

A Review of the Genus *Keteleeria* (Pinaceae) in Vietnam

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Abstract: *Keteleeria* Carrière is a small genus of the family Pinaceae. Three species are recognized in natural habitats, *Keteleeria fortunei*, *K. davidiana* and *K. evelyniana*, distributed in southern China, Laos, and Vietnam. Southern China has all three species. Laos has one species, *K. evelyniana*. Vietnam is known to have two species (*K. davidiana* and *K. evelyniana*); besides, there are probably introduced and cultivated individuals of a taxon with uncertain status in Lũng Cú, Hà Giang as ornamental. The objective of the present study are to review the species of *Keteleeria* in Vietnam based on 50 collecting numbers collected during the recent 20 years and preserved mainly in the herbarium HNU. Traditional morphological methods are used to examine the morphology of specimens. Photos were made by digital camera at high resolution. Illustrations were processed by using the software Adobe Photoshop CS6. Scientific name, data on the morphology, phenology, distribution, ecology, conservation status and notes are results of the study of their protologue, specimens with detailed labels and literature. Cultivated plants differ clearly with all known species of *Keteleeria*, and may be represented as a new taxon to science.

Keywords: *Keteleeria*, native species, cultivated *Keteleeria* sp., Vietnam.

1. Introduction

The genus *Keteleeria* was established and described by E.A. Carrière, based on a single species, *Keteleeria fortunei* (A. Murray bis) Carrière [1].

In 1862, A. Murray bis described *Picea fortunei* from among specimens sent by R. Fortune to the British Museum (England), but the following year he transferred this species to the genus *Abies*, as *Abies fortunei* (A. Murray bis) A. Murray bis. In 1866, E.A. Carrière noticed that the R. Fortune specimens differed from other species of *Abies* in having cones that did not disintegrate readily at maturity. He therefore established a new genus, *Keteleeria*

Carrière with *Keteleeria fortunei* (A. Murray bis) Carrière, the new combination, basionym of which is *Abies fortunei* (A. Murray bis) A. Murray bis. It was the first species of this new genus. At that time, the genus was known only from China [2].

In 1872, M.C. Bertrand described another new species from southern China, *Pseudotsuga davidiana*, based on material collected by A. David [3]. However, M.C. Bertrand did not examine specimens that had previously been assigned to *Keteleeria*. In 1891, after careful examination of specimens of *Pseudotsuga davidiana*, L. Beissner correctly transferred this name to *Keteleeria*, as *Keteleeria davidiana* (Bertrand) Beiss [4]. This was the second species recognized for the genus *Keteleeria*.

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The third species, and also the last to date, of this genus, *K. evelyniana* was described by M.T. Masters in 1903 [5].

Over the years a number of taxonomic studies were conducted on *Keteleeria* and although many new taxa were proposed there often was not a consensus among researchers concerning the taxonomic status of these taxa. Between 1866 and 1981, 14 species and one variety were described (none has been added since) [2].

A. Farjon was the first author to consider *Keteleeria* as comprising three species, namely, *K. evelyniana*, *K. davidiana*, and *K. fortunei* [2] [6]. However, for a time there remained uncertainty concerning the number of species in the genus. For example, C.N. Page numerated 3 to 7 species, commenting that the taxa were somewhat ill-defined [7]. D.J. Mabberley recognized two species [8] while L.G. Fu et al. accepted approximately 3 to 5 species [9]. D.J. Mabberley followed A. Farjon's three species classification for *Keteleeria* and this classification is adopted in the present study [10].

Keteleeria distributes from southern China to Laos and Vietnam. In southern China, all three species occur as native [9]. Besides, some taxa are also cultivated for afforestation and as ornamental somewhere there. They are *K. fortunei* and *K. davidiana* var. *calcareae* [9].

There are some concerns about which species occur in Laos. M. Newman et al. list two species [11], namely *K. evelyniana* and *K. davidiana*, but only voucher specimens of the first species were cited. The study by L.V. Averyanov et al. (2014) recorded only *K. evelyniana* in Laos [12]. Further study is therefore needed for the genus *Keteleeria* in Laos.

Regarding Vietnam, Phạm-Hoàng Hộ was the first person who recorded *Keteleeria* for the country, listing a single species, *K. evelyniana* [13]. Phan Kế Lộc subsequently added *K. davidiana* to the data of Vietnamese flora [14].

In summary, *Keteleeria* is currently recognized as a genus of three species with a

restricted geographic range confined to southern China, Vietnam and Laos.

The objective of the present study is to review the species of *Keteleeria* in Vietnam.

2. Materials and Methods

This study is based on 50 collecting numbers collected between 1996 and 2015 in Vietnam by authors from living plants at various locations around Vietnam and also from herbarium specimens preserved at Hanoi University of Science, Vietnam National University (HNU), the Institute of Ecology and Biological Resources of the Vietnam Academy of Sciences and Technology, Hanoi (HN), and the Institute of Tropical Biology, Hồ Chí Minh City of the same Academy (VNM).

