Pak. J. Bot., 49(5): 2037-2068, 2017.

NATIVE CONIFERS OF VIETNAM – A REVIEW

PHAN KE LOC[1*], PHAM VAN THE[2], PHAN KE LONG[3], REGALADO J[4],AVERYANOV L.V.[5] AND MASLIN B[6]

[1]*Department of Botany, Faculty of Biology, Hanoi University of Science, Vietnam National University, Hanoi, Vietnam*
[2]*Plant Resources Department, Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, Hanoi, Vietnam*
[3]*Vietnam National Museum of Nature, Vietnam Academy of Science and Technology, Hanoi, Vietnam*
[4]*Bunker Hill Community College, Boston, Massachusetts, U.S.A.*
[5]*Komarov Botanical Institute, Russian Academy of Sciences, Saint Petersburg, Russia*
[6]*Honorary Research Associate of Western Australian Herbarium (PERTH) and Singapore Botanic Gardens Herbarium (SING)*
[*]*Corresponding author's email: pkeloc@yahoo.com*

Abstract

This review includes 33 species,2 subspecies and 5 varieties of native conifers belonging to 5 families and 19 genera from Vietnam. The largest family is Pinaceae (5 genera, 13species). Next are Cupressaceae (7 genera, 7 species), Podocarpaceae (4 genera, 7 species), Taxaceae (2 genera, 5 species) and Cephalotaxaceae (1 genus and species). Thirty taxa, representing 90% of the total are assessed as nationally threatened. Among them 3 as - CR (*Cupressus tonkinensis, Glyptostrobus pensilis*, *Xanthocyparis vietnamensis*), 8 as - EN (*Abies delavayi* subsp. *fansipanensis, Calocedrus macrolepis* var. *macrolepis, Cunninghamia lanceolata* var. *konishii, Fokienia hodginsii, Keteleeria davidiana, Pinus armandii* subsp. *xuanhaensis, P. henryi, Taxus wallichiana*) and 19 as VU. Data on morphology, ecology, biology and habitat for acceptedtaxa are updated in the light of critical study of new collections. Notwithstanding the revised information presented here, it is likely that further changes to the conifer flora of Vietnam will occur in the future because many mountain regions remain poorly explored botanically, many existing collections lack fertile parts that are needed for positive identifications, and there exists a number of species-groups that require further critical taxonomic study. These groups include the following: *Keteleeria davidiana* and *Keteleeria evelyniana, Nageia fleuryi* and *Nageia nagi, Taxus chinensis* and *Taxus wallichiana, Tsuga chinensis* and *Tsuga dumosa, Podocarpus annamiensis* and *Podocarpus neriifolius, Pinus dalatensis* and *Pinus anemophila, Pinus kwangtungensis* and *Pinus wangii*. *Podocarpus neriifolius* var. *annamiensis* (N.E. Gray) L.K. Phan, comb. et stat. nov. is also proposed.

Key words: Vietnam Conifers, Native Conifers, Checklist.

Introduction

Conifers form a distinct relictual group of vascular plants, representing the most endangered declining ancient elements of modern world floras. Nevertheless, these plants still play a significant role in many primary plant communities, particularly in temperate and boreal regions, as well as in mountainous areas in the tropics, where they often reach maximal taxonomic diversity (Averyanov *et al.*, 2002, 2008, 2009; Nguyen *et al.,* 2004; Phan *et al.*, 2013b). At the same time conifers are highly vulnerable to numerous destabilizing factors presently affecting the biosphere. Most conifers appear as recognizable indicators of primary plant communities, where they are often dominant or co-dominant of primary native forests. In regional tropical forests these species are precise indicators of intact habitats supporting the highest plant diversity with a full-spectrum of native endemic species.

All native conifers in Vietnam grow in primary closed evergreen forests. However, much of this original vegetation has long-since been destroyed by humans for agriculture. Therefore, thirty taxa, representing 90% of total conifer taxa are now regarded as threatened (Nguyen & Thomas, 2004; Nguyen, 2004; Nguyen *et al.,* 2004; MOST & VAST, 2007).

The first account of conifers in Vietnam was presented in "Flore générale de l'Indo-Chine" (Hickel, 1931), which recognized 14 species from 10 genera. More than sixty years later these numbers increased significantly due mainly to scrutiny of numerous new collections hosted at the herbarium of the Muséum national d'Histoire naturelle (Nguyen & Vidal, 1996). In that account 27 species from 15 genera in 6 families were recognised. Following a series of assessments by Nguyen *et al.,* (2004), Phan *et al.,* (2011) and Phan *et al.,* (2013b), there are today 33 species and 19 genera belonging to 5 families of conifers recognized for Vietnam. The aim of this Checklist is to collate and synthesize scientific knowledge, and determine conservation status, for the native conifers in Vietnam.

Materials

This work is based on a study of all relevant literature to 2015, together with a critical assessment of nearly 800 collections made in Vietnam throughout thirty five provinces (Fig. 6) during the past 20 years. Most of these collections are housed at the herbarium of the Hanoi University of Natural Science, Vietnam National University, Hanoi (HNU).

Results

This assessment represents an annotated list of all currently accepted taxa of Vietnamese native conifers (Table 1), presented in accordance with the taxonomic concepts of the first author of this paper.

The Annotated checklist of native conifers in Vietnam: Annotations for each taxon mostly include the following information: currently accepted scientific name; literature references to bonafide uses of these names; main synonyms used in regional literature; distribution; data on phenology; ecology; uses; Red List IUCN status; notes on taxonomy and biology; selected studied voucher collections arranged by province (given in bold) of occurrence.

Table 1. List of native conifers recognized in the flora of Vietnam.

1.	**Cephalotaxaceae**	9.1.	subsp. *fansipanensis*	22.	*Dacrycarpus imbricatus*
1	*Cephalotaxus mannii*	10.	*Keteleeria davidiana*	23.	*Dacrydium elatum*
2.	**Cupressaceae**	11.	*K. evelyniana*	24.	*Nageia fleuryi*
2.	*Calocedrus macrolepis*	12.	*Pinus armandii*	25.	*N. nagi*
2.1	var. *macrolepis*	12.1.	subsp. *xuanhaensis*	26.	*N. wallichiana*
2.1	var. *rupestris*	13.	*P. dalatensis*	27.	*Podocarpus neriifolius*
3.	*Cunninghamia lanceolata*	14.	*P. henryi*	27.1.	var. *neriifolius*
3.1	var. *konishii*	15.	*P. kesiya*	27.2.	var. *annamiensis*
4.	*Cupressus tonkinensis*	16.	*P. krempfii*	28.	*P. pilgeri*
5.	*Fokienia hodginsii*	17.	*P. kwangtungensis*	**5.**	**Taxaceae**
6.	*Glyptostrobus pensilis*	18.	*P. latteri*	29.	*Amentotaxus argotaenia*
7.	*Taiwania cryptomerioides*	19.	*Pseudotsuga sinensis*	30.	*A. poilanei*
8.	*Xanthocyparis vietnamensis*	20.	*Tsuga chinensis*	31.	*A. yunnanensis*
3.	**Pinaceae**	21.	*T. dumosa*	32.	*Taxus chinensis*
9.	*Abies delavayi*	**4.**	**Podocarpaceae**	33.	*T. wallichiana*

1. Cephalotaxaceae

1. *Cephalotaxus mannii* Hook.f. (Fig. 1A, B)

Hooker's Icon. Pl. 16: tab. 1523, 1886; Hickel, Fl. Gen. Indo-Chine 5: 1066, fig. 122, 1931; Pham, Ill. Fl. Vietnam I, 1: 280, fig. 762, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 116, pl. 9, fig. 1–8, 10–11, 1996; Fu *et al.*, Fl. China 4: 85, 1999;Phan, Gymnospermae, Checkl. Pl. Sp. Vietnam I: 1148, 2001; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 37, 2013b.– *Cephalotaxus oliveri*Mast.,Bull. Herb. Boissier 6: 270. Endemic to China. Records from Vietnam (Pham, Ill. Fl. Vietnam I, 1: 281, fig. 763, 1991) are referable to *C. mannii* (Fu *et al.,* 1999).–*Cephalotaxus oliveri* auct. non Mast. Hickel, Fl. Gen. Indo-Chine. 5: 1066, fig. 122, 1931).– *Cephalotaxus drupacea* auct. non Siebold and Zucc. Pham, Ill. Fl. Vietnam I, 1: 281, fig. 764, 1991.

Vietnamese name: Đỉnh tùng.

