


Pinus rarissima, a new species of the genus *Pinus* L. (Pinaceae) from central Vietnam


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
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
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Abstract

Probably the rarest pine species in the world, *Pinus rarissima* from central Vietnam, is described, illustrated and named, and its present-day distribution is characterized in detail. We classify it as a member of series *Dalatenses* (of the genus *Pinus* subgenus *Strobos* section *Quinquefoliae* subsection *Strobos*). It closely resembles *P. dalatensis* from the same series but also shares some features with *P. anemophila* from *P. series Chylae* subseries *Wangianae*. A thorough morphological comparison of the new pine species with similar taxa is presented, along with a key to the determination of pines of section *Quinquefoliae* occurring in Vietnam, Laos and southern China.

Key words: chorology, critically endangered species, *Pinus* sect. *Quinquefoliae*, taxonomy

Introduction

The area of Southeast Asia, particularly its eastern mainland, and southern China, is known as an important centre of conifer species diversity (Fu *et al.* 1999, Ying *et al.* 2004, Hiep *et al.* 2004, Luu & Thomas 2004, Phan *et al.* 2017). The genus *Pinus* Linnaeus (1753: 1000), pines, constituting the most diversified group of conifers in this region, is divided into two very different generally accepted subgenera: ‘hard pines’ or ‘diploxylon pines’, *Pinus* subgen. *Pinus*, comprising approximately three-fifths of the species of the genus, and ‘soft pines’ or ‘haploxylon pines’, *Pinus* subgen. *Strobos* (Don 1825: 54) Lemmon (1895: 20), comprising almost two-fifths of pine species. Whereas species of the type subgenus, with a few exceptions, occupy large areas of natural geographic distribution, in *P. subgen. Strobos* there is a greater proportion of species with limited or narrowly endemic distribution, particularly in Southeast Asia. The known diversity of the genus in the region of southern China (i.e., south of 26° N with the exclusion of Taiwan) and mainland Southeast Asia comprises seven species of *P. subgen. Pinus* and nine species of *P. subgen. Strobos* (cf. Businský 2016a).

An unknown soft pine belonging to *Pinus* subgen. *Strobos* sect. *Quinquefoliae* Duhamel (1755: 127) was discovered in May 2011 along the northern edge of the sandstone plateau above Dai Hong commune (Dai Loc District) in the north of Quang Nam Province, central Vietnam (L. V. Averyanov pers. comm.). It was reported to occur at an elevation of 550–650 m a.s.l., near to the coordinates 15°49'N, 107°57'E. The primary forests on this plateau were purportedly burnt during the United States' Vietnam War, which left only a few trees of this pine surviving on rocky sites. The original collections were tentatively determined as *P. wangii* Hu & Cheng (1948: 191). Based on original information and photographs available in the 2010s, this pine was later provisionally connected also with the names *P. dalatensis*

Ferré (1960: 178; Businský 2013, Phan *et al.* 2013) or mentioned to be partly similar to *P. anemophila* Businský (2010: 5; Businský 2016b). Still, however, the Dai Hong pine definitely required further field study for its taxonomic identity to be ascertained.

This article is based on a long-term study by the second author (R. Businský) focusing on the taxonomic revision of pines in Eurasia, particularly in China, Vietnam, Japan, and neighbouring countries. In the 1990s, he primarily conducted his research within the REPEA project ('Revision of Pines of East Asia') at the Research Institute for Landscape and Horticulture in Průhonice. Besides identifying several new taxa within the *P.* subgen. *Pinus*, he has distinguished and described three endemic species and one more widely distributed subspecies of five-leaved pines (*P.* sect. *Quinquefoliae*) in the flora of southwestern China, Vietnam and Laos (Businský 1999a, 2004, 2010). Based on his field knowledge and direct study in the tree crowns of all pine species native to Eurasia (Businský 2008), he has also revised some published taxonomic treatments based on incorrectly determined herbarium material of pines collected in Vietnam (Businský 2013, 2016b).

In early October 2024, the second author took an opportunity to study and collect the Dai Hong pine in the field. He observed only six adult trees of this pine at the locality on the Dai Hong plateau (also known as Khe Lim, part of the Huu Nien Mountains) visited by the 2011 expedition. These trees had survived on rocky brook banks near the plateau edge or on exposed cliff tops forming this edge. Only two trees were found to be bearing seed cones, one with only sporadic cones, the other with abundant cones produced in the last three years. Representative samples were collected from three trees (including the abundantly fruiting one, which was selected for the preparation of type specimens), each at a separate location, by climbing their crowns. Below we present the results of our research of the Dai Hong pine population, which we describe here as a species new to science, with the epithet *rarissima* referring to the extreme rarity of this pine.

Material and methods

The field studies on which this article is based were carried out between 1983 and 2024 in over 600 natural pine populations worldwide by R. Businský, the second author of this paper, who has devoted his professional life to the taxonomy of the genus *Pinus*.

Photographs documenting the habitats and habitus of pine trees were taken during a field trip to the Dai Hong plateau. In addition, the morphological characters of the collected samples (morphologically identical with detailed photographs taken during the 2011 expedition) were measured and compared with those of specimens of all relevant taxa of *P.* sect. *Quinquefoliae* from Southeast Asia available in the herbarium collection of the second author, deposited in the herbaria PR and GJO. Additional material stored in the following public herbaria was used to study the morphology of related species: A, CDBI, E, HAST, HN, HNU, IBK, K, KUN, LE, P, PE, SGN, SYS, TAIF, TI, VNM, W and WU (for herbarium acronyms see Thiers 2024). The morphological terminology used for the most part follows Businský (2004).