Traditional morphological methods are used to examine and record specimen details and comparative morphology is used to investigate taxon relationships. Specimen structures such as leaves, seed scales, bracts were photographed by digital camera Canon EOS with Macro Lens EF 100 mm at high resolution (with magnifications of x2, x4 and x10) and illustrations were processed by using the software Adobe Photoshop CS6. Morphological terminology follows that of J.G. Harris & M.W. Harris [15], author names follow those of R.K. Brummitt & C.E. Powell [16] and Authors of Plant Names: List of Authors of Scientific Names of Plants, with Recommended Standard Forms of Their Names [17], names of Journals follow those of G.H.M. Lawrence et al. [18] and of G.D.R. Bridson et al. [19].

3. Results and Discussion

Species of *Keteleeria* are discriminated mainly by the shape of seed scales of mature female cones (as observed from the scales at middle of the cones - Fig. 1).

Results of this morphological study showed that there are two native species of *Keteleeria* in

Vietnam, *K. evelyniana* and *K. davidiana*. *K. fortunei* has not been recorded in the country. *Keteleeria fortunei* has seed scales that are widest in their upper half (Fig. 1), but all the specimens collected in Vietnam possessed seed scales that were widest at their middle or lower half (Fig. 2, Fig. 3, Fig. 4, Fig 5). Additional to the above there is a taxon of uncertain status in Lũng Cú, Hà Giang province of Vietnam, which is known only from a few specimens in cultivation. Although these specimens are

clearly referable to *Keteleeria*, previously they were recognised as a species of the genus *Abies* (pers. comm. with L.T. Chấn). There was another set of misidentified specimens related to *Keteleeria*. Specimens of *Pseudotsuga sinensis* collected in Hà Giang was wrongly identified as *Keteleeria fortunei* (pers. comm. with N.T. Hiệp). In fact *Keteleeria* differs clearly from related genera (*Abies*, *Pseudotsuga*, *Tsuga*, and *Pinus*) in Vietnam (Tab. 1).

Tab. 1. Comparison of morphological characters between *Keteleeria* and other native genera in the family Pinaceae existing in Vietnam

Genus	<i>Keteleeria</i>	<i>Abies</i>	<i>Pseudotsuga</i>	<i>Tsuga</i>	<i>Pinus</i>
Location of mature seed cones on bearing branchlets	Erect	Erect	Pendulous	Pendulous	Pendulous/ Erect
Length of opening seed cones	> 10 cm	> 8 cm	< 6 cm	< 3 cm	< 12 cm
Average number of seed scales in seed cone	more than 70	more than 300	< 30	< 20	< 50
Seed scales on seed cone maturity	persistent	deciduous	persistent	persistent	persistent
Leaves solitary/in bundles	solitary	solitary	solitary	solitary	in bundles

3.1. General characteristics of genus *Keteleeria* in Vietnam

Evergreen trees; bark commences exfoliating in thin layers when plants are three years old. Branching is irregular, branchlets bear leaves that are opposite or sub-opposite and (especially on branchlets bearing seed cones) spirally arranged. Leaves narrowly linear, usually slightly falcate, apex usually obtuse; petiole short, flat, twisted at base. Leaves grow spirally on the branchlets, especially branchlets bearing seed cones, leaving circular or horizontally oval, slightly convex scars when fall. Seed cones solitary, rarely paired on the 2nd year branchlets, erect and turn brown when ripe, cylindrical, narrowed toward the apex, base rounded; peduncle stout. Seed scales closely imbricate, exude milky

white oleoresin. In seed cones maturing of *K. davidiana* and *K. evelyniana* seed scales largely spread, then decline, creating inclined plane more than 90° for seeds ditching out. Cones persistent on trees for many years after seed dispersal. Seed scales at middle of cones subcordate to rhombic-subcordate or short-ovate, auriculated at base. The abaxial surface of the seed scales is longitudinally ribbed. The indumentum is pannose and warts on the abaxial seed scales surface, these processes are concentrated at the base and edge of the scales. Bracts included, attached to seed scales at the base, apex cuspidate or trilobed. Seeds nearly triangular-ellipsoid, with semitrullate light brown wings that envelope the adaxial face of seeds and which are sometimes longer than seed scales and jut out [7, 9, 10, 20].

3.2. *Keteleeria davidiana* (Bertrand) Beissn

Handb. Nadelholzk.: 424, f. 117, 1891. Type: China, A. David, MNHN-P-P00749029 (Holotype); A. Farjon, Notes Roy. Bot. Gard. Edinburgh 46(1): 81, f. 3, 1989; L.G. Fu et al. *Keteleeria*. In: Z.Y. Wu & P.H. Raven, Eds., Fl. China 4: 42, 1999; Phan Kế Lộc. Pinaceae, *Keteleeria*. In: Checklist Pl. Vietnam I: 1158-1159, 2001; Lê Thị Thu, Phan Kế Lộc, Nguyễn Trung Thành, Proc. 6th Natl. Sci. Conf. Ecol. & Biol. Resour., Hanoi, 21/10/2015: 338-344. - *Pseudotsuga davidiana* Bertrand, Bull. Soc. Philom. Paris VI, 9: 38, 1872. - *Keteleeria calcarea* W.C. Cheng & L.K. Fu, Acta Phytotax. Sin. 13(4): 82, 1975; *Keteleeria pubescens* W.C. Cheng & L.K. Fu, l.c.: 82.

