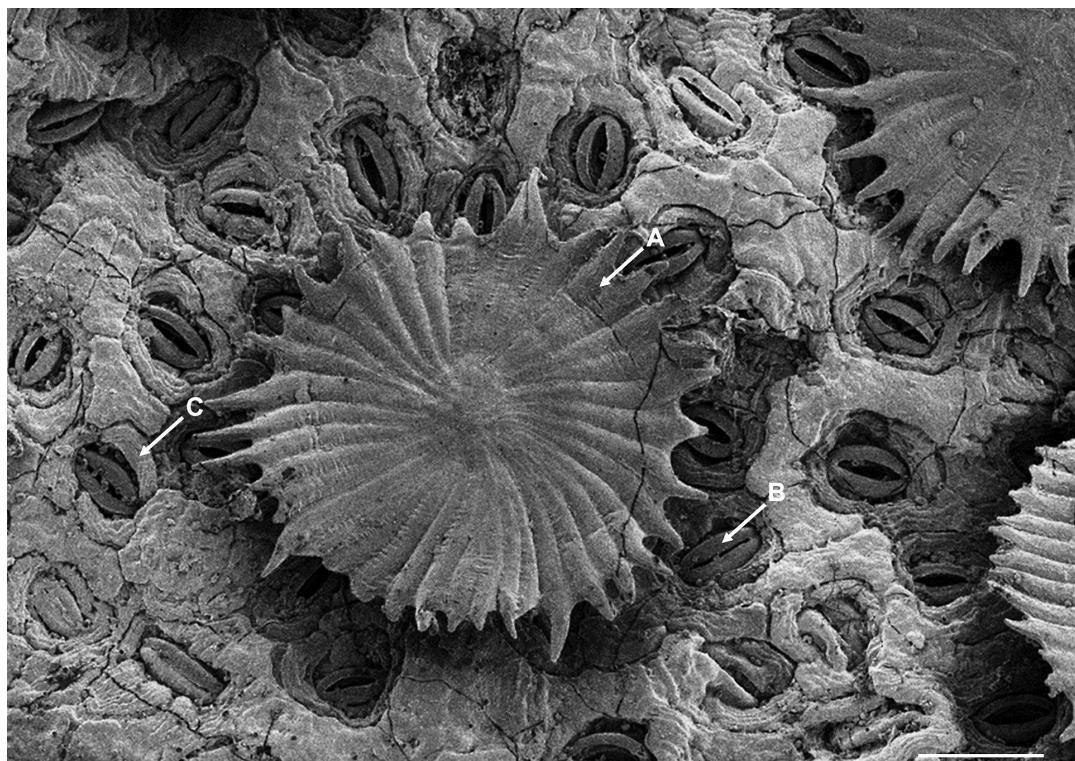
**Description.** Evergreen tree or shrub up to 30 m high. Soft-wooded, a grey to bright brown bark with circular lenticels, inner bark pinkish or pale straw-colored, heartwood white. Roots spread along the soil surface and bear knobbly pneumatophores, lenticellate. Leaves simple, verticillate, exstipulate, obovate (sometimes spatulate), 3–11.5  $\times$  2–6 cm, thick; apex obtuse to retuse, base acute, margin entire; adaxial surfaces shiny green with scattered scale, abaxial surfaces pale green with scattered scales, scales persistent with age, scales peltate up to 200  $\mu\text{m}$  diameter; petiole 1–3.5 cm long, semi-terete to slightly canaliculate, covered by scales. Inflorescences borne in upper axils; peduncle 0.5–3 cm, unbranched, covered by densely spread scales; umbel up to 7(–8) flowers; in all about 1.5–3 cm long at anthesis. Flowers up to 10 mm long; pedicle up to 3 mm long, covered by scales; cup-shaped epicalyx, 2–5 lobes, up to 2 mm long, covered by scales; calyx campanulate, 2–3 mm long, outer surface covered by scales; petal 5 lobes, 3–5  $\times$  2–4 mm, white, apex rounded, outer surface covered by scales; stamens 5, fused into a tube, positioned higher than corolla mouth, anthers bilobed; stigma bilobed; ovary conical-shaped and sessile. Fruit capsule with persistent calyx and epicalyx, pear-shaped, 1–1.5 cm long, bilocular, dehiscent with a septum in the middle, apex rounded, outer surface covered by scales, seeds densely woolly.

**Habitat and ecology.** *Campstostemon philippinensis* occurs in mangrove habitats only and frequently encountered in the inner edges of the mangrove forest, often reaching the margins, and bordering the tidal streams (Giesen et al. 2007) and in the low intertidal region along tidal creeks (Primavera 2009). In Sulawesi, *C. philippinensis* was found in the habitat tidal-stream edge (Djamaluddin 2018a). On the Talaud Islands, Sulawesi, *C. philippinensis* grows facing directly to the open sea, in tidal edge areas covered by the dead coral formation and it was associated with *Sonneratia alba* Sm. (*Lythraceae*). In Borneo, *C. philippinensis* was found near the estuary. *Campstostemon philippinensis* was reportedly one of the mangrove species that had the lowest relative dominance, relative density, relative frequency, and importance values (Middeljans 2014).

**Distribution.** *Campstostemon philippinensis* is distributed in the Philippines (Saenger 1998; Giesen et al. 2007; Duke et al. 2010a; Herison & Romdania 2020; Pratiwi & Juerges 2020), particularly in Luzon (Quezon), Palawan, Masbate, Negros, Bohol, Mindanao (Zamboanga), Basilan (Fernando & Pancho 1980; Pototan et al. 2021), Panay (Leano



**Figure 2.** *Campstostemon philippinensis*. A – habit in rocky areas; B – leafy branches; C – abaxial leaf; D – inflorescences; E – flower from above; F – flower showing stamens united in a column; G – fruit covered with densely scales. Scales: B = 5 cm; C, D = 1 cm; E–G = 5 mm. Photos: K. Rahmawati (A–E), A. Hamas (F) (GBIF 2022b, iNaturalist 2022b) and I. P. G. P. Damayanto (G).



**Figure 3.** The scale of *Campstostemon philippinensis* leaves was observed with SEM at  $\times 300$  magnifications. A – scale with peltate hair type; B – guard cell of stoma; C – epidermal cell. Scales: 50  $\mu\text{m}$ . Photos: specimen of K. Rahmawati Beo55 (BO) from Talaud Islands, Sulawesi.