Results and discussion

Pinus rarissima Businský, *sp. nov.* (Figs. 1–6)

Type:—Central Vietnam, Quang Nam Province, Dai Loc District, Dai Hong commune, north-west side of the Dai Hong plateau, along rocky brook approximately 150 m south-east of the edge of sandstone plateau, 15°48'58.3"N, 107°56'29.0"E (WGS-84), 655 m a.s.l.; middle old tree with 135 cm of trunk circumfer., 15 m high; 4 October 2024, R. Businský 81103 (Holotype—four parts: PR 1015715, PR 1015716, PR 1015717, PR 1016350 (carpological coll.); isotypes: GJO145790, GJO145791, P00917564, P00917565, P00917566, SGN007407, SGN007408). Fig. 1–3.

Description:—Trees reaching a height of 10–20 m, often with a forked trunk up to approximately 0.5 m in diameter; main branches erecto-patent; branchlets fragile. Shoots unevenly pubescent, usually conspicuously pruinose (at least in long sterile shoots). Leaves slender and relatively soft, erect and straight or sometimes only slightly drooping, (7–)9–17(–19) cm long and (0.7–)0.8–0.95(–1.03) mm wide, irregularly acutely serrate on all edges with (12–)15–22(–26) teeth per centimetre in the middle part, light green on all sides (not with glaucous pruinose ventral sides), with (2–)3–5(–6) stomatal lines on each ventral side; resin ducts two marginal on the dorsal side, and occasionally (or often

in some individuals) an additional smaller duct near the ventral edge, either a marginal one situated laterally or a median one situated symmetrically opposite the edge; epidermis thin, with cells somewhat radially flattened, smaller than those of the hypodermis, hypodermis of one cell layer, with thin-walled cells. Pollen cones 5–7 mm long (observed in the end of April 2017). Ovulate cones (conelets) subterminal (on addinodal shoots), solitary or in 2–4-merous whorls, 12–22 mm long. Seed cones pendulous on medium thick, (15–)20–30 mm long peduncle (representing 22–36 % of the cone length), narrowly ovoid or narrowly ellipsoidal with a length/width ratio of 2.4–3.3 when closed, attenuate towards the apex, (6–)7–10.5(–11.5) cm long and 5.5–6.5 cm wide when fully open; opening in September and October of the second year of development, infirmly persisting for one or two years after opening. Scales (65–)70–100(–125), densely arranged; the largest seed scales (23–)26–29 mm long and (17–)18–21 mm wide, with a length/width ratio of (1.2–)1.35–1.6(–1.7); stunted basal sterile scales around the peduncle insertion appressed. Apophyses conspicuously thin, usually with a longitudinally grooved surface, ochre brown and dull on freshly ripened cones; those of the basal part of the cone with their distal edges usually recurved, and those of scales towards the apical part of the cone with the shape gradually changed to distinctly convex with not elevated edges; the apex of all seed scales truncate and inclined towards the cone axis. Umbo transverse, narrow and flat, 4–7 mm wide in seed scales, conspicuously and abruptly depressed into a concavity at the truncate end of the scale; the distal edge elevated upwards. Seeds including the relatively long and narrow wing (14–)15.5–22.8(–23.5) mm long (20.85 mm on average); seed corpus (5–)5.5–7.8 × 3–4.2 mm, representing 31.5–36 % of the overall seed length; corpus border of the wing base distinct, rugose and elongated into a triangular, 1.5–3 mm long thickening, firmly attached to the corpus; the dorsal side of the corpus with irregular black spots. Wing (9–)10.0–15.5(–16) mm long (measured from the corpus apex including the thickening) and 4.7–7.6 mm wide, with a length/width ratio of 1.6–2.5; with dark irregular longitudinal stripes continuing to the ventral coat of the seed corpus.

Diagnostic characters:—Trees not taller than 20 m; leaves mostly 9–17 cm long, light green on all sides; seed cones mostly 7–10.5 cm long, narrowly ovoid or narrowly ellipsoidal, with a relatively long peduncle representing 22–36 % of the cone length; densely arranged seed scales up to 26–29 mm long with thin apophyses; umbo conspicuously abruptly depressed; seeds small (corpus 5.5–7.8 mm long), including a relatively narrow wing mostly 15.5–23 mm long and 4.7–7.6 mm wide.

Ecology:—Growing among broadleaved, often evergreen, low trees on sandstone cliffs along the edge of a mountain plateau or on rocky brook banks, on sandstone bedrock. The elevation range is 500–750 m a.s.l., the lowest among all species of *Pinus* subgen. *Strobos* in southern China and eastern mainland Southeast Asia. Many seeds obtained from well-developed fresh cones of the tree selected for the type specimens were tested for the presence and development of the megagametophyte and embryo. All seeds tested were entirely empty. We attribute this finding to the absence of fertilizing pollination (at least in 2023) by some another individual, caused by the sparseness and isolation of trees in the population in question. Mature cones on the aforementioned abundantly fruiting tree were found largely unopened due to infestation by larvae of a moth from the tortricid group, which is another factor reducing the potential fertility of the species.