Description. Tree up to 25-30 m tall and trunk to 0.6-0.8 m d.b.h. or more. Crown broadly domed. Branchlets weakly ridged and grooved with poorly defined pulvini and leaf scars usually orbicular, slightly protruding. Leaves of junior branchlets very narrow lanceolate and slightly falcate, of adult branchlets narrowly linear, usually slightly falcate, usually 2.6-4 × 0.25-0.35 cm; stomatal lines few or none adaxially, 18-24 lines in each band abaxially, margin slightly revolute, apex obtuse or slightly emarginate. Leaves of junior branchlets usually pectinately arranged due to twisted petiole, of seed cone bearing branchlets almost radially spreading. Pollen cones unknown. Seed cone solitary, terminal on 2nd year branchlets, cylindrical or ovoid-cylindrical, ca. 14-18 × 6-6.5 cm (when not opened), gradually and slightly tapered distally, rounded at both ends, maturing in 1st year (spring of next year), 15-20 × 6-8 cm, brownish (light brown) when mature and opened, sparsely resinous; old seed cones erect; peduncle ca. 5-6 × 0.5-0.7 cm. Seed scales at middle of cones subcordate or rhombic-subcordate, 3-3.2 × 2.3-2.5 cm. Bracts of seed scales

ligulate-spatulate, ca. 13-16 mm, nearly 3/5 times as long as seed scales), the tip ends of the split 3-lobed, middle lobe pointed, longest, two shorter sides and rounded lobes. Seeds oblong, 1.4-1.6 × 0.5-0.6 cm, wing light brown, semitrullate. Seed and wing 2.5-3.3 × 0.9-1.2 cm, nearly as long as seed scale, rarely a bit longer, recurved. - Fig. 2, 5. [14, 20, 24].

Vernacular name. Du sam đá vôi.

Phenology. Pollination unknown; seed maturity October-November.

Distribution. Widely distributed in southern China; in Vietnam it is found only from two small subpopulations in two adjacent, very restricted localities in Bắc Kạn Province, on limestone mountains.

Ecology. It is found in small group intercalated with other conifer species, *Pseudotsuga sinensis* in closed evergreen tropical seasonal submontane forests at the elevation 550-700 m; natural regeneration occasional, saplings very rare.

Conservation status. In Vietnam, there are fewer than 100 mature individuals known. One of two localities where this species occurs is in Kim Hỷ Nature Reserve. Expected IUCN Red List status EN [21]; EN [22].

Note. The number of stomatal lines of each side of abaxial midrib band around 18-24 (vs. 20-32 [9]).

Specimens examined.- Bắc Kạn: Bắc Kạn Prov., Na Rì Distr., Kim Hỷ Comm., around point 20°16'16"N 106°02'55"E, 600 m, 24-4-2013, dominant in primary closed evergreen conifer forest on ridge, seed cones still young, P.K.Lộc et al. P 11094 (HNU); tree ca. 20 × 0.3 m, P 11096 (HNU); evergreen tree ca. 30-35 × 0.4-0.6 m, P 11097 (HNU), tree, ca. 15-20 × 0.21 m, P 11099 (HNU) & tree ca. 30-35 × 0.4-0.6 m, P 11100 (HNU); 22°16'27"N 106°02'54"E, ca. 580 m, 14-11-2013, on ridge of Lún Lạc limestone mountain, in closed evergreen lowland coniferous forest mixed with

Pseudotsuga sinensis, evergreen big trees, all seed cones ripe, opened and most seeds were fallen down, P.K.Lộc et al. *P 11228* (HNU); big tree, *P 11229 & 11230* (HNU); same location, nearly old seed cones, 03-05-1999, Aver. et al. *CBL 2178b* (HNU); Liêm Thủy Comm., Nà Bô Vill., around point 21°56'44"N 106°05'09"E, at elevation 300-700 m, 27-05-2004; in primary lowland evergreen closed wet of coniferous forest on tops of ridge of white solid marble-like crystalline limestone rocks; evergreen tree up to 30 m tall and 1.5 m d.b.h., about 500 years old (on rings calculation), common, occasional co-dominant of fragments; nearly old seed cones erect, about 15 cm long and 3-4 cm in diam., Avev. et al. *HAL 4925* (HNU, HN, CPC).