Description: Straight–boled trees to 25–30 m tall; trunk to 0.8–1.2 m d.b.h.; bark light brown, flaking off in thin, large pieces; leaves opposite, linear, straight, ca. 2–3 × 0.2–0.3 cm; abaxial stomatal bands bluish white. Pollen cones borne 6–14 together, globose. Seed cones solitary or borne 2 or 3 together, pendulous, ovoid–ellipsoid; aril turning reddish brown when ripe, ca. 22–34 ×11–12 × 8–12 mm.
Distribution: Vietnam (where it is rather common in many forested areas of the following provinces: Ha Giang, Cao Bang, Tuyen Quang, Lao Cai, Lai Chau, Dien Bien, Son La, Hoa Binh, Hanoi, Thanh Hoa, Nghe An, Quang Binh, Quang Tri, Thua Thien–Hue, Kon Tum, Lam Dong and Ninh Thuan) (Phan*,* 1984; Pham, 1991; Nguyen & Vidal, 1996; Phan*,* 2001; Nguyen, 2004; Nguyen *et al.,* 2004; Phan *et al.,* 2010, 2011a). India, Myanmar, Thailand, Laos, China (Sykes, 1991; Fu *et al.,* 1999; Farjon, 2001; Averyanov *et al.,* 2014).
Phenology: Pollination February–March; seed maturity August–October.
Ecology: Scattered, sometimes in small groups in primary closed evergreen seasonal tropical broad-leaved on slopes of non limestone mountains, rarely in coniferous forests on limestone mountains mixed with other conifer species, mainly at elevations 700–1600 m; natural regeneration by seed in some observed locations is good.
Use: The timber is of good quality, it is used for house construction, making furniture and fine arts.
Conservation status: VU (Nguyen *et al.,* 2004), VU (MOST & VAST, 2007).
Notes: Most of the studied herbarium specimens of Vietnam plants were collected from mature but sterile trees and therefore it is difficult to be sure of their identity. The relationship between the Vietnamese entity currently called *Cephalotaxus mannii* and the species *C. hainanensis* H.L.Li and*Cephalotaxus griffithii* Hook.f. that are recognized in southern China (Fu *et al.,* 1999), remains unclear and needsfurther study.
Specimens examined: – Ha Giang Prov., *P.K. Loc et al. CBL 1890*. – Cao Bang Prov., *Aver. et al. CBL 540*. – Lai Chau Prov., *P.K.Loc et al. HAL 8722 and HAL 8786*. – Lao Cai Prov., *N.Q.Hieu et al. CKF 213*(CPC). – Son La Prov., *N.T. Hiep et al. HAL 9508*. – Hoa Binh Prov., *P.K. Loc P 10618*. – Hanoi City., *P.K. Loc s.n*. – Thanh Hoa Prov., *Aver. et al. HAL 4032*. – Nghe An Prov., *P.K. Loc et al. HLF 3133*. – Quang Binh Prov., *Aver. et al. HAL 6202, N.T. Hiep et al. CPC 4237*. – Quang Tri Prov., *Aver. et al. HLF 6274, N.T. Hiep et al. HLF 5953*. – Thua Thien–Hue Prov. *P.K. Loc P 7858*. – Kon Tum Prov. *Aver. et al. VH 979, N.T. Hiep NTH 4757, P.K. Loc P 8507*. – Lam Dong Prov., *Aver. et al. VH 3165*, *L.C. Doan et al. HLF 5377, S.G. Wu et al. WP 1451*. – Ninh Thuan Prov., *Aver. et al. VH 3550*.

2. Cupressaceae

2. *Calocedrus macrolepis* Kurz

J. Bot. 11: 196, t. 133, 1873; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 74, pl. 5: 6-10, 1996; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 49, 2004. – *Libocedrus macrolepis* (Kurz) Benth., Gen. Pl. 3, 1: 426, 1880; Hickel, Fl. Gen. Indo-Chine 5: 1084, fig. 126-127, 1931.

Vietnamese name: Bách xanh.

2.1. *C. macrolepis* var. *macrolepis*

Phengklai, Fl. Thail. 2, 2: 196, 1972; Phan, J. Biol. (Hanoi) 6, 4: 5, 1984; Pham, Ill. Fl. Vietnam I, 1: 276, fig. 749, 1991; Sykes, Guihaia 11, 4: 367, 1991; Fu *et al.*, Fl. China 4: 65, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1149, 2001; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 36, 2013b.

Vietnamese name: Bách xanh núi đất (*Pơ mu giả*)

Description: Trees up to 25–30 m tall withtrunk 0.7–0.9 m in d.b.h., sometimes more; crown broadly rounded when old; branches spreading and ascending in one plane. Leaves decussate, almost in whorls of 4, scale–like, dimorphic along branchlets: facial pairs flattened, lateral pairs boat–shaped, usually less than 4 mm. Pollen cones terminal, solitary, ellipsoid or short cylindric, 4–6 × 2–2.5 mm. Seed cones terminal, solitary, obovoid bifacially flattened, 1.6–2×0.8–1cm, dehiscent when mature, comprising 3 pairs of scales decussate, woody; basal pair sterile, small, ca. 3 mm, recurved; median pair fertile, flattened, 2-seeded; apical pair sterile, connate; peduncle up to 1–1.5 cm long; seeds ellipsoid, rich in oleoresin glands, 6 × 3 mm, slightly flattened, bearing two subapical, unequal wings; seed and wings up to 13–16 × 5 mm, slightly shorter than scales.
Distribution: Vietnam (restricted to Lam Dong and some adjacent areas of Dak Lak and Khanh Hoa Prov. with an isolated occurrence ca. 1000 km north, on Ba Vi mt., Hanoi) (Hickel, 1931; Phan, 1984, 2001; Pham, 1991; Nguyen *et al.,* 2004; Orlova & Averyanov, 2004; Phan *et al.,* 2013b). India, Myanmar, Thailand, Laos, China (Sykes, 1991; Fu *et al.,* 1999; Farjon, 2001; Averyanov *et al.,* 2014).
Phenology: February–March; seed maturity September–October.
Ecology: Clustered and scattered in small groups in primary closed evergreen seasonal tropical forest with other conifer species such as *Keteleeria evelyniana*, or mixed with broad-leaved species on non limestone mountains, slopes and along stream banks, at elevation of 600–1600 m. Trees grow slowly.
Use: Timber of highest quality, rich in essential oil, used for making high quality furniture, fine crafts, high quality incence; sometimes cultivated as ornamental treelet.
Conservation status: VU (Nguyen *et al.,* 2004), EN (MOST & VAST, 2007); protected in Ba Vi, Chu Yang Sin and in some ecotourist sites around Dalat city.
Specimens examined: – Hanoi City., *P.K. Loc, N.D. Kien P 10983, P.K. Loc P 10757*. – Ninh Binh Prov., *N.S. Khang, N.M. Cuong HAL 12846* (CPNP). – Dak Lak Prov., *Aver. et al. HLF 5435*. – Khanh Hoa Prov., *Aver. et al. VH 1437, P.K. Loc et al. P 11225*. – Ninh Thuan Prov., Observation. – Lam Dong Prov., *Aver. et al. HLF 5379, L.C. Doanet al. HLF 5380, P.K. Loc, L.C. Doan P 10958, P 10967*.

2.2. *C. macrolepis* var. *rupestris* (Aver., H.T. Nguyen & L.K. Phan) L.K. Phan, Long K. Phan and Aver. (Fig. 1C, D)

Genetics Mol. Res. 10, 4: 3711, 2011b; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 36, 2013b.- *Calocedrus rupestris* Aver., H.T. Nguyen and L.K. Phan, Taiwania 53, 1: 13, 2008.

Vietnamese name: Bách xanh núi đất (*Pơ mu giả*)