2001), Davao Oriental (Pototan et al. 2021), Agusan del Norte (Sarmiento 2020), Capiz, Mabon, and Olongo. In Indonesia, *C. philippinensis* is found in Sulawesi and Borneo (Troll 1933; Saenger 1998; Fernando & Pancho 1980; Giesen et al. 2007; Duke et al. 2010a; Herison & Romdania 2020). In Borneo, *C. philippinensis* can be found in the province of East Kalimantan [Berau (Mukhlisi & Sidiyasa 2014) and Teluk Balikpapan], the province of South Kalimantan (Laut Island), and Malaysia (Sandakan). In Sulawesi, particularly, *C. philippinensis* can be found in the province of North Sulawesi [the Mantehage Island (Djamaluddin 2018a) and the Talaud islands], the province of Gorontalo (Moluo), the province of Central Sulawesi (Donggala) (Wahyuningsih et al. 2012), the province of South Sulawesi (Malili, Lampia), and the province of Southeast Sulawesi (Kabaena Island). The exploration did not find *C. philippinensis* on the Banggai Islands even though intensive mangrove exploration had been carried out in the area (Fig 5).

**Uses.** The wood of *C. philippinensis* is moderately soft but fairly strong. *Campstostemon philippinensis* yields a medium-weight hardwood with a density of 470–635 kg/m<sup>3</sup> at 15% moisture content (Boer & Sosef 1998). It can be used for interior work, pulp and paper production, household utensils, carvings, inlays (Giesen et al. 2007), charcoal (Pototan et al. 2021), fuelwood, construction materials, and other household goods (Duke et al. 2010a).

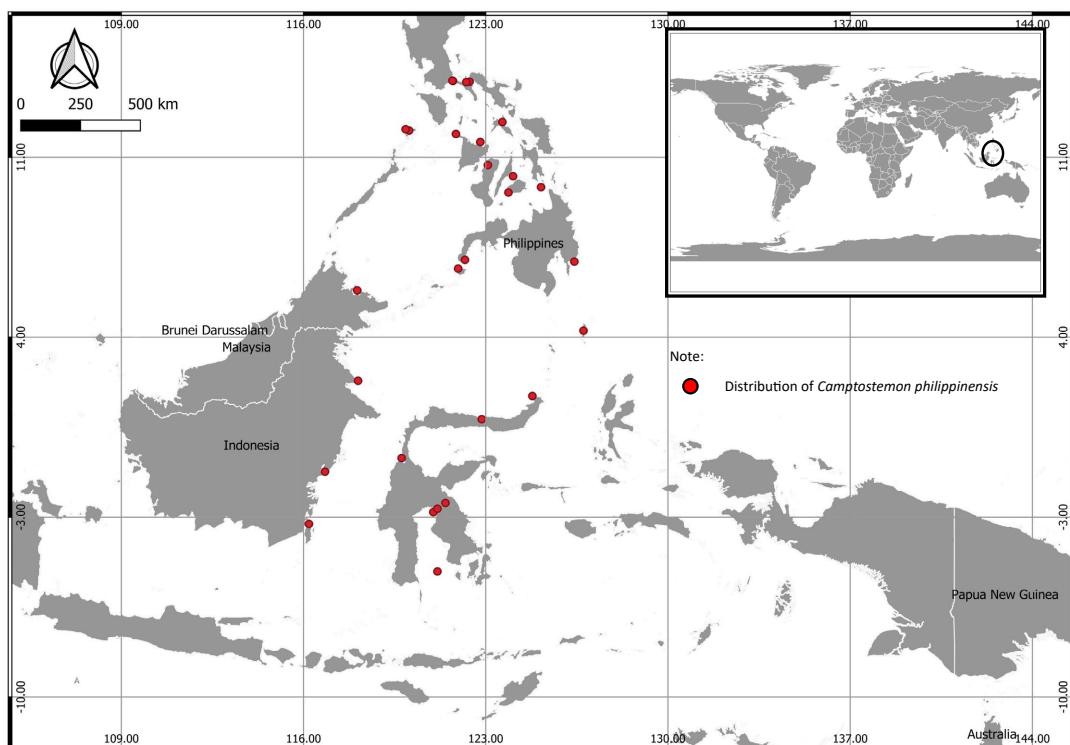
**Vernacular names.** In the Philippines, *C. philippinensis* is known as *baluno*, *dandulit*, *lapa-lapa*, *nigi-puti* (Giesen et al. 2007), *libatong-puti*, *buñgalon* (Boer & Sosef 1998), and *gapas-gapas* (Fernando & Pancho 1980; Primavera

2009; Pototan et al. 2021). In Malaysia, *C. philippinensis* is known as *gapas-gapas* (Ahmad et al. 2018). In Indonesia, *C. philippinensis* is known as *kayu baluno filipina* (Indonesia) (KLHKRI 2018), *kayu pelompong* (North Sulawesi) (Djamaluddin 2018a), *gapas-gapas* (northern part of Sulawesi) (Djamaluddin 2018b), *kapa-kapa* (Central Sulawesi), and *kapas-kapas* (South Kalimantan).

**Conservation status.** The population trend of *C. philippinensis* was reported to be decreasing with only 1,200 mature individuals in 2008 (Duke et al. 2010a). In some areas of the research station, *C. philippinensis* no more than 10 mature plants were found. On the Talaud Islands, Sulawesi, especially, *C. philippinensis* was only found in one spot, namely Makatara Utara, which formed even-aged stands where seedlings were rare. Pollution, habitat shifting and alteration due to climate change, habitat destruction, removal of mangrove areas for aquaculture and settlements, industrial, and tourism areas, were reported to be a threat to *C. philippinensis* (Duke et al. 2010a). *Campstostemon philippinensis*, therefore, is reported as an endangered species according to the IUCN red list of threatened species (Duke et al. 2010a). In Indonesia, *C. philippinensis* is included in the list of protected plants according to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia number P.106/MENLHK/SETJEN/KUM.1/12/2018 (KLHKRI 2018). Recently, Pratiwi and Juerges (2020) reported *C. philippinensis* to be threatened due to renewable energy development on hydropower and wind power in Southeast Asia. The population of this mangrove species is generally decreasing due to anthropogenic threats mainly due to mangrove forest conversion for aquaculture



Figure 4. Syntype of *Camptostemon philippinensis* (Herbweb 2022b).