Distribution:—Central Vietnam, Quang Nam Province, Dai Loc District, currently known only from the type locality area of approximately 5 × 1 km.

Conservation status:—The known remnant of the species' former population consists of scattered young individuals and only a few solitary cone-bearing trees with problematic fertility. The estimated number of all observed and known individuals is not more than twenty. The species' conservation status is therefore tentatively assessed as critically endangered (CR) in accordance with the criterion D of the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Committee 2019).

Based on current information it can be considered the rarest pine in the world. Until the Dai Hong pine was correctly identified, this title rightfully belonged to the Chinese species *Pinus squamata* Li (1992: 259) from section *Gerardia* Murray (1983: 13) of the same subgenus. This species is known only from a single locality in northeastern Yunnan, where approximately thirty mature trees grow (Businský 2008, and pers. observ. in 1998 and 2013), and which is considered critically endangered (Farjon 2001).

Additional specimens collected (paratypes):—Central Vietnam, Quang Nam Province, Dai Loc District, Dai Hong commune, northwest side of the Dai Hong plateau, along narrow rocky brook near the edge of sandstone plateau above waterfalls, 15°49'16.4"N, 107°57'31.6"E (WGS-84), 540 m a.s.l., young infertile tree: 110 cm t.c., 14 m h., 4 October 2024, *R. Businský 81101* (PR 1015713, GJO 145808); same locality, summit of sandstone rock forming the edge of sandstone plateau, 15°48'55.5"N, 107°56'10.6"E (WGS-84), 695 m a.s.l., stunted infertile tree branched from 1 m, 112 cm t.c. in 0.6 m, 6 m h., 12 m crown diam., 4 October 2024, *R. Businský 81102* (PR 1015714, GJO 145809); same locality, Khe Lim, 15.829709°N, 107.973822°E, 24 April 2017, *Tran Huu Dang TRAN-0476* (SGN 007388–007395).



FIGURE 1. Holotype of *Pinus rarissima* (PR 1015717—fertile branchlet with open cone).



FIGURE 2. Holotype of *Pinus rarissima* (PR 1015716—sterile branchlet).



FIGURE 3. Holotype of *Pinus rarissima* (PR 1015715—fertile branchlet with two ovulate cones).