Description: Differs from var. *macrolepis* by peduncles shorter, 0.5-1.5 mm (vs. 3-5 mm) and habitat on limestone mts. (vs. non limestone mts.). Straight-boled trees to 22–27 m tall; trunk to 0.8–1 m or greater; crown wide hemispheric or dome shape. Pollen cones terminal, cylindric when opened, ca. 4–6 × 1.5–2 mm. Seed cones 1.5–2 × 1–1.2 cm.
Distribution: Endemic to Vietnam (limestone areas of Ha Giang, Cao Bang, Tuyen Quang, Son La, Hoa Binh, Nghe An and Quang Binh provinces) (Averyanov *et al.*, 2008, 2012; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2009b, 2011b, 2013b).
Phenology: Pollination January–April; seed maturity October–December.
Ecology: Grows usually in pure stands in primary closed evergreen seasonal tropical forests on cliff slopes and ridge tops of highly eroded solid crystalline white limestone mountains, at elevations 600–1500 m, regeneration by seeds occasionally abundant. Trees grow very slow, observed annual rings are 0.2–0.25 mm wide.
Use: Timber is of high quality, rich in essential oil, used for making high quality furniture, fine crafts sought as replacement for near extinct *Cupressus tonkinensis* for making high quality incence**.**
Conservation status– EN (Nguyen *et al.,* 2004).
Note: Study of the distinctive morphological divergence and ITS1 partial sequences of *Calocedrus rupestris* and *C. macrolepis*has shown that *Calocedrus rupestris*is best regarded as a variety of *C. macrolepis* rather than as a distinct species (Phan *et al.*, 2014b).
Specimens examined: – Ha Giang Prov., *Aver. et al. CBL 1977 and HAL 8548, D.K. Harder et al. DKH 4854 and DKH 6224, N.S. Khang HAL 11857 A, P.K. Loc et al. HAL 1457, HAL 1471, HAL 1493, HAL 1513, HAL 8668 and HAL 11873, P.K. Loc, G.M. Hai P 11114, P.K. Loc*, *Vang Mi Sinh, Vu Mi Xoong P 10909 and P 10910, T.V. Thao ToVT 021, N. Tap 2B, T.V. Dong, N.D. Bien P 10905 and P 10907*. – Cao Bang Prov., *Aver. et al. CBL 1462, N.S. Khang, N.M. Tam CB 4* . – Bac Kan Prov., *Aver. et al. HAL 4919,* 3–6–2004, *P.V. The HAL 5441 (Type), P.V. The HAL 5441 and HAL 5440, S.K. Wu et al. WP 464*. – Tuyen Quang Prov., *N.Q. Hieu et al. CPC 1318*(CPC). – Son La Prov., *Aver. CPC 1864* (CPC), *N.T. Hiep HAL 9447, N.T.Hiep et al. HAL 9315, HAL 9352 and HAL 9514, D.K. Harder et al. DKH 7066 and DKH 5763, N.T. Hiep et al. P.K. Loc, H.V. Thien P 10919, P 10920, P 10921, P 10922, P 10923, P 10924, P 10925, P 10926, P 10927, P 10928, P 10929,P 10930 and P 10931, P.K. Loc et al. DKH 7747*. – Hoa Binh Prov., *N.T. Hiep HAL 629, HAL 754 and 777, N.T. Hiep et al. HAL 367, Tan and Truong* (HNU). – Nghe An Prov., *P.K. Loc et al. HLF 3136*.–Quang Binh Prov., *Aver. et al.*, *HAL 6164, P.K. Loc et al. P 10938, P 10939, P 10940, P 10941, P 10942, P 10943, P 10944, P 10945, P 10946 and P 10947, Wu S.G. et al. WP 1111*.

3.*Cunninghamia lanceolata* (Lamb.) Hook. Bot. Mag. 54: pl.2743, 1827.

Vietnamese name: Sa mộc.

3.1. *C. lanceolata* var. *konishii* (Hayata) Fujita (Fig. 1E, F)

Trans. Nat. Hist. Soc. Form. 22: 49, 476, 1932; Fu *et al.*, Fl. China 4: 55, 1999; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 37, 2013b.-*Cunninghamia konishii* Hayata, Gard. Chron., ser. 3, 43: 194, 1908; Pham, Ill. Fl. VietnamI, 1: 274, fig. 743, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 58, Pl. 4, fig. 7-8, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1165, 2001; Farjon, World Checklist Bibliogr. Conifers 2nd ed.: 44, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 53, 2004.

Vietnamese name: Sa mộc dầu (*Ngọc am*)

Description: Differs from type var. by adult seed cones smaller, rarely exceed 3 × 2.5 cm (vs. 2.5–4.5× 2.5–4) and apex of adult leaves obtuse (vs. spinescent). One of some biggest tree in Vietnam, straight-boled to 40–45 m high and 2–3.5 m d.b.h., crown pyramidal; exuded resin milky white; leaves of adult, bearing pollen and seed cone trees narrowly linear-lanceolate, 2-3 × 0.25 cm. Pollen cone fascicles terminal, usually 1–3 together, broadly obovoid, occasionally around base of seed cone; each cone 1.5–2.5 cm long. Seed cones pendulous, ovoid, persistent for some years after seed dispersal; seed scales in middle of cones broadly-ovate or triangular-ovate, base with short claw, distal part narrowed toward pointed apex, around 13 ×13 mm; seeds dark brown, obovate, narrowly winged laterally, around 4–5 × 2.5–3.5 mm including wings. –
Distribution: Vietnam (Ha Giang, Son La, Thanh Hoa and Nghe An provinces, in the border area with Laos) (Nguyen *et al.*, 2004; Phan *et al.*, 2009a, 2011a, 2013b). Laos, China (Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2003).
Phenology: Pollination January-March; seed maturity January-April in following year.
Ecology: Usually forming pure stands along non limestone rocky stream banks, emergent storey of primary evergreen forests mainly at elevations 1000-1600 m, on thick, humid and well-drained soils; germination of seeds in nature very good, but regeneration very rare because seedlings cannot be emerge from seed scales. Grows very slow, annual ring observed ca. 0.6 mm wide; old trunk sometimes not resistant to rot.
Use: Quality of timber is high, especially when in contact with water, used for making houses, the roofs of which can last some decades, making of very high quality coffins.
Conservation status: EN (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007).
Note: Results of aDNA study of specimens collected in Vietnam (Nguyen *et al.*, 2009b; Nguyen *et al.*, 2011) confirmed the infraspecific rank of this taxon as proposed by Fujita since 1932**.**
Specimens examined: – Ha Giang Prov., *P.K. Loc P 10903, P.K. Loc et al. DKH 6500A.* – Son La Prov., *T.H. Thai et al. 126.* – Thanh Hoa Prov., *P.K. Loc et al. HAL 11184, HAL 11200, HAL 11216 and HAL 11218.* – Nghe An Prov., *Aver. et al. HLF 6551, B.D. Dung P 331* (PMNP), *P.K. Loc et al. HLF 3106, P.K. Loc, N.T. Vinh HAL 11334 and HAL 11348, T.D. Nghia T 181.*

4. *Cupressus tonkinensis* Silba

J. Int. Conif. Preserv. Soc. 1, 1: 23, 1994; Little *et al.* Brittonia, 63, 2: 171–196; Pham *et al.* Bull. Conserv. Conif. Project 2, 1:10–16, 2013; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 38, 2013b.-*Cupressus torulosa* D. Don ex Lamb., Descr. Pinus 2: 18, 1824Farjon, World Checklist Bibliogr. Conif. 2ed.: 50, 2001; auct. non D. Don: Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1150, 2001.-*Cupressus* sp., Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 55, 2004.

Vietnamese name: Hoàng đàn hữu liên (Hoàng đàn kai kinh)

Description: Trees to 20–25 m; trunk to 0.6–0.9 m d.b.h.; crown of young trees pyramidal, turning large spherical in old trees; branches on upper part of trees spreading, on lower parts drooping or pendulous. Branchlets densely arranged, terete or 4–angled, slender 1–1.4 mm in diam. Leaves of pollen and cone branchlets closely arranged, scale-like 1–1.8 mm, flat, decussate, 4–ranked, apex sharply pointed; with an abaxial resin gland. Pollen cones solitary, terminal on lateral branchlets, ellipsoid, 3–5 mm long; microsporophylls 14–16, decussate, each usually with 4 pollen sacs. Seed cones solitary, terminal on lateral branchlets, globose, 1.1–1.8 cm in diam. when open, dark gray brown at maturity; seed scales 6–8, woody, decussate, pentagonal pyramid , bifacially flattened, with short mucro; each fertile scale usually 2–3–seeded. Seed lustrous brown, obovate–rhombic or suborbicular, flattened, ridged, 3–4 × 3–4 mm (including) wings with lateral, narrow wings less than ca. 0.6 mm wide (*HAL 11345*).
Distribution; Endemic to Vietnam (Local endemic in Lang Son province. Restricted to Cai Kinh limestone massif, growing at elevations 300–450 m, between 22°16' and 22°32'N, 105°22' and 105°29'E) (Nguyen *et al.*, 2004; Little, 2011; Pham *et al.*, 2009, 2013).
Phenology: Pollination December–February; seed maturity September–November.
Ecology: Once formed pure stands in primary closed evergreen seasonal tropical conifer forests on ridges of highly eroded solid crystalline white limestone mountains. But it was completely cut in the last 20 years of the past century; later roots were dug up for their essential oils in the manufacture of very high quality incense; most saplings were removed from nature for cultivation in private gardens as precious ornamental; less than 25 small saplings survive on vertical cliffs and show no signs of commercial exploitation (Pham *et al.*, 2013)0. Six treelets have been seen to bear seed cones; regeneration from seed very poor, almost none seen these days. Saplings grow very slowly because of poor soil quality. About 80 trees in cultivation from saplings taken directly from nature around 10–15 years ago cultivated nearby on foot of mountains, on deep, limestone and clay soils rich in humus. Here they grow much better than in wild, after 15 years the average height was 5–7 m with average diam. near ground level 10.4 cm. Trials to propagate by cuttings and to establish plantations were successful (Nguyen T.H., personal comm.).
Use: Timber has straight, fine texture grain that is resistant to termites and insects, aromatic, especially root. Used for making high quality crafts and statues. Planted as an elegant ornamental tree with attractive juvenile foliage and mature shape. Recent surveys have indicated that there is a substantial demand for this species in production of highest quality of incence.
Conservation status: DD (Nguyen *et al.*, 2004), CR (MOST & VAST, 2007); CR A1d (Pham *et al.*, 2013). Protected in Huu Lien nature reserve, *in–situ* and *ex–situ*.
Note: Study of phylogenetic relationship with native *C. funebris* from S China and *ex–situ* collections should be undertaken to better understand the phylogenetic relations between *Cupressus funebris* and *Cupressus tonkinensis*.
Specimens examined:– Lang Son Prov., *Hoang Van Chiem et al. HAL 11220 E, Nong Van Tiep NoT 2336, N.T. Hiep et al. HAL 11918* (CPC), *P.V. The 160*, *P.V. The et al. 402 and H_HL 01 and H_YT 01, P.K. Loc et al. HAL 11290A, P 2004*.