**Figure 5.** Distribution of *Campstostemon philippinensis*.

and cutting for charcoal and wood (Pototan et al. 2021). Furthermore, slow propagation rates of *C. philippinensis* threaten their long-term survival (Spalding & Leal 2021).

**Notes.** Duke et al. (2010a) noted that the name of *C. philippinensis* is spelt two different ways. *Camptostemon philippinensis* was listed in several references as *C. philippinensis* or *C. philippinense* inconsistently. As mentioned above, Beccari (1886–1890) made a combination name *Camptostemon philippinensis* from basionym *Cumingia philippinensis*. However, Beccari (1886–1890) wrote *Camptostemon philippinense*, instead of *Camptostemon philippinensis*. Based on the International Code of Nomenclature for Algae, Fungi, and Plants (Shenzhen Code) by Turland et al. (2018), *Camptostemon* is a masculine word (Chapter VIII, section 2, article 62.2.a). Therefore, the correct spelling of this species is *C. philippinensis* due to a masculine genus with geographic epithet should be terminated by ‘-ensis’ (Manara 1991; Smith 2017) although Beccari (1886–1890) treated it as ‘*philippinense*’ on his protologue.

*Camptostemon philippinensis* was known to flower and fruit from May to August. *Schizochytrium mangrovei* Raghu-Kumar (a straminipilous organism) was reportedly found on fallen senescent leaves of *C. philippinensis* (Leano 2001). The generation length of *C. philippinensis* is 40 years (Duke et al. 2010b).

**Specimens examined.** PHILIPPINES. Basilan, Nov. 1912, D. P. Miranda 17887 (L; P; US); Bohol, Cabasinan, Jun.–Aug. 1918, F. Franco 27341 (P); Capiz Province, Jun. 1916, J. D. Sandique 25824 (BO); Quezon, Tagkawayan, Katimo, 03 Jun. 1965, D. R. Mendoza 97724 (L); Luzon Island, Province of Tayabas, Apr. 1908, H. M. Burraw 10328 (BO); Luzon Island, Province of Tayabas, Apr. 1913, L. Escritor 1584 (BM; BO; L; P); Luzon, Tayabas Prov., Apr. 1908, H. M. Curran 10328 (LY; US);

Luzon, Tayabas, Unisan, Jan. 1884, S. Vidal 653 (L; MA); Luzon, Tayabas, Unisan, Jan. 1884, S. Vidal 1170 (K); Maboa Island, Mar. 1919, S. Reyes 27440 (US); Masbate, Mar. 1913, A. De Mesa & D. Domingo 17998 (US); Mindanao Islands, District of Zamboanga, May–Jun. 1912, Foxworthy, Demesa & Villamil 18762 (BO; L); Negros, Jun. 1910, H. M. Curran 19382 (L; P; US); Olango Island, province of Cebu, Lapulapu City, Babag, Sitio Poo, Brgy. Sta. Rosa, 21 Mar. 1993, D. A. Madulid et al. 7672 (L); province of Palawan, Busuanga, Coron, May 1950, M. D. Sulit 12277 (BM; L; US); Palawan, Feb. 1906, H. M. Curran 3865 (US). INDONESIA. Sulawesi, province of North Sulawesi, Talaud Islands, Beo, Makatara Utara, 30 Apr. 2016, K. Rahmawati Beo55 (BO); Sulawesi, [province of Gorontalo], Manado, Gorontalo, Moloco [Moluo], 13 Aug. 1930, M. Laleno 13 (bb. 14.450) (BO; L); Sulawesi, [the province of Central Sulawesi], Manado, Donggala, Abo, 17 Aug. 1931, J. Pesik 66 (bb:15.575) (BO); Sulawesi, [the province of Central Sulawesi], Manado, Donggala, Tolongan [Tolongan], 15 May 1932, F. Ch. J. Bish 6 (BB.16713) (BO; L); Sulawesi, [the province of South Sulawesi], Lampea [Lampia], 03 Oct. 1929, G. Kjellberg 2409 (BO); Sulawesi, [the province of South Sulawesi], Malili, Kampung Lampia, 22 Feb. 1935, van Z. de Jong 31 E22 (bb: 19.520) (BO); Sulawesi, [the province of South Sulawesi], Malili, Waroe-waroe [Waru-waru], 08 Aug. 1929, G. Kjellberg 2066 (BO); Sulawesi, Southeast of Sulawesi [the province of Southeast Sulawesi], Poeloe Kabaena [Kabaena Island], Jun. 1921, W. A. P. de Boer BB.3627 (BO); Borneo, East Kalimantan, Teluk Balikpapan, 30 Jul. 2022, T. Atmoko, Mukhlisi, I. Prihatini & R. Chasani s.n. (BO); Borneo, [the province of South Kalimantan], Poeloe Laoet [Laut Island], Sei Tajib [Tajib River], 15 Aug. 1919, C. Delmaar & Opz. Boschwezen 1973 (BO; L; P); Borneo, [the province of South Kalimantan], Poeloe Laoet [Laut Island], Sei Tajib [Tajib River], 20 Jun. 1919, Opz. Boschwezen 1973 (BO; L). MALAYSIA. Borneo, District Sandakan, near Kg. Bahagia Batu Sapi, 09 May 1996, N. Yusop & Clement M. 140722 (L); British North Borneo [Malaysian Borneo], Jan.–Mar. 1916, F. W. Foxworthy 616 (L).

***Campstemon schultzii*** Mast., Hooker's Icon. Pl. 12: 18, t. 1119. 1872. (Figs 6–8)

Type: Australia, northern territory Port Darwin, Schultz 511 (K – holotype!, code K000671530) (Fig. 9).

Synonyms: *Campstemon aruensis* Becc. Malesia 3: 274. 1889. Type: Maluku Islands, Aru Islands, Maikor, O. Beccari s.n. (FI – holotype!, code FI007729) (Fig. 10).