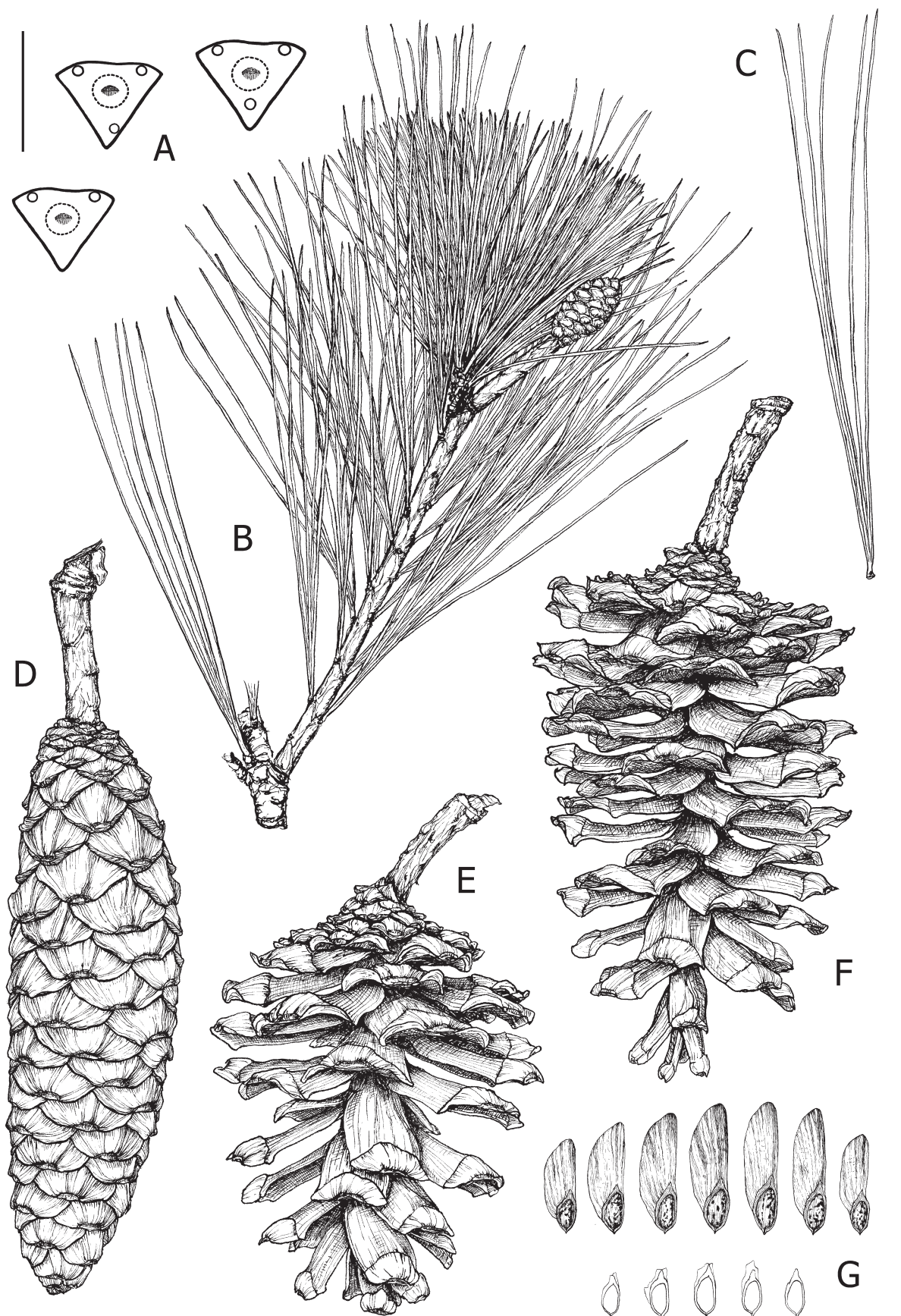


FIGURE 4. *Pinus rarissima*: A: Sketch of leaf sections showing different positions of resin ducts; B: annual fertile branchlet with addinodal shoot and ovulate cone in autumn season; C: leaf fascicle from long sterile shoot; D–F: three seed cones; G: seeds. Scale bars: 1 mm, top left (A) 10 cm, top right (B, C); 10 cm, middle right (D–F); 1 cm, bottom right (G). All from the tree selected for the type specimen. Drawn by Ludmila Businská.

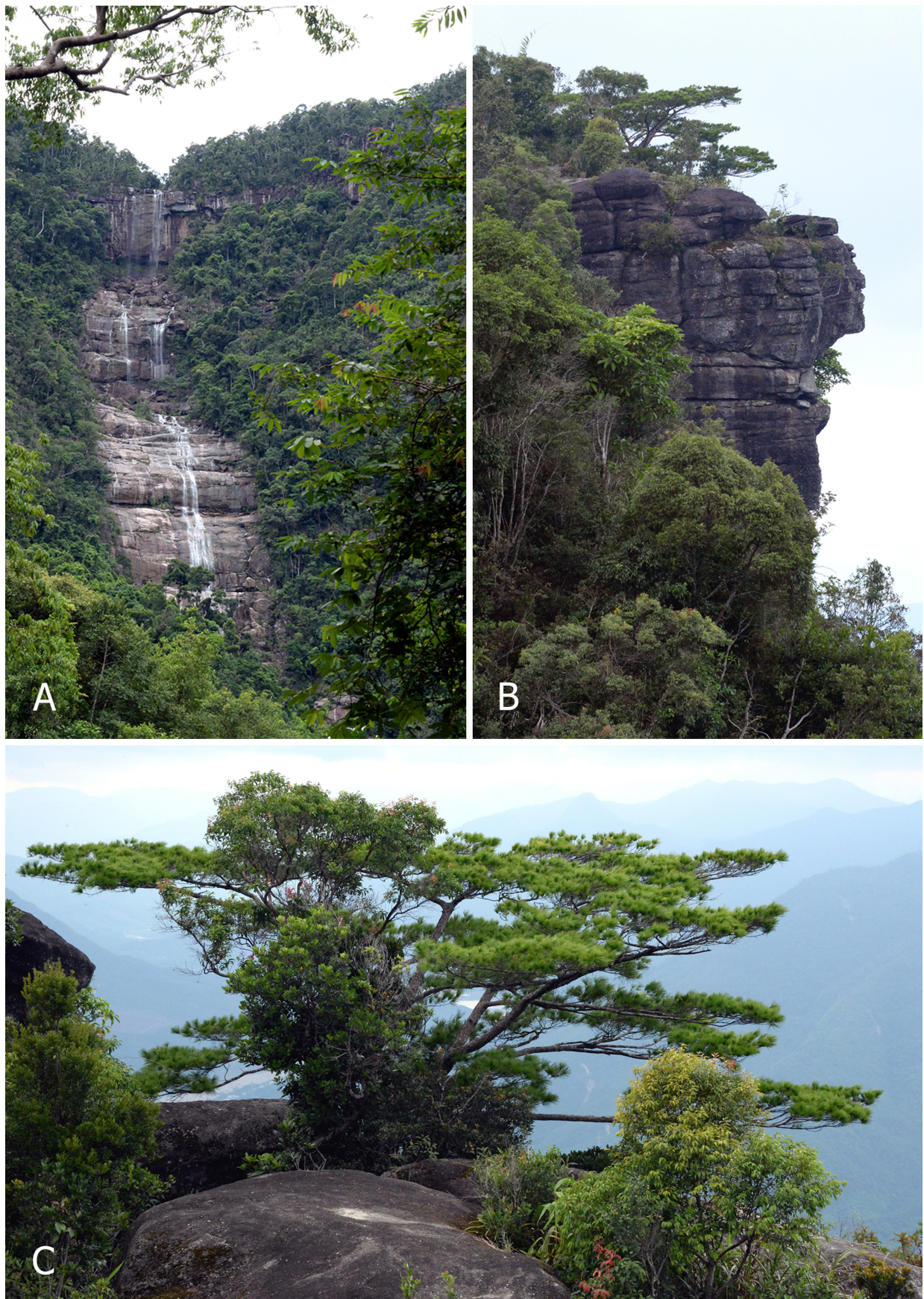


FIGURE 5. A: View from below towards the upper edge of the Dai Hong plateau, where a group of mostly young individuals of *Pinus rarissima* occurs; B, C: stunted infertile tree of *P. rarissima* on a sandstone cliff forming the edge of the plateau (see specimen R. Businský 81102). Photos R. Businský.