5. *Fokienia hodginsii* (Dunn) A. Henry and H.H. Thomas (Fig. 1G, H)

Gard. Chron., ser. 3, 49: 66-68, fig. 32-35, 1911; Hickel, Fl. Gen. Indo-Chine, 5: 1082, fig. 127, 1931; Phan, J. Biol. (Hanoi) 6, 4: 6, 1984; Sykes, Guihaia 11, 4: 369, 1991; Fu *et al.*, Fl. China 4: 69, 1999; Pham, Ill. Fl.VietnamI, 1: 276, fig. 750, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 76, Pl. 5, fig. 11-15, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1150, 2001; Farjon, World Checklist Bibliogr. Conif. 2ed.: 54, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 57, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 39, 2013b. -*Cupressus hodginsii* Dunn, J. Linn. Soc, Bot. 38: 367, 1908.

Vietnamese name: Pơ mu (*Mạy long lanh*- Thai name)

Description: Straight–boled trees to 25–30 m tall; trunk to 1.2–1.8 m d.b.h. or greater, to 40 × 2.5 m; all plant parts glabrous. Crown of adult trees dome shaped. Branchlets arranged in a plane, flattened; leavesdecussate, in whorls of 4, scalelike, dimorphic along branchlets; facial leaves on adult plants 4–6 mm, ridged; lateral leaves slightly longer than facial ones, 5–7 mm, boot–shaped, with 2 white stomatal bands abaxially. Pollen cones oblong–ellipsoid, ca. 7–8 mm long. Seed cones solitary, terminal on branchlets, usually globose, 2–2.5 cm in diam., comprised of 10–16 woody scales, decussate, peltate, with a free bract apex a mucro; seed cones persistent for some years after seed dispersal; seed scales usually bifacially flattened, pentagonal pyramid, 16 × 8 mm; fertile scales 2–seeded; seeds ovoid, 3–4 ridged, 3.5–4 × 2.5–3 mm, at base with a prominent umbilicus, top including two unequal wings, larger wing ovate–dolabriform, ca. 6–7 × 3.5 mm, smaller wing 1.5–3.5 mm or a mere strip; seed with wing ca. 6–7 × 6–7 mm (voucher specimens – *P 10756, WP 1281B*).
Distribution: Vietnam (Ha Giang, Bac Kan, Bac Giang, Lao Cai, Dien Bien, Son La, Hoa Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Nam, Kon Tum, Gia Lai, Dak Lak, Lam Dong and Ninh Thuan provinces) (Hickel, 1931; Phan, 1984; Pham, 1991; Nguyen & Vidal, 1996; Phan, 2001; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2009a, 2010, 2011a, 2013b; Averyanov *et al.*, 2012). Laos, China (Sykes, 1991; Fu *et al*., 1999; Farjon, 2001; Averyanov, 2014). – **Phenology:** Pollination January–February; seed maturity September–November.
Ecology: Usually forms pure stands at elevations 800–2200 m, mainly on slopes and ridges of non limestone mountainous, on deep, humus–rich, wet and drained soils, rarely onlimestone; natural regeneration by seeds not common.
Use: One of most important timber tree species; grows slowly, observed annual rings are ca. 0.5 mm wide; timber of high quality, rich in essential oils, used for making high quality wood houses and roofs that can last some decades, precious furniture, fine crafts.
Conservation status: EN (Nguyen *et al.*, 2004); EN (MOST & VAST, 2007); protected in Pu Mat, Phong Nha–Ke Bang, Tay Giang, Kon Ka Kinh, Chu Yang Sin, Bidoup–Nui Ba, Phuoc Binh and Hon Ba.

Specimens examined: – Ha Giang Prov., *P.K. Loc et al. HAL 1523 and HAL 11133B.* – Bac Kan Prov.,*Aver. et al. HAL 4742, N.Q. Hieu et al. CPC 1206* (CPC), *P.K. Loc P 4939, P.K. Loc et al. HLF 829*. – Bac Giang Prov., *P.K. Loc et al. HAL 11230.* – Lao Cai Prov., *D.H. Thoi 3781G, DDTTNTV 1156, P.K. Loc et al. HAL 8844*. – Son La Prov., *N.T. Hiep et al. HAL 9714, P.K. Loc, N.T. Vinh HAL 11273, P.K. Loc et al. HAL 11287.* – Hoa Binh Prov., *P.K. Loc P 4939.* – Thanh Hoa Prov., *P.K. Loc et al. HAL 11154 and HAL 11191.*– Nghe An Prov., *Aver. et al. HLF 6933, T.D. Nghia T 1817*. – Ha Tinh Prov., *Aver. et al. HAL 5070, N.T. Hiep et al. VA 74 and VA 297.* – Quang Binh Prov., *Aver. et al. HAL 11730.* –Kon Tum Prov., *Harder et al. DKH 4692.* – Gia Lai Prov., *T.T. Bach et al. KNP 281* (HN), *H.V. Tue HAL 11907.* – Dak Lak Prov., *Aver. et al. VH 6162.* – Lam Dong Prov., *Aver. et al. VH 3053.* – Ninh Thuan Prov. observation.

6. *Glyptostrobus pensilis* (Staunt. ex D. Don) K. Koch (Fig. 1I; 2A)

Dendrol. 2 (2): 191, 1873; Phan, J. Biol. (Hanoi) 6 (4): 10, 1984; Pham, Ill. Fl. VietnamI, 1: 273, fig. 741, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 60, Pl. 4, fig. 9-14, 1996;Fu *et al.*, Fl. China 4: 57, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1166, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 60, 2004; Phan*et al.*, Ecol. Econ. J. (Vietnam) 45: 37, 2013b.– *Thuja pensilis* Staunt. ex D. Don in Lamb., Descr. Pinus, ed. 2, 2: 115, 1828.

Vietnamese name: Thông nước (*Thủy tùng*)

Description: Trees to 20–25 m tall; trunk to 1–1.6 m d.b.h., sometimes more; bark brown, cracking intolong, irregular strips; basal part not long and large buttressed. Crown pyramidal when young, large when old. Main branches spreading horizontally; branchlets dimorphic; perennial branchlets green for several years, annual ones deciduous, short. Leaves trimorphic: leaves on main branches, perennial and fertile branchlets, leaves on annual branchlets of mature trees and leaves of annual branchlets of young trees. Lateral branchlets in two rows, those on older branches often very dense and broomlike; scale leaves on mature branchlets appressed, 1.5–3 × 0.4–0.6 mm; leaves of 1st–year branchlets erect–spreading, sometimes subulate. Pneumatophores up to 5–7 m away from the base. Pollen cones terminal on short, erect branchlets bearing scalelike leaves, solitary, globose; seed cones terminal, shotly pedunculate, erect when mature, pyriform, 20–22– scaled, woody, 1.8–2.5 × 1.5–2.1 cm when opened; basal and distal scales sterile; mediane scales obovate oblong, ca 13–15 × 4–5 mm, two–seeded, pendulous with only one recurving flatty spine on the centre of abaxial face of distal part; seeds narrowly ovoid, slightly flattened, 6–7 × 2.5–3 mm with a triangle, 9–10 mm long wing, acute at apex; seed with wing together 12–15 × 3.5–4.5 mm (voucher photos: *P.K.Loc 24540*).
Distribution: Vietnam (known only from three very small subpopulations in Dak Lak province at Ea Ral, Cư Né và Trap Ksor) (Pham, 1991; Nguyen & Vidal, 1996; Nguyen, 2004; Nguyen *et al.*, 2004; Averyanov *et al.*, 2009; Phan *et al.*, 2013b). No longer exists in the wild in China (Fu *et al.*, 1999) native in Laos (where hundreds of hectares still remain) (Phan *et al.*, 2013b; Averyanov *et al.*, 2014).