**Description.** Evergreen tree or shrub up to 33 m high, diameter 35 cm. Soft-wooded, a grey to brown bark with circular lenticels, inner bark pinkish or pale straw-colored, heartwood white. Roots spread along the soil surface and bear knobbly pneumatophores, lenticellate. Leaves simple, verticillate, exstipulate, elliptic (broadly elliptic in Maluku and Indonesian Papua specimens and narrowly elliptic in most specimens of Australia and Papua New Guinea), 4.5–14 × 2–6.4 cm, thick; apex obtuse, retuse to acute (obtuse to retuse in Maluku and Indonesian Papua specimens and acute in most specimens of Australia and Papua New Guinea), base cuneate to rounded, entire margin; adaxial surfaces shiny green and glabrous or sometimes with scattered scale but easily fall, abaxial surfaces pale green with densely spread scales, scales peltate up to 200 µm diameter; petiole 1–4.5 cm long, semi-terete to slightly canaliculate, covered by scales. Inflorescences borne in upper axils; peduncle 0.4–1.5 cm, unbranched, covered by densely spread scales; umbel up to 6 flowers; in all about 1.5–1.8 cm long at anthesis. Flowers up to 10 mm long; pedicel up to 5 mm long, covered by scales; cup-shaped epicalyx, 2–5 lobes, up to 5 mm long, covered by scales; calyx campanulate, 3–4 mm long, outer surface covered by scales; petal 5 lobes, 4–5.5 × 3–4 mm, white, apex rounded, outer surface covered by scales; stamens 20, fused into a tube with scattered hairs, positioned higher than corolla mouth, anthers bilobed; stigma bilobed; ovary conical-shaped. Fruit capsule with persistent calyx and epicalyx, pear-shaped, 1–2 cm long, bilocular, dehiscent with a septum in the middle, outer surface covered by scales, seeds densely woolly.

**Habitat and ecology.** *Campstemon schultzii* appear in mangrove habitats only (Giesen et al. 2007; Herison & Romdania 2020) and can be found in mid to low intertidal areas and along seashores (Duke et al. 2010b), sandy beaches within the tidal range, open rocky shores (Giesen et al. 2007), intermediate to downstream estuarine zone in the low to the mid-intertidal region (Duke et al. 2010b), as well as in beachfront communities and lowland forest at an altitude of 0–30 m. On the Aru Islands, *C. schultzii* was found in sandy soil area, sandy-rocky area, near the rivers with water salinity of 0–10 ppm, with total dissolved solids (TDS) 575–3610 ppm, water temperature 28–30°C and air temperature about 31–33°C. It was associated with some other true mangrove species i.e., *Aegiceras corniculatum* (L.) Blanco (*Primulaceae*), *Bruguiera gymnorhiza* (L.) Lam. ex Savigny (*Rhizophoraceae*), *Ceriops tagal* (Perr.) C.B.Rob. (*Rhizophoraceae*), and *Xylocarpus moluccensis* (Lam.) M.Roem. (*Meliaceae*).

**Distribution.** *Campstemon schultzii* is locally common in northern Australia (Mueller 1889) (from Cape Bossut

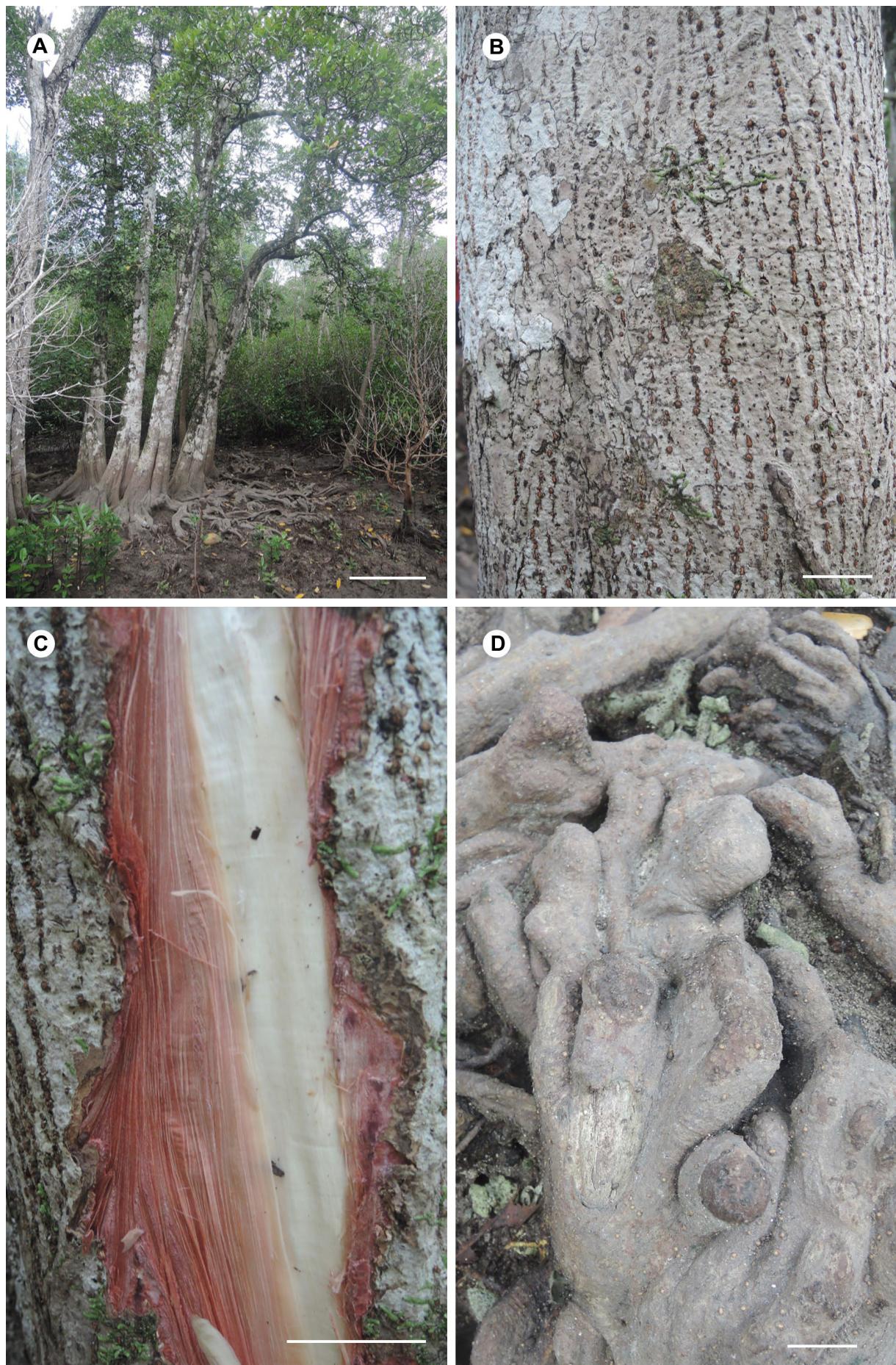
to Gove in the northern territory, Joseph Bonaparte Gulf region, and the north coast of Melville Island) and southern Papua New Guinea (Duke et al. 2010b), such as in the Gulf Province and the Western Province. *Campstemon schultzii* also appears in Indonesia (Giesen et al. 2007; Duke et al. 2010b), such as in Papua [Waigeo (Prawiroatmodjo & Kartawinata 2014), Yapen, Japakopa, Bomberai Peninsula, and Manokwari], and Maluku (Giesen et al. 2007; Herison & Romdania 2020) (Amboin, Aru Islands, and Tual) (Fig 11). Giesen et al. (2007) mentioned that the geographic range of *C. schultzii* does not overlap with *C. philippinensis*. Saenger (1998) mentioned that *C. schultzii* possibly appear as far north as Borneo, however, whether there is any overlap between these species in Borneo is not known. So far, *C. schultzii* were never found in Borneo. *Campstemon schultzii* also never found on the Banggai Islands even though intensive mangrove exploration had been carried out in the area. Therefore, based on this study, the geographic range of *C. schultzii* does not overlap with *C. philippinensis* in Borneo. Both of these species are found in different geographic areas and do not share the same island.