FIGURE 6. *Pinus rarissima*: A: cone-bearing branch; B: habit of a tree of intermediate age; C: branchlet with one ovulate cone and two closed seed cones just before opening; D: branchlet with freshly opened seed cones; A–D from the type tree (see *R. Businský 81103*); E: trunk of a young infertile tree 110 cm in circumference at 1.3 m (see specimen *R. Businský 81101*). Photos R. Businský.

Synonym:—*Pinus petrophila* Aver. et al., nom. inval. (Turland et al. 2018, Art. 32.1a). Holotype: Vietnam, Quang Nam Prov., Dai Loc Distr., Dai Hong municipality, environs of Dai Hong town around point 15°49'19"N 107°56'58"E, ..., at elev. about 600 m a.s.l., ..., 19 May 2011, L. Averyanov et al. CPC 3465, LE 01282396. Paratypes: same locality, around point 15°49'01"N 107°56'31"E, ..., at elev. about 600–650 m a.s.l., ..., 22 May 2011, L. Averyanov et al. CPC 3627, LE 01282393, LE 01282394; same locality, around point 15°49'44"N 107°57'19"E, ..., at elev. about 550 m a.s.l., ..., 21 May 2011, L. Averyanov et al. CPC 3575, LE 01282395.

Taxonomy:—The original opinion of the discoverers of the Dai Hong pine (L. V. Averyanov, L. K. Phan and others of the 2011 expedition) that it could belong to the less known Chinese species *Pinus wangii* was partly based on a controversial identification and erroneous localization by Hiep and Vidal (1996) of specimen *Chevalier 38353* (P) from 1918, later included in the newly described taxon *P. dalatensis* subsp. *procera* Businský (1999a: 133). The cited discoverers later reviewed their tentative identification of the Dai Hong pine and classified it as a new species closely related to *P. dalatensis*, proposing for it the name *P. petrophila*. However, this name has not been published and is only given on the labels of herbarium specimens in the LE herbarium (see above), available at <https://en.herbariumle.ru/> under this name only from April 2025 (L. V. Averyanov, pers. comm. in July 2025).

True *P. wangii* s.str. was discovered in northern Vietnam (in the provinces Cao Bang and Ha Giang) in 1998 and 1999 not far from the type area in southeastern Yunnan, China. The relevant collections, however, were determined as *P. kwangtungensis* Chun ex Tsiang (1948: 113; a similar species from southern China) and reclassified later (Businský 2013, 2016b). After the taxonomic concept of all relevant taxa had been corrected, *P. wangii* was accepted to be represented by two subspecies (Businský 2016a), the ranges of which both extend from China to northern Vietnam (Businský 2016b). *Pinus wangii* s.l. is in fact morphologically vastly dissimilar from *P. rarissima* and is also limited to very different, karstic habitats (for both see Tab. 1) in northern Vietnam and southwestern China. The second subspecies of *P. wangii*, *P. w.* subsp. *variifolia* (Nan Li & Y.C.Zhong in Li & Fu 1997: 262) Businský (1999b: 11), additionally differs in having entirely glabrous, not pruinose shoots and fascicles of varying numbers of leaves. Nevertheless, a photograph taken during the original discovery and collections of the Dai Hong pine is still included under the name *P. wangii* on the website ‘Threatened conifers of the world’ (Royal Botanic Garden Edinburgh 2024; the middle right photograph from Quang Nam, Dai Loc, taken by L. V. Averyanov).

Among pine species native in Vietnam and adjacent countries, *Pinus dalatensis* shares certain similarities and occurs in the closest geographic proximity to *P. rarissima* (Fig. 7), so it was formerly speculated to be taxonomically identical with it (see Introduction). It is represented by two subspecies, of which the northern one, *P. d.* subsp. *procera*, occurs in scattered populations on higher mountain massifs in south-central Vietnam and southeastern Laos, with an overall range spanning approximately 270 km, which is geographically close to the locality of *P. rarissima*. However, this subspecies is morphologically even more different (particularly in having densely pubescent shoots, cylindrical cones mostly 13–20 cm long on short peduncles taking up only up to 15 % of the cone length, the largest seed scales mostly 34–44 mm long, seeds mostly 25–35 mm long in total) from the new species than the type subspecies of *P. dalatensis*, which is distributed in the Da Lat Highlands in southern Vietnam, more than 370 km from the Dai Hong plateau. Although *P. dalatensis* is generally a rather variable species, it is possible to define several diagnostic traits that differentiate it well from the new species (in particular the height of mature trees, which is greater than 20 m, leaves mostly only 5–11 cm long, loosely arranged seed scales up to 48 mm long, and overall seed length up to 39 mm). Moreover, *P. rarissima* and *P. dalatensis* inhabit distinctly different habitats and elevational ranges (Tab. 1). *Pinus dalatensis* has been designated as the type species of the Eurasian group named *P. series Dalatenses* Businský (2004: 250), placed within *P. sect. Quinquifoliae* subsect. *Strobis* and characterized particularly by small seeds with a relatively long wing and a distinct elongated thickening of the corpus border. The morphology of *P. rarissima* best fits into this series although it does not fully correspond to the original diagnosis of this group with its longer leaves and thin apophyses.