3.3. *Keteleeria evelyniana* Mast

Gard. Chron., ser. 3, 33: 194, f. 82, 1903 (Type); P.R. Hickel, Flore Générale de l'Indo-Chine 5, 1931; A. Farjon, Notes Roy. Bot. Gard. Edinburgh 46(1): 81, f. 4, 1989; Phạm-hoàng Hộ, Cây cỏ Việt Nam, An Illustrated Fl. Vietnam 1(1): 272, f. 735, 1991; L.G. Fu et al. *Keteleeria*. In: Z.Y. Wu & P.H. Raven, Eds., Fl. China 4: 42, 1999; Phan Kế Lộc. Pinaceae-Keteleeria. In: Checklist Pl. Vietnam I: 1158-1159, 2001; N.T. Hiệp, J.E. Vidal, Fl. Camb., Laos, Viêt. 28: 46, f. 3, 1996; Lê Thị Thu, Phan Kế Lộc, Nguyễn Trung Thành, Proc. 6th Natl. Sci. Conf. Ecol. & Biol. Resour., Hanoi, 21/10/2015: 338-344. - *Tsuga rouletii* A. Chev., Bull. Econ. Indochine, 20: 878, 1918. - *Keteleeria rouletii* (A. Chev.) F. Flous, Bull. Soc. Hist. Nat. Toulouse, 69: 404, 1936. - *Keteleeria dopiana* F. Flous, l.c.: 404. - *Keteleeria hainanensis* Chun & Tsiang, Acta Phytotax. Sin. 8(3): 259, 1963 [25].

Description. Tree up to 30-35 m tall; trunk to 1-1.4 m d.b.h., sometimes up to 2 m, semideciduous in regions with dry period more than four months. Leaves of bearing seed cones branchlets narrowly linear, sometimes slightly falcate, usually 3.5-4.5 × 0.2-0.3 cm; leaves

grow spirally on the branchlets, especially branchlets bearing seed cones. However, because twisted stalks create the comb-toothed shape, and then most of leaves will erect (creates V shaped). Pollen cones lateral or terminal, 4-8 in umbellate clusters arising from a single bud. Seed cones solitary, terminal on 2nd year branchlets, erect when old on stout peduncle, ca. 4.5-5.5 × 0.5-0.6 cm. Seed cones ellipsoid-cylindric, ca. 11-18 × 5-6 cm when not opened, glaucous, maturing in 1st year (spring in following year), rounded at both ends, brownish when mature, 12-21 × 6-7.5 cm when opened, exude oleoresin. Seed scales at middle of cones rhombic-ovate, convex, 3-3.6 × 2.1-2.6 cm; exposed part of abaxial face glabrous, its outer has longitudinal veins ribbed, woody-leathery straight or slightly recurved, margin rounded toward apex, erose-denticulate, apex rounded, 2-seeded. There are pannose and warts on the seed scales surface, concentrate at base and edge of their abaxial face; exposed part of abaxial surface glabrous. Bracts in seed cones 14-16 mm long, nearly 1/2 times as long as seed scales, trilobed at apex. Seeds obovoid-oblong, 1.2-1.6 × 0.5-0.8 cm, rich in big oleoresin glands, covered on adaxial face by wing membranous. Seed with wing ca. 30-38 × 10-14 mm, slightly longer than seed scale; seed and part of wing pannose abaxial. - Fig. 3, 5. [13, 14, 20, 23, 24].

Vernacular name. Du sâm núi đất

Phenology. Pollination February-March (voucher specimen - *P 11372* et al.), seed maturity around 12 months later, in spring of following year.

Distribution. Laos, China; in Vietnam it has wide geographical distribution, extending from Northwestern (Sơn La, Thanh Hóa), down along the border with Laos (Nghệ An, Hà Tĩnh, Thừa Thiên-Huế), and ended at the southern part of Trường Sơn range (Kon Tum and Lâm Đồng).

Ecology. It is found mainly in secondary closed evergreen tropical seasonal submontane coniferous forests/woodlands mixed with other

conifer species such as *Pinus latteri* or *Pinus kesiya* (from 700-1800 m) regenerated on abandoned slash and burn areas of non-limestone mountains, sometimes concentrated into small clusters in riverine mixed forests; natural regeneration is abundant. This is one of three conifer species (two other species are *Pinus latteri* and *Pinus kesiya*) of Vietnam that can be grown on these habitats.

Conservation status. Large parts of its natural habitat have been converted to agriculture. It has been overexploited for timber by local people. In Vietnam, it has been listed as Vulnerable Expected IUCN Red List status: VU [21], VU [22]. Exploitation of the species is limited by government policy so in theory, this tree is safeguarded in protected forests (such as Bạch Mã national park in Thừa Thiên Huế, Ngọc Linh nature reserve in Kon Tum, Bi Doup national park in the South Central Highlands [22]).

Note. The number of stomatal lines of each side of abaxial midrib band around 13-16 (vs. 28-38 [9]).

Specimens examined. - **Sơn La:** Sốp Cộp Distr., Mường Lạn Comm., ca. 907 m, L.T. *Chấn C 175* (HNU); Sốp Cộp Distr., Dầm Cang Comm., NE of Tin Tốc Vill., Sốp Cộp nature reserve, 900-1100 m, about 4 km to N of around point 20°58'39"N 103°34'55"E, 13-11-2007, medium part of slope of mountains on sandy stone; in slightly and heavily logged primary closed evergreen broad-leaved submontane forests; semideciduous tree; scattered in primary forests; regeneration occasionally common, especially in secondary vegetation on open ridges of mountains, P.K.Lộc et al. *HAL 11285* (HNU); Yên Châu Distr., Phiêng Khoái Comm., 20°57'44"N 104°17'34"E, 974 m elevation, 07-10-2012, before was found in primary closed evergreen seasonal tropical submontane mixed with broad-leaved forests on slopes and top ridges of silicat mountains, now remain scattered