Phenology: Pollination October–December; seed maturity around 10–12 months later.
Ecology: Grows in pure stands along stream banks and marshes with slow water flow, at elevation 550–715 m. Nowadays natural regeneration from seeds is not observed any more; observed annual rings are 2 mm wide (voucher specimen *HAL 11948A*) (Averyanov *et al.*, 2009; Averyanov *et al.*, 2014).
Use: Timber good quality, used in making furniture and fine crafts.
Conservation status: CR (2004) (Nguyen *et al.*, 2004); CR (MOST & VAST, 2007). During the eighties and nineties of the last century most areas of *Glyptostrobus pensilis* forest in marshes of Vietnam were destroyed completely for making permanent water rice fields. Trees of this species today, even in protected areas, are dying rapidly because their pneumatophores are submerged in rising water levels caused by the building of dams for fish culture and coffee plantation irrigation (Averyanov *et al.*, 2009; Phan *et al.*, 2013b).
Specimens examined: – Dak Lak Prov., *N.T. Hiep et al. HAL 11349, HAL 11357, HAL 11358, and HAL 11406, P.K.Loc and N.H. Cuong HAL 1194, HAL 11946, HAL 11947, HAL 11948 and HAL 11950.*

7. *Taiwania cryptomerioides* Hayata (Fig. 2B)

J. Linn. Soc., Bot. 37: 330 1906; Fu *et al.*, Fl. China 4: 56, 1999; Farjon, World Checklist Bibliogr. Conif. 2ed.: 97, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 63, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 46, 2013b.

Vietnamese name: Bách tán đài loan.

Description: Tallest, straight–boled trees of Vietnam, up to 40 m high, forming the emergent storey; trunk to 3–3.5 m d.b.h. or greater; bark brownish, cracking into long, irregular flakes; crown pyramidal; main branches horizontally spreading; branchlets pendulous. Leaves spirally arranged, dimorphic: those on old branchlets densely arranged, subulate, scalelike, 3–7 × 0.8–1.2 mm, upward curved; those on young trees and new branchlets "S"–shaped–ovate or subulate, ± quadrangular in cross section, 6–12 × 1.2–2 mm. Pollen cones borne in terminal clusters of 2–7. Seed cones terminal, solitary, erect, small, shotly cylindric to ellipsoid, around 1.2–2.2 × 0.9–1.2 cm when opened, comprising 15–39 seed scales; seed scales on middle cones broadly obdeltoid, 7–8 × 7–8 mm, cuneately narrowed into claw ca. 2/5 × total length of scale, broadening distally into an exposed, rounded–spathulate, transversally convex portion, ovules two per seed scales. Seeds oblong–ovate, 4–7 × 2.5–4.5 mm (including wing 1–1.5 mm wide projecting 1–1.5 mm beyond apex).
Distribution: Vietnam (Lao Cai and Yen Bai provinces, one subpopulation in each) (Nguyen *et al.*, 2002, 2009a; Nguyen, 2004; Phan *et al.*, 2013b). Myanmar, China (including Taiwan) (Fu *et al.*, 1999; Farjon, 2001).
Phenology: Pollination April–May; seed maturity October–November.
Ecology. Grows in primary closed evergreen seasonal tropical forests on non limestone basement rocks, deep, drained soils, at elevations 1700–2100 m, mixed with other conifer species such as *Fokienia hodginsii* along rivulet banks; observed annual rings are 1.7 mm wide (voucher specimen of HAL 12867) (Nguyen *et al.*, 2002, 2009a).
Use: Good timber for house construction including long–term roofing, and furniture manufacture.
Conservation status: CR (Nguyen *et al.*, 2004); CR (MOST & VAST, 2007)0.Threats in Lao Cai province include slash and burn agriculture while in Yen Bai province plants are cut for timber used in building construction and long–term roofing. Protected by FFI Programme.
Specimens examined: – Lao Cai Prov. *N.T. Hiep et al. NTH 5184*. – Yen Bai Prov. *N.T. Hiep et al. HAL 12867.*

8. *Xanthocyparis vietnamensis* Farjon and Hiep (Fig. 2C, D)

Novon 12 (2): 179-189, 2002; Averyanov *et al.*, Turzaninowia 5(4): 31-39, 2002; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 65, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 48, 2013b.

Vietnamese name: Bách vàng việt.

Description: Trees to 25–30m tall; trunk to 1.2–1.5m d.b.h., sometimes greater; crown broad, flattened when mature. Bark soft and fibrous, brown to gray–brown, exfoliating in numerous thin strips. One of the striking morphological features is the occurence of three types of leaves: juvenile leaves found mainly in seedlings and saplings, in whorls of four narrow lanceolate, 1.5–2.5 × 0.15–0.25 cm leaves, radially disposed in others; mature leaves decussate, dimorphic in shape and size; transitional leaves on pollen and seed–bearing cones branchlets predominantly with mature leaves and transitional leaves divided in facial and lateral of nearly equal size; two on mature trees, the 3rd one mainly on seedlings and young saplings. Pollen cones terminal and solitary on lateral branchlets with small scale leaves, elliptic, 2.5–4 × 2–2.5 mm; each microsporophyll bearing 2 microsporangia. Seed cones sparse but sometimes grouped with 2 or 3 together at the outer margins or neare the base of foliage sprays with mature leaves. Mature cones developing in two years, green, turning dark or dull brown, subglobose, 9–11 × 10–14 mm when open, some cones ± persistent after seed dispersal. Seed–scale complexes in 3 (sometimes 4) decussate pairs in normally developed cones; the lowest pair is smallest, aborted; next are the second and third pairs, developed and fertile; the uppermost pair, if present sterile; fertile seed scales peltate and 4–5–angled, widest distally, rounded but irregular upper margin; outer surface smooth, becoming rugose or radiately furrowed from a prominent, 1–2.5 mm long umbo (including the bract apex spine); inner surface red–brown marked proximally with white or gray seed scars; ovules 1 to 3 per fertile bract (upper bracts in 6–scaled cones sterile); seeds up to 8 or 9 per cone, ovoid or irregular, flattened, 4.5–6 × 4–5 × 1.5–2 mm, including two lateral wings.
Distribution: Vietnam (endemic to Ha Giang and Tuyen Quang provinces) (Averyanov *et al.* 2002; Farjon *et al.*, 2002; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2013b). Recently probably found at one site in Guangxi province, southern China (B.X.Wei, pers. comm.).
Phenology: Pollination December–January; seed maturity ca. 12 months, in December–January of the following year.
Ecology: Originally it formed pure stands, rarely mixed with other conifers ,forming the highest storey of primary

non disturbed closed evergreen forests on ridges of limestone mountains at elevations 1100–1600 m. Due to long–term selective cutting, nowadays only small trees remain scattered among *Amentotaxus argotaenia*, *Nageia fleuryi*, *Podocarpus pilgeri* and *Taxus chinensis* as well as angiospermspecies,in the heavily disturbed woodlands and scrubs on cliff slopes and ridge tops of highly eroded solid crystalline white limestone mountains atelevations 1100–1500m; regeneration by seed sometimes observed (Phan *et al.*, 2013b).

Use: Heart wood is fine, yellow–brown, very hard, and fragrant; the superb quality of the wood, has made it a highly prized timber. Most of the timber has been traded locally, used for house construction and in making high quality furniture.

Conservation status: CR (Nguyen *et al.*, 2004); CR (MOST & VAST, 2007). Protected in Bat Dai Son nature reserve.

S**pecimens examined: –** Ha Giang Prov., *Aver. et al. HAL 8464, D.K. Harder et al. DKH 5186, N.T. Hiep et al. NTH 6027, P.K. Loc et al. HAL 1430* and *HAL 1491*. – Tuyen Quang Prov., *PV The et al. CPC 4553*(CPC).

3. Pinaceae

9. *Abies delavayi* Franch.

J. Bot. (Morot) 13 (8): 255, 1899, Fu *et al.*, Fl. China 4: 48, 1999.- *Abies delavayi* var. *nukiangensis* (W.C. Cheng & L.K. Fu) Silba, Phytologia 68 (1): 13, 1990; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 45, Pl. 3, fig. 9-23, 1996; Phan, Gymnospermae, Checkl. Pl. Sp. Vietnam I: 1158, 2001.– *Abies nukiangensis* W.C. Cheng and L.K. Fu, Acta Phytotax. Sin. 13 (4): 83, 1975; Pham, Ill. Fl. VietnamI, 1: 271, fig. 734, 1991.

9.1. *Abies delavayi* subsp. *fansipanensis* (Q.P. Xiang, L.K. Fu & N. Li) Rushforth Int. Dendrol. Yearb.1998: 62, 1999; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 34, 2013b. –*Abies fansipanensis* Q.P. Xiang, L.K. Fu and N. Li, Acta Phytotax. Sin. 35(4): 356, 1997.