Habitats harbouring *Pinus rarissima* are almost identical ecologically to those with the occurrence of *P. anemophila*, a species narrowly endemic to margins of the Phou Ak plateau in Khammouan Province, central Laos, along the border with Vietnam, approximately 310 km from the Dai Hong plateau. Both these species occur on sandstone rocks along edges of mountain plateaus with small vertical differences in the relief and within the elevational ranges of 500–750 m versus 780–1100 m a.s.l., respectively. However, the morphological differences between the latter species and the new one are also substantial (particularly leaves only up to 8 cm long, the cone peduncle usually up to 15 mm long, seed scales loosely arranged in small numbers, usually 50–70, with thick apophyses, and a larger seed corpus with a relatively broad wing), as shown in Table 1. One rather curious character, not discernible in herbarium specimens, that differentiates these two species is the toughness of branches. Whereas *P. rarissima* has fragile branchlets, as is typical for other species of section *Quinquifoliae*, those of *P. anemophila* are conspicuously tough and resistant to breaking

in the wind. We have classified the latter as a member of *P.* subseries *Wangianae* Businský (2004: 251), formally belonging to series *Chylae* Landry (1977: 471), which is parallel to series *Dalatenses*.

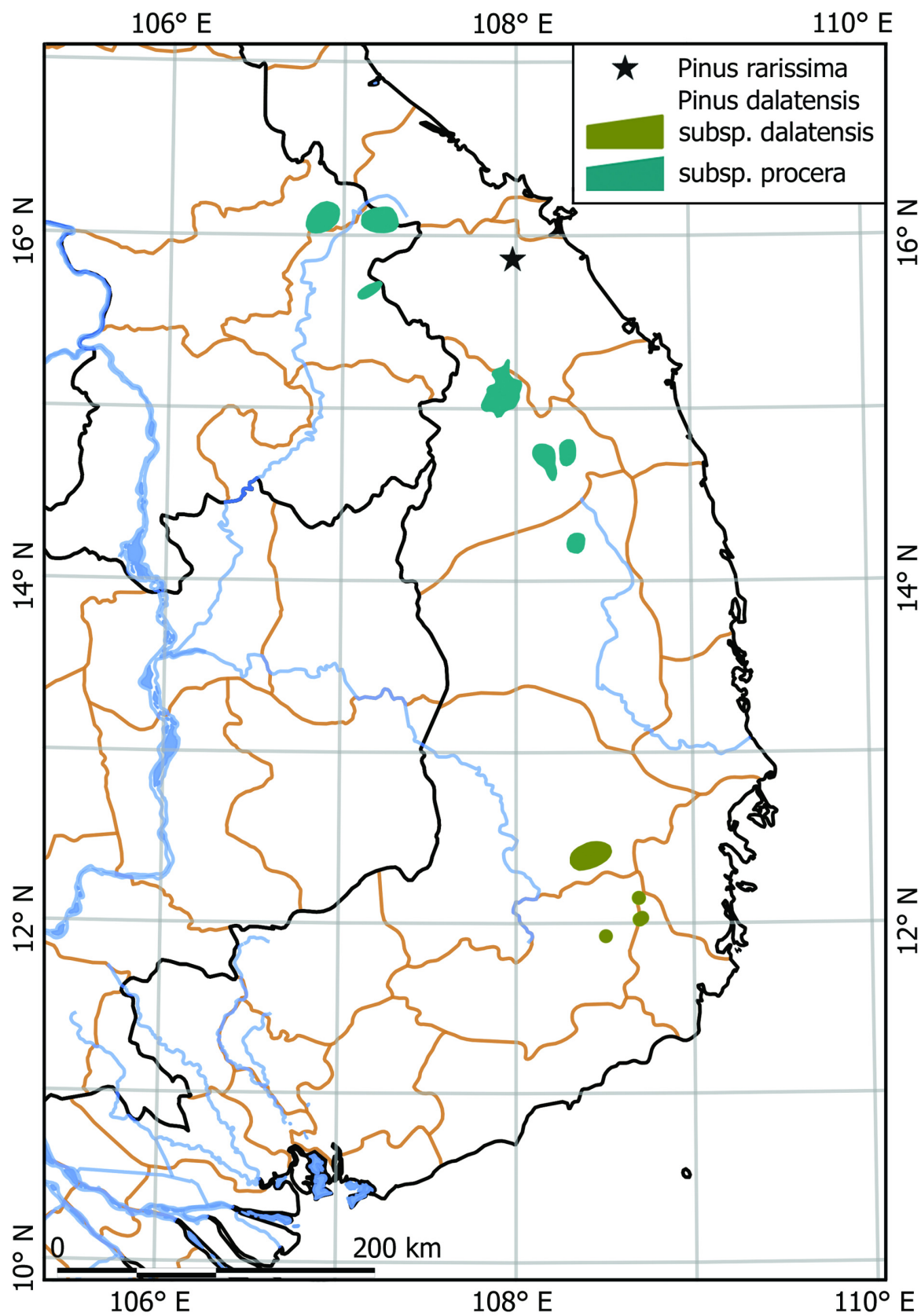


FIGURE 7. Position of the single known locality of *Pinus rarissima* in the context of the distribution of both subspecies of *P. dalatensis*.