semideciduous trees in crop plantations, P.K.Lộc, V.D.Duy P 11032, P 11033, P 11035, P 11037, P 11038, P 11039 (HNU); Mộc Châu, P.K.Lộc 1911961 (HN). - **Thanh Hoa:** Mường Lát Distr., Mường Lý Comm., Sa Loong Vill., around point 20°32'37"N 104°40'10"E, 400-600 m, 28-08-2007, sandstone mountains, in logged evergreen mixed lowland forests on slopes, sometimes with *Pinus latteri* near stream banks; medium-sized semi-evergreen tree, up to 20-25 m tall, 0.6-0.7 m d.b.h. or more; was common, nowadays become endangered species due to logging for timber and mainly to enlarged shifting cultivation, P.K.Lộc et al. *HAL 11215* (HNU). - **Nghệ An:** Kỳ Sơn Distr., Mường Ải Comm., near Phà Nồi Vill., at elevation about 800-900 m, around point 19°16'38"N 104°02'43"E, 26-3-2007, in mixed open semi-deciduous submontane secondary forest on very steep slopes composed with granite and shale; locally very common, occasional co-dominant of mixed and coniferous forest; semideciduous tree up to 20 m tall and 0.4 m d.b.h., Aver. et al. *HLF 6550* (HNU), same locality, 06-3-2015, in mixed with *Pinus latteri* open semi-deciduous submontane secondary forest/woodland on very steep slopes and top ridges composed with granite and sandstone, rarely shale; locally very common, occasional co-dominant of mixed and coniferous communities; semideciduous tree up to 10 m tall and 0.25 m d.b.h.; ripening seed cones, P.K.Lộc, L.Thu P 11372, P 11373, P 11382-P 11397 (HNU); Kỳ Sơn Distr., Mường Típ Comm., near Phà Nồi Vill., at elevation about 800-900 m, around point 19°16'38"N 104°02'43"E, 26-03-2007; mixed open semi-deciduous submontane secondary forest on very steep slopes composed with granite and shale; semideciduous tree up to 20 m tall and 0.4 m d.b.h.; locally very common, occasional co-dominant of mixed and coniferous forest, Aver. et al. *HLF 6550* (HN). - **Hà Tĩnh:** Hương Sơn Distr., Sơn Kim Comm., N.T.Hiệp et al.

VA 2014 (HN). - **Kon Tum:** Đắk Glây distr., about 10-12 km to the SE of Đắk Glây town (4-6 km to the E of Đắk Tung Vill.; primary evergreen mountain forest at 800-850 m; tree up to 50 m high and about 2 m in diameter at the base of stem, common; codominant in mixed forests on W macroslopes at 1100-1300 m, *Aver. et al. VH 2252a* (HN, LE). - **Lam Dong:** Da Lat city, Mimosas road, from Prenn waterfall to city's center, 11°54'33" 108°27'42", 1250 m, 26-7-2014; deciduous tree up to 15-20 m, 0.3-0.5 m d.b.h., scattered or clustered in groups on edges of *Pinus kesiya* forest, usually along stream, in sandy-shale rocky mts.; leaves of this year appeared since spring time, certainly Mar-Apr.; all parts of leaf glabrous; leaflets oblanceolate; all seed cones of previous year fallen down, some left on tree, decayed, *P.K.Lộc P 11320* (HNU); Dat bridge, *N.T.Hiệp 22-3-1981* (HN), Đà Lat, *L.K.Biên 1261* (HN), Da Lat, *N.D.Chính 902* (HN); Lac Duong Distr., Lat Comm., Langbian, *Millet 3J64J* (VNM), Suối Vàng locality, around point 11°59'12"N 108°22'12"E, at elevation about 1450 m, 25-10-2005, primary disturbed closed evergreen coniferous montane forest or woodland with domination of *Pinus kesiya*; deciduous tree 15-20 m tall, 0.6 m d.b.h., occasional, *L.C.Đoàn et al. HLF 5382* (HNU, LE, CPC), Đa Chays, around 12°08'N 108°39'E, at 1700-1900 m, 24-03-1997; primary closed evergreen broad-leaved forest on W macroslope of Bi Doup mt. silicat system, semideciduous tree up to 30-35 m hg.; very common at 1600-1800 m, sometimes codominant of 1 forest stratum, *Aver. et al. VH 3234* (HNU, HN, LE); Đơn Dương Distr. (Dran), *Chevalier 30669* (VNM); *Poilane 31049* (VNM).