Vietnamese name: Vân sam phan xi păng (Lãnh sam hoàng liên sơn). (Fig. 2E, F)

Description: Upright trees to 20–25 m tall; trunk to 0.6–0.8 m d.b.h., sometimes greater; crownalargepyramid, aging dome shaped in very old trees. 1st year branchlets reddish brown, glabrous. Leaves ascending on upper side of branchlets, pectinately arranged in 2 lateral sets on lower sides; linear, ca. 1.8–2.2 cm long, bright green adaxially, margin strongly recurved, glaucous abaxially with stomatal line in two white bands, apex emarginated, scar rounded. Pollen cones borne in leaf axils of previous year's branchlets. Seed cones erect, cylindric, 6–10 × 3.5–4.5 cm; peduncle stout, 1 × 1.2 cm; seed scales closely overlapping, fast and completely disintegrated at maturity, at middle of cones flabellate–trapeziform, 1.6–1.9 × 2.1–2.4 cm, slightly convex, distal part thickened, apex rounded; exposed part glabrescent; bracts included, obovate–cuneate, 2/3– 3/4 as long as seed scales, distal part 2–rounded lobed, margin erose–denticulate, apex with short cuspidate, shorter than two lateral lobes; seeds obtriangular–ellipsoid, ca. 9 × 3.5 × 2 mm, rich in oleoresin; wing cuneate at base, apex truncate, ca. 8–11 × 8 mm; seed with wing ca. 16–18 × 11 mm, 9/10 as long as seed scale.

Distribution: Vietnam (Extremely narrow endemic, found only at the peak of Mount Fansipan, Lao Cai province) (Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2013b).

Phenology: Pollination around April; seed maturity November–December.

Ecology: Formerly grew in pure stands forming primary closed evergreen seasonal tropical subalpine forest on granite or gneiss slopes at the elevation between 2600–3100 m; but in the sixties of the past century all population suffered from fires caused by visitors, only some old trees remaining; nowadays forming scattered highest tree layer of woodlands with the understorey comprised mainly of short bamboos. Regeneration by seed not observed.

Use: Good timber never suffered from exploitation due to remoteness of plants from local villages.

Conservation status: Threats are due to tourist activities, forest fires and lack of natural regeneration. Assessed as VU (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007). Protected in Hoang Lien national park.

Note: We agree with Rushforth in regarding the Vietnamese taxon as a subspecies of a widely distributed *Abies delavayi* which occurs in the floristic Sizang–Yunnan province of the East Asia Region within the Holarctic Kingdom (Farjon, 2001).

S**pecimens examined: –** Lao Cai Prov., *V.V. Chi 3787, N.V. Dien 7095, T.A. Trang, P.K. Loc P 11112, P 11196 and P 11209, Hoang Van Sam s.n.*

10. *Keteleeria davidiana* (Bertrand) Beissn.

Handb. Nadelholzk.: 424, f. 117, 1891; Fu *et al.*, Fl. China 4: 43, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 69, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 40, 2013b.–*Pseudotsugadavidiana* Bertrand, Bull. Soc. Philom. Paris, sér. 6, 9: 38, 1872.– *Keteleeria calcarea* W.C. Cheng and L.K. Fu, Acta Phytotax. Sin. 13 (4): 82, 1975.– *Keteleeria davidiana* var. *calcarea* (W.C. Cheng & L.K. Fu) Silba, Phytologia 68: 34, 1990.

Vietnamese name: Du sam đá vôi.

Description: Trees to 22–28 m tall; trunk to 0.8–1.2 m d.b.h., rarely larger; crown pyramidal, turning conical and broadly dome shaped with age, finally umbrellalike in old trees. Bark grayish brown, irregularly and longitudinally fissured, flaking; bark from 3rd year starts to exfoliate in thin, brownish scales. Winter buds ovoid, ca. 0.4 × 0.3 cm; bud scales reddish brown, rhomboid, slightly convex, margin entire. Axes of first year branchlets grass green, pubescent, turning gray or light brown in 2nd and 3rd year, glabrous. Leaves densely covering branchlets. Leaves of seed cone–bearing branchlets narrowly linear, sometimes slightly falcate, usually 2–3.5 × 0.25–0.3 cm, radially. Leaves of vegetative, non bearing seed cones branchlets of adult trees slightly longer and larger, 2.8–4 × 0.3–0.35 cm, arranged in 2 lateral sets. Leaf blades convex adaxially on both sides of midvein. Leaves not bearing branchlet on 1st year branchlet greenish adaxial, white abaxial except for midvein and narrow marginal bands due to dense stomatal lines, usually 12–14 in each band, occasionally with discontinuous stomatal lines on adaxial face usually 2–8 lines and incomplete. Leaf apex acute, base decurrent into widened flattened, very short and twisted petiole, ca. 2–3 mm, margin

slightly revolute. Pollen cones unknown. Seed cones solitary, erect, terminal on 2nd year horizontally spreading–ascending branchlets; old seed cones cylindric, gradually and slightly tapered distally, 11 × 4 cm, maturing in 1st year, rounded at both ends, brownish then dark brown when mature, sparsely resinous, on stout peduncle, 3–5 × 0.6 cm. Seed cones opened usually 12–18 × 5.5–7 cm. Seed scales closely overlapping, persistent on trees for many years after seed dispersal. Seed scales at middle of cones broadly oval–pentagonal, 2.7–3.4 × 2.2–2.8 cm, oftensubcordate, convex, as long as or slightly longer than wide with the widest point at the middle; all abaxial face of seed scale except for the central area of exposed part densely pannose in the centre, and bordered lateral and bottom sides by warty areas, glabrous adaxial, distal margin entire or slightly serrulate with downward–pointing teeth, apex obtuse rounded, sometimes emarginate, often reflexed, base stalked, woody–leathery with two seeds adaxially, straigh or slightly revolute, margin rounded toward apex, sharply denticulate, apex rounded, slightly retuse or emarginate. Bracts of seed scales included, ligulate–spatulate, ca. ½–3/5 as long as seed scale, adnate basally with scale, ligulate, then a bit enlarged, abruptly terminating in an cusp, narrow triangular, stalked cusp. Seeds obovoid–triangular, 12–16 × 5–7 × 4 mm, rich in oleoresin glands; wing yellowish brown, semitrullate, together with seed at middle part of cone 30–34 × 12–16 mm, rarely sligthly longer than seed scale; lower part of wing forms seed containing room, closed in adaxial face, in abaxial face comprising two flaps, edges of them have stage right nearly triangular–ellipsoid.

Distribution: Vietnam (very rare, known from only two small, adjacent subpopulations, very restricted areas in Kim Hy and Liem Thuy, Na Ri district, Bac Kan province) (Nguyen & Vidal, 1996; Nguyen, 2004; Nguyen *et al.*, 2004; Phan *et al.*, 2013b; Le *et al.*, 2015). China (Sykes, 1991; Fu *et al.*, 1999; Farjon, 200).

Phenology: Pollination unknown; seed maturity October–December.

Ecology: Grows in small groups scattered within primary closed evergreen seasonal tropical forests on ridges of highly eroded solid crystalline white limestone mountains, mixed with other conifer species such as *Pseudotsuga sinensis*, at elevations 500–700 m. –

Use: Timber of good quality, it has been used locallyfor construction and partition houses, making furniture and fine crafts.

Conservation status: EN (Nguyen *et al.*, 2004); EN 0(MOST & VAST, 2007). Protected in Kim Hy nature reserve.

Note: Study of phylogenetic relationships with the more widely distributed *K. evelyniana* would be desirable.

S**pecimens examined: –** Bac Kan Prov., *Aver. et al. HAL 4925, N.T. Hiep et al. NTH 3733*, *P.K. Loc, N.P. Phong P 11096*, *P 11100, P 11229* and *P 11230*

11. *Keteleeria evelyniana* Mast. (Fig. 2G, H)

Gard. Chron., ser. 3, 33: 194 1903; Pham, Ill. Fl. VietnamI, 1: 272, fig. 735, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam. 28: 48, Pl. 3, fig. 17-22, 1996; Fu *et al.*, Fl. China 4: 43, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1158, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 71. 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 40, 2013b.– *Keteleeria dopiana* F. Flous, Bull. Soc. Hist. Nat. Toulouse 69: 404-406, f. 1-13, 1936.– *Keteleeria roulletii* (A. Chev.) F. Flous, Bull. Soc. Hist. Nat. Toulouse69: 406-408, fig. 1-11, 1936; Phan, J. Biol. (Hanoi) 6 (4): 6, 1984.–*Keteleeria hainanensis* Chun and Tsiang, Acta Phytotax. Sin. 8 (3): 259, 1963; Farjon, World Checklist Bibliogr. Conif. 2nd.: 140, 2001.

Vietnamese name: Du sam núi đất.

Description: Straight–boled trees to 30–35 m tall, bole up to 20–25 m long; trunk 1–1.8 m d.b.h. or greater; bark brown, irregularly and longitudinally fissured, flaking in thick pieces; crown of young trees pyramidal, domed shape in old trees. Leaves of adult trees oblong–lanceolate, 3–4.5 cm, stomatal bands abaxially, apex usually mucronate. Pollen cones lateral or terminal, 4–8 in umbellate clusters, arising from a single bud.Seed cones erect, cylindric, 8–18 × 5–7 cm (*HLF 5382*); cones persistent on trees for many years after seed dispersal; seed scales in middle of cones rhombic–ovate, distinctly longer than wide, 3–4 × 2.5–3 cm, apex subacute, erose–denticulate; scales in maturity seed cones largely spread, then decline, creating inclined plane more than 90° for seeds ditching out, similar as in *K. davidiana*. Seeds oblique ovoid, 5–7 mm long; wing brownish, semitrullate, 8–14 mm long.