TABLE 1. Differences of Pinus rarissima from similar or considered species.

Traits / Ecological conditions	<i>Pinus rarissima</i>	<i>Pinus dalatensis</i> (two subspecies)	<i>Pinus anemophila</i>	<i>Pinus orthophylla</i>	<i>Pinus wangii</i> (two subspecies)
Height of mature trees	10–20 m	20–30(–40) m	10–25 m	10–20 m	8–20 m
Shoots	unevenly pubescent	glabrous or pubescent	unevenly pubescent	glabrous	pubescent or glabrous
Leaves					
general character	straight, soft	straight, soft	straight, soft	straight, rigid	arc-shaped bent, rigid
colour	light green on all sides	slightly glaucous on ventral sides	slightly glaucous on ventral sides	greyish glaucous on ventral sides	greyish-green or greyish-white on ventral sides
*length [cm]	9–17	5–11	5–7	5.5–8	3–6
*width [mm]	0.8–0.95	0.6–1.1	0.85–1.05	0.95–1.25	1.0–1.5
*number of teeth per cm	15–22	unknown	20–33	12–28	20–40
position of dorsal resin ducts	marginal	marginal	marginal	marginal	median
Seed cones					
peduncle % of the cone length	22–36 %	*9–22 %	10–20 %	15–23 %	*10–20 % in subsp. <i>wangii</i>
shape of closed cones	narrowly ovoid or narrowly ellipsoidal	often cylindrical	oblong-ovoid, narrowly ovoid or narrowly ellipsoidal	narrowly ovoid or narrowly ellipsoidal	oblong-ovoid or narrowly ellipsoidal
length [cm]	(6–)7–10.5(–11.5)	(6–)8–20(–23), *13–20 in subsp. <i>procera</i>	(4.5–)6.5–9.5(–10.5)	(4–)6–10(–12)	(3–)4–8.5(–10)
width when fully open [cm]	5.5–6.5	*6–9	(4.5–)5–6.5	4.5–6.5	4–6.5
*number of seed scales	70–100	50–100	50–70	40–65	35–65
relative density of seed scales	densely arranged	loosely arranged	loosely arranged	loosely arranged	loosely arranged
basal sterile scales around the peduncle insertion	appressed	usually appressed or deflected	deflected to recurved	usually appressed or deflected	usually appressed or deflected
*length of the largest seed scales [mm]	26–29	33–44	25–30	26–30	18–30

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TABLE 1. (Continued)

Traits / Ecological conditions	<i>Pinus rarissima</i>	<i>Pinus dalatensis</i> (two subspecies)	<i>Pinus anemophila</i>	<i>Pinus orthophylla</i>	<i>Pinus wangii</i> (two subspecies)
apophyses	thin, with longitudinally grooved surface	mostly thick, with longitudinally grooved surface	thick, almost smooth	thick, smooth	thick, smooth or with longitudinally grooved surface
umbo	conspicuously abruptly depressed	usually abruptly depressed	usually \pm depressed	conspicuously abruptly depressed	usually even with the apophysis surface
Seeds					
*overall seed length [mm]	15.5–23	22–37	15–28	17–27	19–26.5 in subsp. <i>wangii</i>
*seed corpus length [mm]	5.5–7.8	7–10	7–9.5	5.7–8.7	8.5–11.5
*seed corpus % of the overall seed length	32–36 %	23–36 %	35–45 %	29–40 %	40–50 %
wing length [mm]	*10–15.5	*15–27	8–19	11–19	*4.5–17
wing width [mm]	4.7–7.6	5.3–11	6–10	4.5–8.7	6.5–10.5
length/width ratio of wings	1.6–2.5	*2.2–3.2	1.3–2.2	*1.7–2.9	1.0–2.1
Habitat	rock cliffs along the edge of plateau or rocky banks of brooks, sandstone bedrock	mountain ridges, elevations or ribs, usually igneous bedrock	rocky plateau, sandstone bedrock	rocky summits and ridges, igneous bedrock	karstic rocky hills, limestone bedrock
Elevation range [m a.s.l.]	500–750	*1500–2200	780–1100	1000–1865	1200–1900 in subsp. <i>wangii</i>

New relevant materials and information on the Dai Hong pine, as well as photographs of it, were obtained from the field by the last author (H. T. Luu) in late April 2017. Based on this new information, another species, *P. orthophylla* Businský (2004: 229), more or less similar to the Dai Hong pine, began to emerge as its possible taxonomic identity. *Pinus orthophylla* is an endemic of the highest mountains on the Chinese island of Hainan, located approximately 360 km to the north-east. It also grows on summits and ridges built of silicate rock (but of the igneous type) and at elevations above 1000 m a.s.l. It is also classified as a member of *P. series Dalatenses* (Businský 2004). However, a new direct study of several trees of the Dai Hong pine in October 2024 and additional morphological comparison revealed substantial differences between these taxa (Table 1).