3.4. *Keteleeria* sp

Four collecting numbers from four cultivated trees in Lung Cu mt., Ha Giang Prov. were collected, of which two numbers bear seed

cones. They clearly represent the one taxonomic entity, and belong to genus *Keteleeria* (Tab. 1). It is not similar to three known species of this genus not only by the form of seed scales (Fig. 1), but by some other morphological characters (Fig. 5). Their salient features are as follows:

Description. Trees attain about 20 m tall, 32 cm d.b.h. at around 30 years old. Leaves spirally arranged, on cone-bearing branchlets longer than 5.5 cm (vs. shorter than 4.5 cm in all three native species). The leaves of vegetative branchlets of mature trees (voucher specimens are *P 11416* and *C 180*) are slightly larger, 49-63 × 3-3.2 mm. Leaves on the upper side of the 1st year of branchlets ascend early and strongly, forming two opposite, adaxial to adaxial sets, few of leaves on the lateral side spread in two lateral sets and leaves are absent from the lower side of branchlets, similar to the arrangement of leaves on 1st year branchlets of some species of *Abies*, such as *A. fabri*, *A. beshazuensis* (vs. leaves pectinately or radially arranged in other species of *Keteleeria*). Pollen cones unknown. Seed cones cylindrical, 9-11 × 3-3.4 cm when slightly opened, ca. 2/3 as long as those of native species. Seed scales short-ellipse, broadest at the middle, 19-24 × 17-20 mm, margins erose-denticulate, apices concave in the middle, exude oleoresin. Peduncle ca. 3-3.3 × 0.5-0.6 cm. Seeds nearly triangular-ellipsoid, ca. 4-5 × 1.5-2 mm, brown, with wing ca. 13-18 × 6-8 mm, sometimes longer than seed scales and juts out. Bracts spatulate, 1/2-3/5 as long as seed scales; the upper half largely obdeltoid, truncate and cuspidate at apex. - Fig. 4, 5. [20].

Phenology. Pollination unknown; specimens collected in August bear seed old cones, but not opened yet (most of seeds still young but eaten and destroyed by insects), at the meantime all seed cones in May fall down and start to decompose on ground; therefore seed maturity probably from October to December.

Distribution. Only known four trees cultivated from Lung Cu Comm., Dong Van Distr., Ha Giang Prov.

Ecology. Cultivated on primary seasonal tropical completely disturbed by cutting timber and firewood submontane broad-leaved woodlands and scrubs on upper part of slope of limestone mt., on drained, poor in humus, bad quality soil mix with fragmented rocks. This site is situated in the border of Tropic of Cancer with monsoon tropical climate associated with mountains higher than 1500 m elevation.

Specimens examined. - Hà Giang: Dong Van Distr., Lung Cu Comm., Cot Co mt., 23°21'43"N 105°18'59"E, 1309 m, 12-5-2013, cultivated on completely disturbed submontane woodlands on upper part of slope of limestone mt.; evergreen trees, 10-15 m tall, 0.2-0.3 m d.b.h.; new leaves of this year appeared; seed cones fallen down on ground, start to decay, *P.K.Lộc, G.M.Hải P 11127* (HNU); same site, 27-08-2015, origine unknown, introduced probably since 20-30 years, cultivated 4 trees, 14, 16, 19 and 20 m tall respectively, ca. 20, 27, 30 and 32 cm d.b.h. respectively. *P.K.Lộc, N.V.Cương P 11416* collected from tree 20 m tall, 32 cm d.b.h. (HNU), *L.T.Chấn C 180* (HNU).

We suspect that this entity represents a new to science taxon of *Keteleeria*. The scientific name of these specimens at the time being is preliminarily determined as *Keteleeria* sp. Types and descriptions are not mentioned. Further study is needed to determine whether or not it is a new taxon.

3.5. Key to *Keteleeria* taxa

1a. Leaves on seed cone bearing branchlets rarely exceed 4.5 cm long; seed scales at middle of cones longer than 3 cm; seed cones nearly opened more than 5-6 cm in diam.; native species.

2a. Widest site of seed scales at their middle or below the middle

3a. Seed scales at middle of cones distinctly longer than wider, broadest below the middle; distribution very large, growing on non-limestone mountains, from North-Western, Central and ended at southern part of Trường Sơn range 1. *K. evelyniana*

3b. Seed scales at middle of cones as long as or slightly longer than wide, broadest at the middle; distribution very restricted, found only on limestone mts. of two small sites at Na Rì (Bac Kan Prov.).....2. *K davidiana*

2b. Widest site of seed scales at their upper half *K. fortunei*, not found yet in Vietnam

1b. Leaves on seed cone bearing branchlets usually longer than 5.5 cm long; seed scales at middle of cones shorter than 3 cm long, broadest at the middle; seed cones nearly opened less than 4-5 cm in diam.; cultivated taxon in Hà Giang Prov., Đồng Văn Distr., Lung Cu Comm.....3. *Keteleeria* sp.

4. Conclusion

The genus *Keteleeria* in Vietnam has two native species, namely *K. evelyniana*, *K. davidiana*. Further study is needed to determine whether or not it is a new taxon for the entity of specimens collected only from cultivation in Lũng Cú, Hà Giang Prov., and preliminarily determined as *Keteleeria* sp. A key to taxa based on reliable morphological diagnostic characters and their geographical distribution was setting up.

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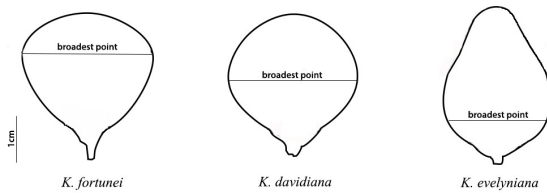


Fig. 1. Shape of seed scales of mature female cones. Drawn by Lê Thị Thu based on the species conception of A. Farjon, and now accepted by taxonomists.