Distribution: Vietnam (Son La, Thanh Hoa, Nghe An, Ha Tinh, Thua Thien–Hue, Kon Tum and Lam Dong provinces) (Pham, 1991; Nguyen & Vidal, 1996; Nguyen, 2004; Nguyen *et al.*, 2004; Phan, 2001; Phan *et al.*, 2009b, 2010, 2011a, 2013b). Laos, China (Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2014).

Phenology: Pollination February–March; seed maturity November–December.

Ecology: Clustered in small groups in primary closed semi-deciduous seasonal tropical forests, mainly along streams on non limestone mountains, but more common in secondary forests or woodlands mixed with other conifers such as *P. latteri* or *P. kesiya,* regenerates well on abandoned slash and burn areas, on drained, but poor quality soils, at elevations 700–1600 m; regeneration by seeds common.

Use: Observed annual rings are 2 mm wide (voucher specimen- *HAL 11215*) to 2.5 mm wide (*HAL 11285*). Timber is mediocre quality in comparison with that of*K. davidiana* and is used for nonlong-lasting construction and partition houses, making furniture, wrapping materials.

Conservation status: VU (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007).

Note: Study of phylogenetic relationships with the *K. davidiana*, which has a more restricted distribution and occurs on limestone mts, would be desirable.

S**pecimens examined: –** Son La Prov., *Aver. et al. CPC 1156 E*(CPC), *P.K. Loc et al. HAL 11285*. – Thanh Hoa Prov., *P.K. Loc et al. HAL 11215*. – Nghe An Prov., *Aver. et al. HLF 6550, P.K. Loc, L.T. Thu, P 11373*, *P 11382 and P 11389*. – Ha Tinh Prov., *N.T. Hiep et al. VA 400 and VA 440*. – Thua Thien–Hue Prov., *M.V. Pho, N.D. Tao 418*. – Kon Tum Prov., *Aver. et al. VH 2252a.* – Lam Dong Prov., *L.C. Doan et al. HLF 5382, Aver. et al. VH 3134, P.K. Loc P 5204*.

12. *Pinus armandii* Franch.

Nouv. Arch. Mus. Hist. Nat., sér. 2, 7: 95, 1884; Fu *et al.*, Fl. China 4: 23, 1999.

12.1. *Pinus armandii* subsp. *xuanhaensis*

L.K. PhanVNU J. Sci.: Nat. Sci. and Technol., 30 (3S): 53-60, 2014b(Fig. 2I; 3A).–*Pinus armandii* auct. non Franch.: Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 42, 2013b.–*Pinus fenzeliana* Hand.-Mazz., Oesterr. Bot. Z. 80: 337, 1931; Fu *et al.*: Fl China 4: 23, 1999.– *Pinus fenzeliana* auct. non Hand.-Mazz.: Businský: 2011: 80, excl. photo neotype specimen *Businský* Franch.– *Pinus cernua* L.K. Phan ex Aver., K.S. Nguyen and T.H. Nguyen, Nord. J. Bot. 32: 792–793, 2014.

Vietnamese name: Thông xuân nha.

Description: Trees to 20–25 m tall; trunk 0.5–0.7 m d.b.h., rarelyup to 30 × 0.9 m; trunk straight or crooked; bark dark brown–reddish, thick, fissured deeply into square plates and shedding; inner bark reddish–brown, finely fibrous; crown narrowly conical when young, domed shape when old; upper branches suberect, lower branches pendulous; winter buds reddish–brown, cylindric–conical, 1.2–1.6 cm long, 3–5 mm in diam., slightly resinous, scales narrowly lanceolate, 4–5 mm long, 1–2 mm wide at the base, long acuminate, opened and young leaves appear on Mar–Apr; axes of new shoots grass–green; 1st year leafy branchlets brownish, glabrous. Needles tufted at branchlet tips, 5 per bundle, dark green, slender, (11–) 16–21(–23–25) × 0.06–0.08 cm, slightly twisted, margin finally serrulate, flabellate–triangular in cross–section; adaxial surface green without stomata, two abaxial surfaces conspicuous whitish bloomed, each with 4–6 stomatal lines; base with basal sheath ca. 1.1–1.5 cm long, deciduous, and basal scalelike leaves not decurrent; needles persisting for two years, pendulous. Pollen cones numerous, in spiral clusters at the base of new shoots; axe of shoot grass–green, soon turning greyish white; pollen cones suberect, milky–white ovoid, more or less stout, about 0.6 × 0.5 cm before opening, brownish ovoid–ellipsoid, ca. 0.8–1 × 0.3–0.4 cm after opening. Seed cones solitary or commonly clustering by 2–4, even 5–6 in whorl, erect, finally turning horizontal making 90° to main branchlet, dehiscent; peduncles of ripe seed cones stout, about 1.5–2 × 0.6–0.9 cm; ripe seed cones green, maturing dark brown, usually resinous, conical–cylindric before opening, ovoid–conical when opening, 7.5–9.5 × 4.5–6.5 cm, persistent for several years after seed dispersal. Seed scales woody, rigid, rhombic–obovate, in middle of cones 2.6–3.1 × 2.5–2.7 cm; apophyses rhomboid, not ridged, brown when dry, apex not recurved or slightly recurved, obtuse–rounded, and thickened in form of transversal finally grooved cushion, umbo not obvious without mucro; the lower portion of the scale (lower apophysis) dark brown or blackish brown when exposed to the light; longitudinal ridges left in shed seed' hole of scales. Seeds smooth, narrowly obovoid, 13–16 × 7–8 × 4–5 mm, with rudimentary scarious thin wing 1–2 mm wide desintegrating by seed maturity and occasionally remaining in form of low irregular abaxial ridge; seed grey–blackish; seed coat thick 0 (Phan *et al.*, 2014b).

Distribution: Subspecies *xuanhaensis* is a local endemic to Vietnam. It is known only from 3 adjacent subpopulations on E slopes of Pha Luong non limestone mountainous range, Moc Chau district., Son La province, along the border with Hua Phan province, Laos; it probably will be found elsewhere on the same mountain in Laos. *Pinus armandii*. subsp. *armandii* occurs in Myanmar and China (Sykes, 1991; Businský, 2013); it is separated from the more southerly subsp. *xuanhaensis* by some hundred kilometers (Phan *et al.*, 2013b, 2014b; Averyanov *et al.*, 2014).

Phenology: Pollination February–March; seed maturity after 17–18 months, around September–October in following year.

Ecology: This pine usually forms primary evergreen seasonal tropical, monodominant communities, forests or woodlands, occasionally mixed with other conifers such as *Pinus latteri, Fokienia hodginsii, Podocarpus neriifolius* var. *annamiensis, Dacrycarpus imbricatus*, or broad–leaved species, grows on narrow ridges and cliffs of non limestone mother rocks, at elevations 850–1150 m, on deep soil, poor in humus, drained. Seedlings and saplings are rarely observed. Almost all near-ripe seeds are eaten by squirrels direct from seed cones on trees or after cones have fallen, squirrels also eat seedlings. Squirrels are the most serious threat to this pine 0 (Phan *et al.*, 2014b).

Use: This is the native Pinus in Vietnam with the worst wood quality and shortest lifespan. Wood, both sapwood and heartwood are destroyed easily by termites and some other insects, therefore its only use is for provisional construction. Observed annual rings are around 1.5–2.5 mm wide.

Conservation status: CR (Averyanov *et al.*, 2014); EN under criteria A4cd, B1b (iii), B2b (iii, iv, v), C1 (Phan *et al.*, 2014b). Three main criteria are: a. restriction of EOO and AOO; b. absence of natural regeneration; c. number of adult trees is less than 200 distributed in 5 subpopulations, concentrated in Chieng Xuan Comm. Protected in Xuan Nha nature reserve.

Specimens examined: – Son La Prov., *P.K. Loc, P.V. Thang, H.C. Liem P 11077* (holotype: HNU, isotypes: HN, LE, CPC Herb., VNMN, VNM, SGN). Paratypes: Kho Hong: same locality as type specimen, *P.K. Loc et al. P 11078–P 11080*; Po mu ridge: 20º42'08"N, 104º41'21"E, 1010 m, 18–4–2013, *P.K. Loc et al. P 11084–P 11089, P 11177–11179, P 11081–P11082, P 11186–P 11191, P 11244, P 11250, P 11255–P 11263, P 11264–P 11273, P 11274–P 11283, P 11294–P 11302, P.K.Loc, H.C. LiemP 11303–P 11311, P.K.Loc et al. P 11284 and P 11289.*

13. *Pinus dalatensis* Ferré (Fig. 3B, C)

Bull. Soc. Hist. Nat. Toulouse 95: 178, 1960; Phan, J. Biol. (Hanoi) 6 (4): 7, 1984; Pham, Ill. Fl. VietnamI, 1: 270, fig. 729, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam. 28: 40, Pl. 2, fig. 13–16, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1159, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 73, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 43, 2013b; R. Businský, Phyton 53(2): 256, 2013.