The Dai Hong sandstone plateau is exceptional from the point of plant diversity, as is illustrated by the list of species of different families described from this area as new to science since the first botanical expedition conducted there in 2011, namely, for example, *Hoya longipedunculata* Pham & Averyanov (2012: 705; Apocynaceae); *Oreocharis hapii* Nguyen, Averyanov & Lin (2024: 236; Gesneriaceae); *Peliosanthes nutans* Averyanov & Tanaka (2012: 158; Asparagaceae); *Phyllagathis phamhoangii* V.T.Pham, V.T.Chinh & Ranil in Pham *et al.* (2017: 141; Melastomataceae); *Sonerila quangnamensis* K.S.Nguyen, H.H.Truong, Aver. & C.W.Lin in Nguyen *et al.* (2024: 289; Melastomataceae); and *Tainia cornuta* Averyanov (2012: 14; Orchidaceae).

Identification key to known species of *Pinus* sect. *Quinquefoliae* occurring in Vietnam, Laos, and southern China

- 1 Seeds always without effective wings, vestigial wing tissue in the form of narrow distal border, or prolonged into short membranous blade easily broken off and sometimes stuck to the seed scale; seed scales \pm thickened in the apophysis area (i.e., the scale apex with umbo protruding above the adjacent scale).....2
- 1* Seeds mostly with a fully effective, adnate wing, exceptionally wings reduced and easily broken off (occasionally in *P. eremitana*, see below), but then scales of closed cones with the apex (umbo) appressed to adjacent scales (apophyses)3
- 2 Cones erecto-patent on short, straight peduncle, 5–9(–12) cm long; leaves mostly 12–20 cm long; crown of fully developed older trees domed (\pm umbrella shaped) [S China, NW Vietnam]*P. fenzeliana* Hand.-Mazz. (1931: 337) [syn.: *P. cernua* L.K.Phan ex Averyanov *et al.*, 2014: 792]
- 2* Cones pendulous on short, often a bent peduncle, 9–25 cm long; leaves 8–15 cm long; crown of older trees \pm cylindrical [SW, S and C China, N Myanmar, Taiwan].....*P. armandii* Franch. (1884: 95) [including subsp. *armandii* and subsp. *mastersiana* (Hayata 1908: 194) Businský (1999b: 13)]
- 3 Seeds large (corpus 7–18 mm long), with a relatively short (2–20 mm) and broad wing (representing 35–65 % of the overall seed length); cones with thick, stout apophyses, the largest seed scales with a length/width ratio mostly of 0.9–1.654
- 3* Seeds small (corpus 5–10 mm long), with a relatively long ((11–)15–35 mm) and narrow wing (representing 20–40 % of the overall seed length); cones often with relatively thin, flexible scales (if apophyses thickened, then umbo usually depressed), the largest seed scales with a length/width ratio mostly of 1.25–2.257
- 4 Leaves, on average, wider than 1 mm, conspicuously arc-shaped bent5
- 4* Leaves, on average, about 1 mm wide or narrower, straight or indistinctly bent.....6
- 5 Cones 4–8.5(–10) cm long; leaves greyish-green or greyish-white pruinose on the ventral sides, with dorsal resin ducts median [SW China: SE Yunnan, W Guangxi, S Guizhou; N Vietnam]*P. wangii* (including subsp. *wangii* and subsp. *variifolia*, both in N Vietnam, limestone bedrock)
- 5* Cones (5–)7–10(–11) cm long; leaves conspicuously white pruinose on the ventral sides, with dorsal resin ducts mostly marginal [S China: NE Guangxi, S Hunan, N Guangdong, igneous bedrock].....*P. kwangtungensis*
- 6 Leaves (2–)3–4.5(–6.5) cm long, edges mostly with 8–25 teeth per centimetre in the middle part, with dorsal resin ducts mostly median; cones (4–)5–7(–9) cm long, apophyses with the umbo conspicuously abruptly depressed [NW Vietnam, limestone bedrock].....*P. eremitana* Businský (2004: 234)
- 6* Leaves (3–)5–7(–8) cm long, edges mostly with 20–33 teeth per cm in the middle part, with dorsal resin ducts mostly marginal; cones (4.5–)6.5–9.5(–10.5) cm long, apophyses with the umbo at the level of the apophysis surface or moderately depressed [EC Laos, sandstone bedrock]*P. anemophila*
- 7 Cones (6–)8–20(–23) cm long, often cylindrical, mostly 6–9 cm wide when fully open; mature trees high, usually exceeding 20 m in height [S to C Vietnam, SE Laos]*P. dalatensis* (including subsp. *dalatensis* and subsp. *procera*, both in Vietnam, the second in Laos)
- 7* Cones (4–)6–10(–12) cm long, narrowly ovoid or narrowly ellipsoidal, 4.5–6.5 cm wide when fully open; mature trees low, usually not exceeding 20 m in height.....8
- 8 Shoots glabrous; leaves mostly 5.5–8 cm long and 0.95–1.25 mm wide, rigid; cones on mostly 8–20 mm long peduncle, with apophyses thick, smooth [S China: Hainan Island, igneous bedrock]*P. orthophylla*
- 8* Shoots unevenly pubescent; leaves mostly 9–17 cm long and 0.8–0.95 mm wide, soft; cones on mostly 20–30 mm long peduncle, with apophyses thin, longitudinally grooved [C Vietnam: N Quang Nam Province, sandstone bedrock]*P. rarissima*

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