On the other hand, Hur et al. (2020) reported that *C. schultzii* was found in Arosbaya, Bangkalan Madura Regency, East Java, Indonesia, but there is no photograph or description provided. Therefore, this information is still doubtful. Morley et al. (2020) found a small amount of pollen *Campstemon* in Perning, 12 km northeast of Mojokerto in East Java, Indonesia and then interpreted the extinction of the *Campstemon* from Java as the disappearance of hypersaline mangroves following the development of wetter climates during the mid-Pleistocene. Meanwhile, Yoga et al. (2020) reported that the pollen fossils of *C. schultzii* were found in the Bojongmanik formation, Banten basin sediments, West Java, Indonesia. The information on *C. schultzii* distribution in Java and its pollen fossils needs validation. There is uncertainty about the presence of *C. schultzii* in Java because the authors (KR and DN) have explored extensively in mangrove habitats in Java without recording *C. schultzii*.

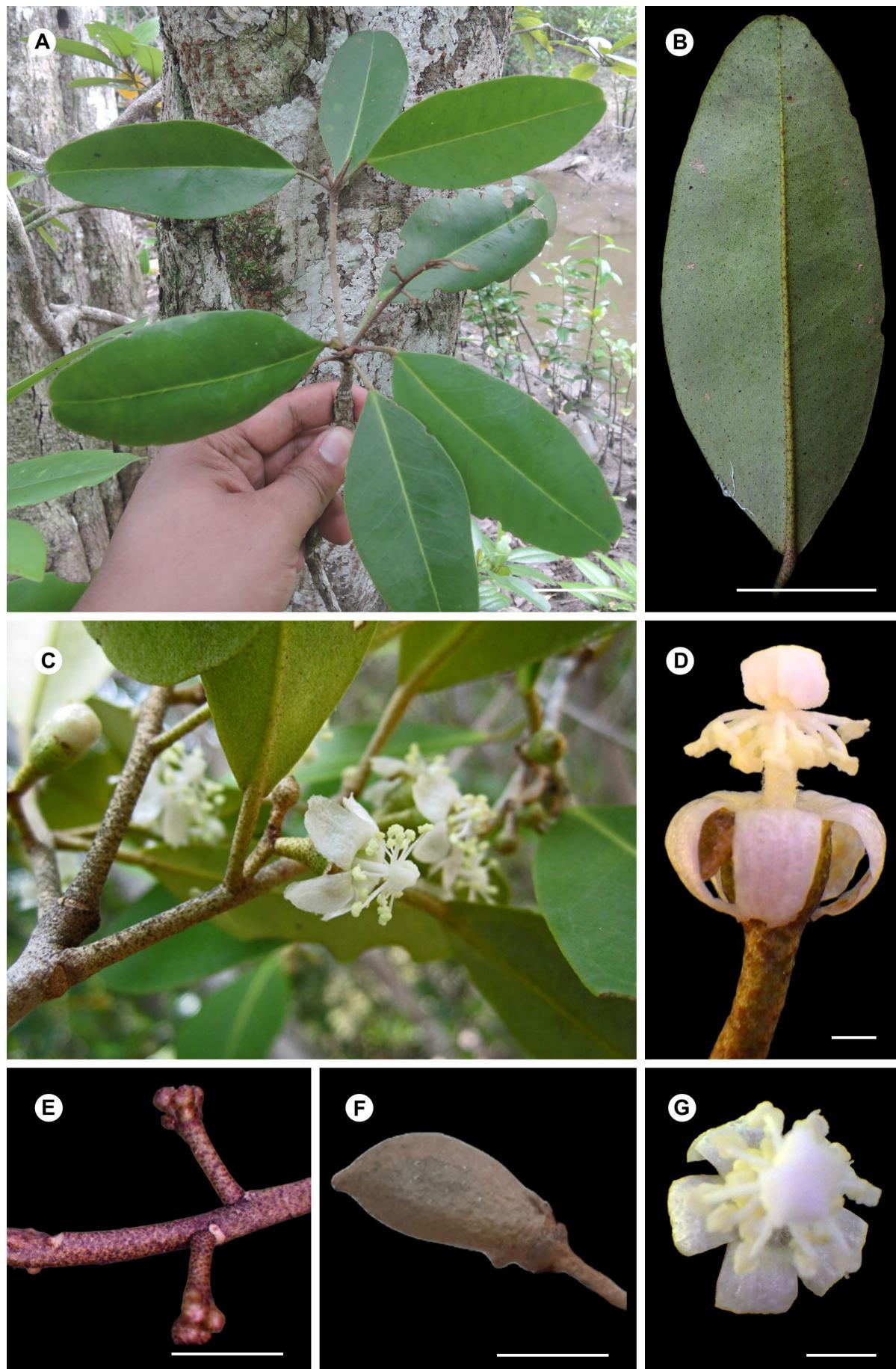
**Uses.** In Australia, *C. schultzii* is used as poles of rafts (Baishya et al. 2020) and materials for pulp and paper production (Herison & Romdania 2020), such as sulfate-paper pulps with good strength properties (Giesen et al. 2007). Aboriginals in Australia used *C. schultzii* to treat skin infections (Duke et al. 2010b). In Aru Islands, *C. schultzii* is used as fuelwood and cork.