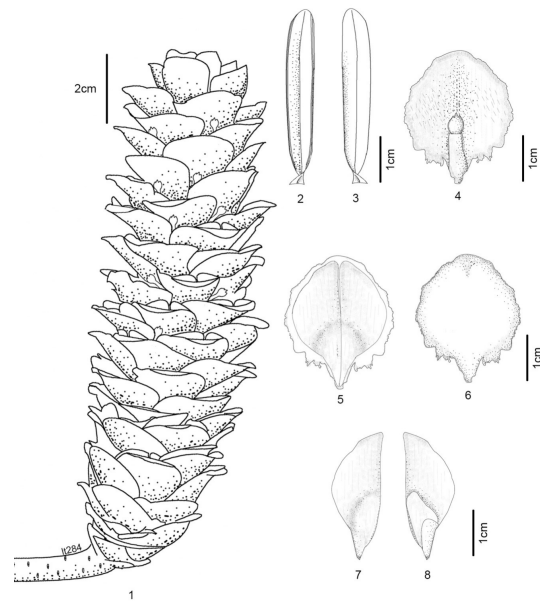


Fig. 2. *Keteleeria davidiana* (đề nghị bỏ dấu chấm).

1. Seed cones; 2. Leaf (abaxial view); 3. Leaf (adaxial view); 4. Seed scales and bracts (abaxial view); 5. Seed scales (adaxial view); 6. Seed scales when seed shed (adaxial view); 7. Seed (adaxial view); 8. Seed (abaxial view). Drawn from P 11228 by Lê Thị Thu.

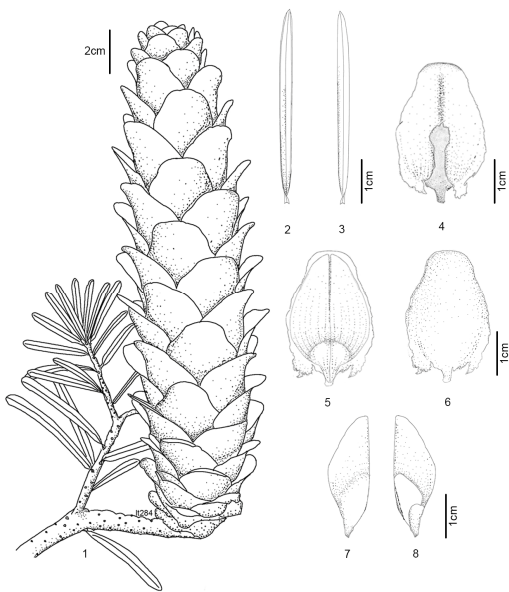


Fig. 3. *Keteleeria evelyniana* (đề nghị bỏ dấu chấm).

1. Seed cones; 2. Leaf (abaxial view); 3. Leaf (adaxial view); 4. Seed scales and bracts (abaxial view); 5. Seed scales (adaxial view); 6. Seed scales when seed shed (adaxial view); 7. Seed and wing (adaxial view); 8. Seed (abaxial view). Drawn from HLF 5382 by Lê Thị Thu.

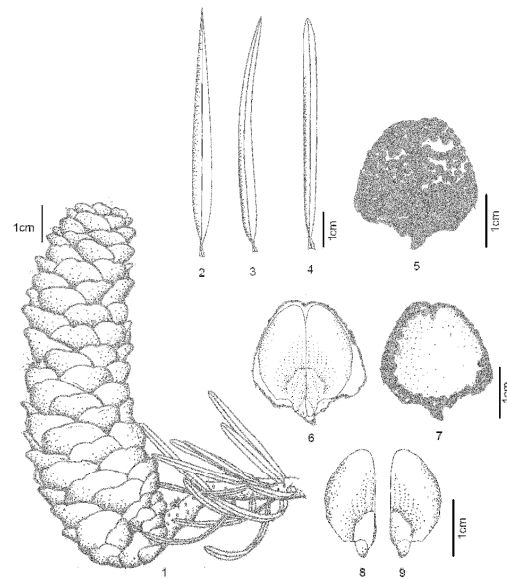


Fig. 4. *Keteleeria* sp.

1. Seed cones; 2, 3. Young leaf (adaxial view); 3. Leaf when mature (adaxial view); 5. Seed scales and bracts (abaxial view); 6. Seed scales (adaxial view); 7. Seed scales when seed shed (adaxial view); 8. Seed with wing (adaxial view); 9. Seed (abaxial view). Drawn from P 11416 by Lê Thị Thu.