**Vernacular names.** Based on Atlas of Living Australia (ALA 2021), *C. schultzii* is known as *kapok* mangrove. In Papua New Guinea, *C. schultzii* is known as *tamagama*, and on the Aru Islands as *maum*.

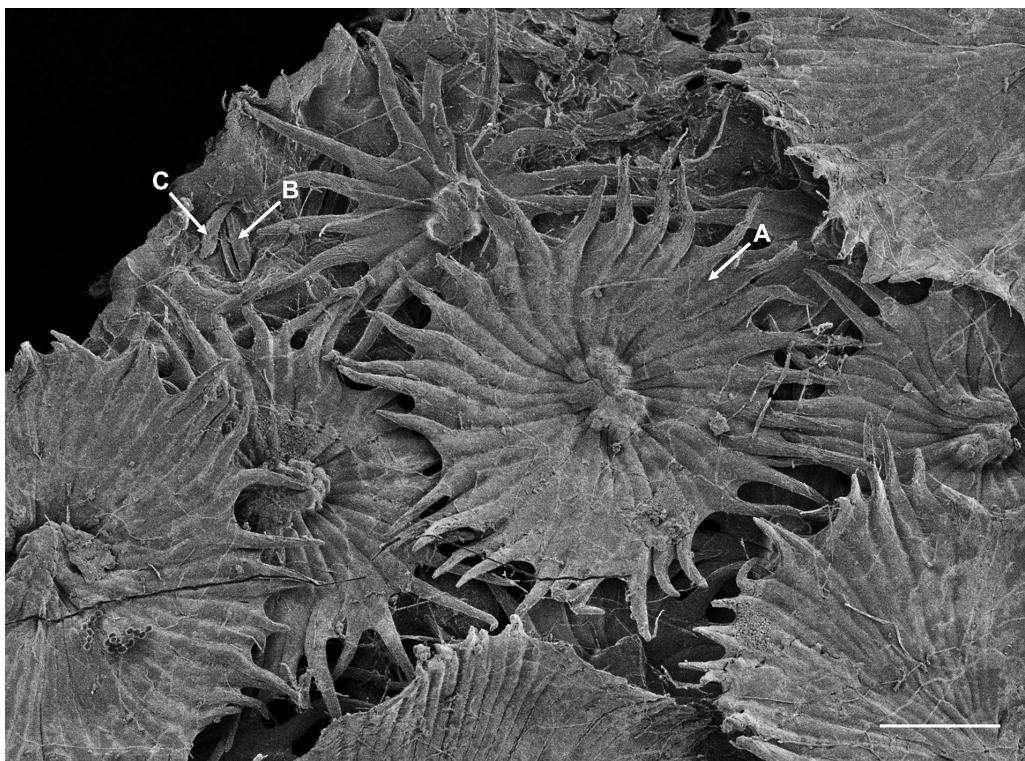
**Conservation status.** In 2008, the population trend of *C. schultzii* was reportedly stable, therefore, *C. schultzii* was categorized as the least concern based on the IUCN red list of threatened species (Duke et al. 2010b). On the Aru Islands, *C. schultzii* was found scattered throughout the area, and unfortunately, some of them were found to be decaying.



**Figure 6.** *Campstostemon schultzii*. A – habit; B – bark with lenticels; C – inner part of bark; D – pneumatophores. Scales: A = 1 m; B–D = 5 cm. Photos: I. Martiansyah and I. P. G. P. Damayanto.



**Figure 7.** *Campstemon schultzii*. A – leafy branches; B – abaxial leaf with scales; C – inflorescences; D – flower; E – flower buds; F – fruit; G – flower from above. Scales: A = 4 cm; B = 2 cm; D, G = 2 mm; E, F = 1 cm. Photos: I. Martiansyah, D. Nurdiansah, I. P. G. P. Damayanto (A, B, D, E–G) and F. F. Zich (C) (ALA 2021).



**Figure 8.** Scales of *Camptostemon schultzii* leaves were observed with SEM at  $\times 300$  magnifications. A – scale with peltate hair type; B – guard cell of stomata; C – epidermal cell. Scales: 50  $\mu\text{m}$ . Photos: specimen of P. Buwalda 348/bb 25381 (BO) from Aru Islands, Maluku.

**Notes.** According to Troll (1933) and Giesen et al. (2007), scales on the leaf surface of *C. schultzii* are only found in the abaxial. Based on this study, the scales were present on both sides of *C. schultzii* leaves in some specimens, but become glabrous when old on the adaxial surface. The young leaves of *C. schultzii* of some Papuan specimens bear scales on both sides of the leaves and the adaxial surface scales easily fall off when old, however, the scars of these scales are still visible on the upper surface of some mature leaves. On the other hand, Bakhuizen v. d. Brink (1924) stated that *C. aruensis* was a synonym of *C. schultzii* without leaving any notes on his publication. However, ALA (2022), COL (2022), Dahdouh-Guebas (2022), EOL (2022), GBIF (2022a), iNaturalist (2022a), Mindat (2022), POWO (2022), Tropicos (2022), WFO (2022), and WP (2022) reported that *C. aruensis* is an accepted species. Based on the type specimens (*O. Beccari s.n.*, FI – holotype, code FI007729, JSTOR 2021) and better specimens collected from type-locality of *C. aruensis* in Maikor, Aru Islands, these specimens are morphologically very similar to *C. schultzii*, with elliptic leaves, flower with 20 anthers, and a hairy filament tube. Broadly elliptic leaves were found in Maluku and Indonesian Papua specimens and narrowly elliptic in most specimens of Australia and Papua New Guinea. Hence, *C. aruensis* is a synonym of *C. schultzii*, concurrent with the previous work of Bakhuizen v. d. Brink (1924).