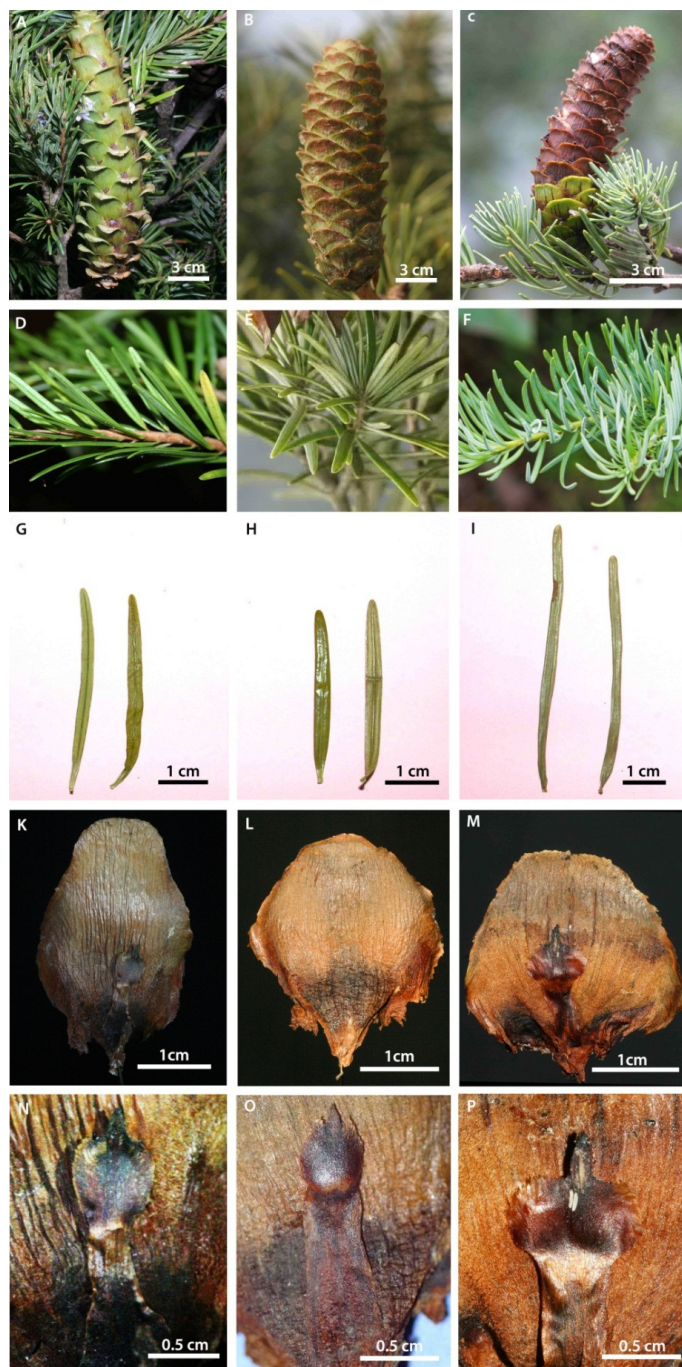


Fig. 5. Comparison between *K. evelyniana*, *K. davidiana* and *Keteleeria* sp.
 A, D, G, K, N: *Keteleeria evelyniana*; B, E, H, N, O: *Keteleeria davidiana*; C, F, I, M, P: *Keteleeria* sp.; A-C: Seed cones; D-F: Leaf arrangement; G-I: Leaves; K-M: Seed scales; N-P: Bracts.
 Photographed by L.T.Thu and P.K.Lộc.

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Nghiên cứu tu chính chi *Du Sam Keteleeria* Carrière (Pinaceae) ở Việt Nam

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Tóm tắt: *Keteleeria* Carrière Du sam là một chi ít loài và phân bố khá hẹp thuộc họ Pinaceae Thông. Cho đến nay đã công nhận 3 loài mọc tự nhiên là *Keteleeria fortunei*, *K. davidiana* và *K. evelyniana*. Ở Trung Quốc gặp cả 3 loài. Ở Lào chỉ mới biết chắc chắn có 1 loài là *K. evelyniana*. Ở Việt Nam chỉ gặp 2 loài là *K. davidiana* và *K. evelyniana*, còn loài thứ ba, *K. fortunei* chưa ghi nhận được; ngoài ra còn thu được mẫu của ba cây trồng ở Lũng Cú. Mục đích của nghiên cứu này là tu chính các loài *Keteleeria* ở Việt Nam dựa trên nghiên cứu 50 số hiệu mẫu vật thu được trong 20 năm qua và được lưu trữ chủ yếu tại HNU. Đã áp dụng phương pháp so sánh hình thái truyền thống. Hình vẽ được thực hiện bằng phần mềm photoshop CS6, ảnh chụp bằng máy ảnh kỹ thuật số Canon EOS với ống kính Macro EF 100 mm có độ phân giải cao. Các dẫn liệu về tên gọi, đặc điểm phân bố, hiện tượng học, sinh thái, hiện trạng bảo tồn, nhận xét là kết quả của việc đối chiếu các Bản tên hợp lệ với các mẫu vật nghiên cứu kèm theo lý lịch chi tiết và tham khảo các tài liệu đã công bố được nêu lên. Các mẫu cây trồng ở Lũng Cú thuộc về chi *Keteleeria*, phân biệt rõ rệt với các loài đã biết và có thể là một taxon mới cho khoa học.

Từ khóa: *Keteleeria*, Du sam mọc tự nhiên, cây trồng Lũng Cú *Keteleeria* sp., Việt Nam.