Flowers appear from February to November. It is probably pollinated by wind and/or insects. In Australia, mature fruit appear between October and February (Giesen et al. 2007). Fruits are probably dispersed by water, while woolly seeds are dispersed by wind and/or

water (Giesen et al. 2007; Herison & Romdania 2020). The generation length of *C. schultzii* is 35 years (Duke et al. 2010b).

**Specimens examined.** AUSTRALIA. Darwin, northern territory Port Darwin, no date: probably before 1870, Schultz 511 (K); Darwin, 19 Jul. 1960, R. F. Thorne, N. Eddy & B. Bateman 27755 (L); Darwin, near Rapid Creek, 15 Aug. 1967, N. B. Byrnes 274 (L); Darwin, Rapid Creek, 24 Jan. 1968, D. Wheelwright 24 (L); Darwin Harbor, East Arm, 17 Des. 1971, J. Must 879 (L); Queensland, Cook, Cape York, 27 Oct. 1965, L. S. Smith 12508 (L); [Queensland], Cook District, Topsy Creek, Kowanyama Aboriginal Reserve, 17 Aug. 1980, J. R. Clarkson 3391 (L); Western Australia, 21 Sep. 1967, C. den Hartog 603; 603A (L); Western Australia, Cape Bossut, N. of Eighty Mile Beach, SW Kimberley, 05 May 1977, K. F. Kenneally 6302 (L). PAPUA NEW GUINEA. Coast between Oriomo and Fly River, Apr. 1936, L. J. Brass 6465 (L); Gulf District [Gulf Province], Beara, Feb. 1957, G. McDonald 8156A (L); Gulf District [Gulf Province], East Purari River Delta Channel, ~1 Mile Inland from Coast, 15 Feb. 1966, L. A. Craven & R. Schodde 4479 (L); Gulf District [Gulf Province], Port Romilly, 19 Feb. 1952, A. J. Hart & Jackson 4536 (L); Gulf District [Gulf Province], Purari Delta, Near Ravikivau, 11 Feb. 1966, L. A. Craven & R. Schodde 799 (L); Gulf Division [Gulf Province], Romilly Sound, Vanakori, 28 Mar. 1953, A. J. Hart 5037 (L); Western District [Western Province], Bensbach Sub-district, Mouth of Bensbach River, 05 Aug. 1967, C. E. Ridsdale & M. Galore 33631 (L); Western District, Daru Sub-district, Daru Island, 21 Sep. 1972, H. Streimann & Y. Lelean NGF 18453 (L; US); Western Division [Western Province], Mabaduan, Apr. 1936, L. J. Brass 6475 (BM; L); Western Division [Western Province], Tarara, Wassi Kussa River, Dec. 1936, L. J. Brass 8517 (BM; L). INDONESIA. New Guinea [province of Papua], Jappen [Yapen], Seroei [Serui], S. Laoet [Serui Laut], Airewang, 23 Sep. 1939, Aet & Idjan (Exp. L. J. van Dijk) 982 (L); Papua, Japakopa, near Oeta, 17 Jul. 1941, Aet (Exp. Lundquist) 546 (L); Papua, PT Freeport Indonesia



Figure 9. Holotype of *Campstemon schultzii* (Herbweb 2022a).

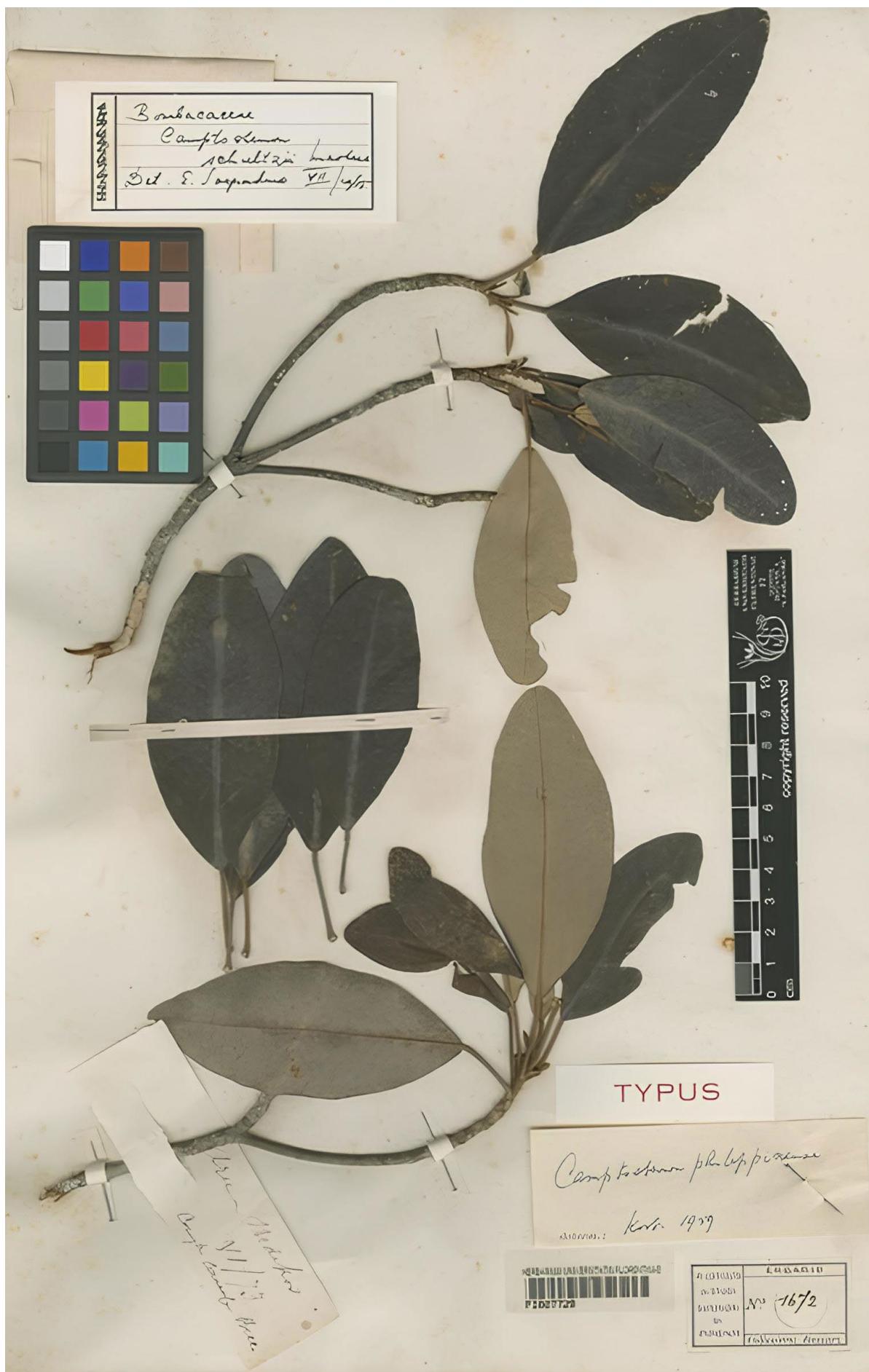
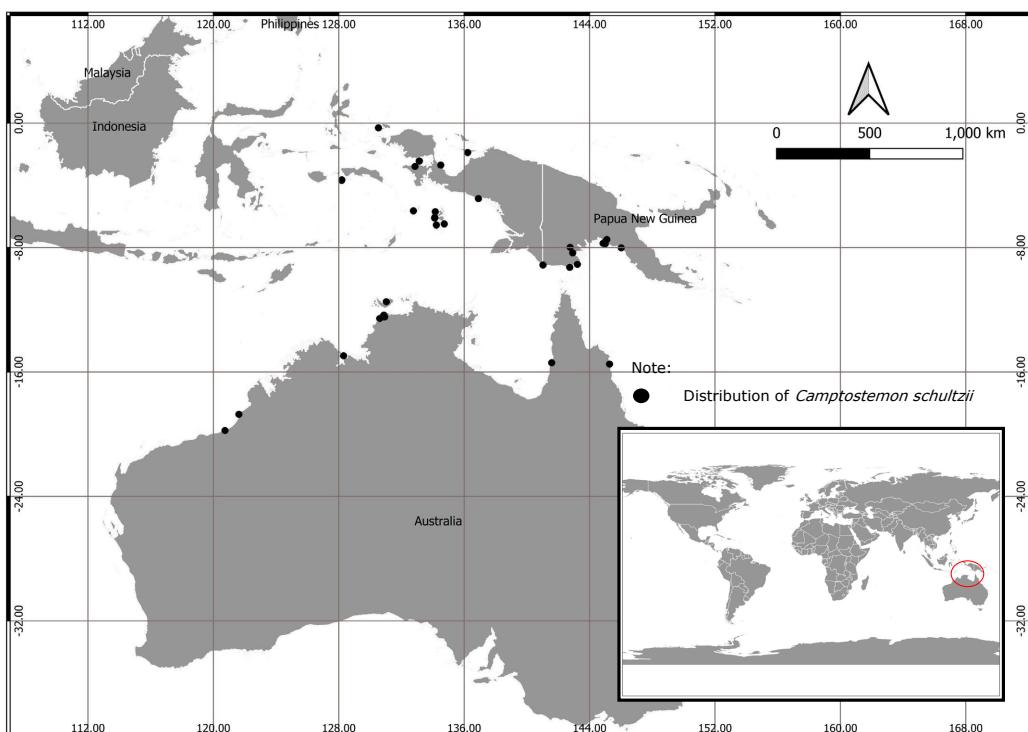


Figure 10. Holotype of *Campstostemon aruensis* (Jstor 2021).



**Figure 11.** Distribution of *Camptostemon schultzii*.

Project Area, site on a distributary of Aikwa [Ajkwa], 03 Mar. 1999, T. M. A. Utteridge TMA58 (BO); West Papua, Bomberai Peninsula, northeast of Saengga Basecamp, 15 Feb. 2002, W. Takeuchi, E. Sambas & R. Maturbongs 15800 (BO; L); province of West Papua, Bomberai Peninsula, northeast of Saengga Basecamp, 15 Feb. 2002, W. Takeuchi, E. Sambas & R. Maturbongs 15807 (BO; L); West Papua, Bomberai Peninsula, Tangguh Survey Area, 15 Feb. 2002, W. Takeuchi, E. Sambas, R. Maturbongs 15810 (BO; L); West Papua, Manokwari District, Wasior Villgae Rado, Hamlet Rado, 01 Jul. 1991, E. A. Widjaja EAW 4590 (BO; L); Maluku, Ambon, Kate-kate, 03 May 1993, M. M. J. van Balgooy 6521 (BO; L); Maluku, Pulau Ambon, Poka, 14 Nov. 1994, M. M. J. van Balgooy & M. Gylstra 6936 (L); Maluku, Aru Islands, Pulau Baun, 12 Apr. 1993, M. M. J. van Balgooy & J. A. B. Mamesah 6231 (L); Maluku, Aru, Wokam Islands, Dosinamalawe, 06 Jun. 1938, P. Buwalda 348 (bb 25381) (BO; L); Maluku, Aru Islands, Pulau Trangan between Sia and Beltubun, 27 Oct. 1994, M. M. J. van Balgooy 6713 (L); Maluku, Aru Islands, 26 Jun. 1873, Maikor, O. Beccari s.n. (FI); Maluku, Aru Islands, Maikor Island, 20 Jun. 2022, I. Nagwaem & I. P. G. P. Damayanto 1604 (BO); Maluku, Aru Islands, Maikor Island, Garjala, 22 Oct. 2022, I. P. G. P. Damayanto, K. Rahmawati, D. Nurdiansah, I. Martiansyah, B. W. Broto, R. S. Tit & E. D. Gardjalay 1700, 1701, 1702, 1703, 1784, 1785, 1786, 1787 (BO); Maluku, Aru Islands, Maikor Island, Baloiloidi, 22 Oct. 2022, I. P. G. P. Damayanto, K. Rahmawati, D. Nurdiansah, I. Martiansyah, B. W. Broto, R. S. Tit & E. D. Gardjalay 1728, 1729 (BO); Maluku, Aru Islands, Maikor Island, Ratu, 24 Oct. 2022, I. P. G. P. Damayanto, K. Rahmawati, D. Nurdiansah, I. Martiansyah, B. W. Broto, R. S. Tit & E. D. Gardjalay 1777, 1778, 1783, 1788 (BO); Maluku, Tual, Pulau Dullah Selatan District, Teluk Un Luar, 10 Oct. 2021, D. Nurdiansah & I. P. G. P. Damayanto 1559 (BO).

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