Vietnamese name: Thông đà lạt.

Description: Straight–boled trees to 30–35 m tall, even greater, to maximum 40 m; bole up to 20–25 m or more; trunk slightly buttressed at base, to 1.5–2.5 m d.b.h., even greater. Crown domed to broadly obconical. Bark brown, irregular to longitudinal fissured. Buds brown, scales triangular, caudate. 1st year branchlets pubescent, later glabrous. Needles slender, 5 in fascicle, linear, usually 5–9 cm long, 0.05–0.1 mm wide, margin denticulate; stomate lines 2–5 in two adaxial faces; sheath to 1–1.5 cm long, brownish, caducuous. Pollen cones cylindrical, 4–6 × ca. 2 mm, solitary in axil of bud scales at base of 1st–year branchlets. Seed cones pendulous, solitary or several clustered near apex of 1st year branchlets, ovoid to cylindric tapering to apex and base, much various in size, 4–14 × 3–5.5 cm when opened, comprising 30–50 scales; persistent for many years on trees after seed dispersal; peduncle stout, 1–5–1.8 × 0.4–0.6 cm; scales in middle of cone keeled, 2.5–3.5 × 1.4–2.1 cm, narrowly oblong obovoid; apophyses shiny, subrhombic, not ridged, apex obtuse–rounded, slightly recurved; umbo distinct, terminal, abruptly depressed (ending in a slightly recurved protuberance); seeds narrowly ovoid, 8–10 × 3.5–4.5 × 2–2.5 mm, base acuminate, apex obtuse; wing brown, 14–16 × 8–10 mm; 30 mm long including seed.
Distribution: Vietnam (Quang Binh, Quang Tri, Thua Thien–Hue, Kon Tum, Gia Lai, Dak Lak, Khanh Hoa, Ninh Thuan and Lam Dong provinces) (Phan, 1984, 2001; Pham, 1991; Nguyen & Vidal, 1996; Farjon, 2001; Nguyen, 2004; Nguyen *et al.*, 2004; MOST & VAST, 2007; Phan *et al.*, 2010, 2011a, 2013b; Luong *et al*., 2010; Averyanov *et al.*, 2012, 2014; Businský, 2013;). Found recently in Central Laos, eastern Khammuoan and Saravan Prov., in the border region with Vietnam (Averyanov *et al.*, 2014).
Phenology: Pollination February–April; seed maturity after around 19–21 months, October–December in following year.
Ecology: Grows in small pure stands or mixed with other conifers, mainly *Pinus krempfii*, rarely *Fokienia hodginsii, Dacrycarpus imbricatus, Dacrydium elatum* in the highest storey of primary closed evergreen forests on foot of non limestone mountains, along stream banks and pooly drained swamps, on slopes up to ridges with deep soil, rich in humus and drained, from elevations 550 to 2598 m (mainly 1000–1600 m). Natural regeneration occasionally abundant, but seedlings are shade intolerant and plants may require periodic fire to provide clearings for regeneration (voucher photo *10801 P.K. Loc)* (Averyanov *et al.*, 2014).
Use: Timber of good quality and having large size, used for house construction and making furniture.
Conservation status: VU (Nguyen *et al.*, 2004). Main threats are deforestation and selective logging for timber. Protected in Bach Ma, Ngoc Linh, Kon Ka Kinh, Chu Yang Sin, Bi Doup–Nui Ba and Phuoc Binh provinces.
Note: Further study is required to determine if *Pinusanemophila* Businský (from Laos) is a variety of *P.dalatensis* (Averyanov *et al.*, 2014). Both taxa occur in the Giang Man mountain range where at present *P. dalatensis* is recorded for the E slopes in Vietnam (e.g. *HAL 11720* Vietnam, Quang Binh, Minh Hoa, Dan Hoa, 17º41'09" N, 105º44'54" E, 1000–1100 m) and *P. anemophila* (?=*P. dalatensis* var. *anemophila*) from the W slopes in Laos (e.g. *Businský 68102* Khammouan, E margin of Phou Ak plateau, 17º40'21" N, 105º44'54" E, 995 m) (Businský, 2010).
Specimens examined: – Quang Binh Prov., *Aver. et al. HAL 11783 and HAL 12426*. – Thua Thien–Hue Prov., *L.V.Hung HBM5*. – Quang Nam Prov., *Aver. et al. CPC 3575* (CPC)*, CPC 3465* (CPC)*, CPC 3627* (CPC). – Kon Tum Prov., *Aver. et al. VH 165 and VH 498, P.K. Loc et al. P 10205*. – Gia Lai Prov., *T.T. Bach et al. KNP 143* (HN). – Dak Lak Prov., *Aver. et al. VH 6313, V.N. Long NS 029*. – Lam Dong Prov., *T.T.T. Trang et al. HLF 5295, S.G.Wu et al. WP 1360*. – Khanh Hoa Prov., observation. – Ninh Thuan Prov., *S.G. Wu et al. WP 1347 B*.

14. *Pinus henryi* Mast. J. Linn. Soc., Bot. 26: 550, 1902. (Fig. 3D, E)

– *Pinus tabuliformis* var. *henryi* (Mast.) C.T. Kuan, Fl. Sichuan 2: 113, 1983; Fu *et al.*, Fl. China 4: 18, 1999; Phan *et al.* Genet. and Applic. 1–4: 4–48, 2008; *Pinus tabuliformis* subsp. *henryi* (Mast.) Businský, Acta Pruhon. 68: 26, 1999.
–*Pinus hwangshanensis* auct. non W.Y. Hsia: Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 43, 2013b.

Vietnamese name: Thông đá vôi quả nhỏ.

Description: Trees to 25–30 tall and trunk to 0.6–0.8 m; bark brown, thick, scaly outside, pale brown inside; crown flat topped; 1st year branchlets light grayish brown, glabrous, thick, turning dark brown 2nd–3rd branchlets when older; winter buds oblong, slightly resinous; scales rusty pubescent. 1st year branchlets brownish when dry. Needles 2 per bundle, ca. 8–11 × ca. 1 mm; base with persistent sheath, 0.6–1 cm. Pollen cones unknown. Seed cones brown at maturity, usually ovoid to ovoid–globose, rather varying in dimension, 2.5–5.5 × 2.4–4.5 cm, persistent for many years after seed dispersal; peduncle ca. 0.6 × 0.3 cm, seed scales on middle of cones suboblong–obovate, 16–25 mm long, to 12–13 mm wide at apophyses to 0.3–0.4 mm at base; apophyses irregularly rhombic, ca. 1.2–1.4 cm wide, cross keeled; umbo ca. 2 × 3 mm, prodruced into a short (less than 1 mm) and stout spine; unexposed abaxial face slightly pubescent; bracts orbicular, ca. 2 × 1.8 mm, mucronate at apex; seed and wing 13–15 × 5–6 mm, wing articulated to seed; seeds shothly oblong or obovoid, 4 × 3 × 2 mm; all their faces are rich in big resin glands.
Distribution: Vietnam (Ha Giang and Bac Kan provinces) (Nguyen *et al.*, 2007; Phan *et al.*, 2007a; Phan *et al.*, 2008; Businský, 2013; Phan *et al.*, 2013a, 2013b), China (Fu *et al.*, 1999).
Phenology: Pollination March–April; seed maturity about 16–18 months later, August–October in following year.
Ecology: Forms small pure stands on ridges of highly eroded solid crystalline white limestone mountains in primary closed evergreen seasonal tropical conifer forests at elevations 900–1500 m.
Use: The timber is of good quality, but due to its very limited resources it is used only locally in the construction of small houses and in making furniture.
Conservation status: EN A2acd, A3acd, B1+2a, D1 (Phan *et al.*, 2013a); protected only in Na Hang nature reserve.

Note: The relationship between *P. hwangshanensis* W.Y. Hsia from China and *P. henryi* should be re–assessed to see if it is more appropriate to consider these entities as infraspecific taxa of a single species.
Specimens examined: – Ha Giang Prov., *Aver. et al. HAL 8604, P.K. Loc et al. HAL 8679.* – Tuyen Quang Prov., *T.X. Bac HLF 107, H.V. Chat et al. HLF 700, V.V. Chien HLF 117.*

15. *Pinus kesiya* Royle ex Gordon (Fig. 3F)

Gard. Mag. and Reg. Rural Domest. Improv. 6: 8, 1840; Hickel, Fl. Gen. Indo-Chine, 5: 1077, Fig. 125, 1931 [sub *P. khasya* Hook.f.]; Phan, J. Biol. (Hanoi) 6 (4): 7, 1984 [sub *P. khasya* Hook.f.]; Pham, Ill. Fl. Vietnam I, 1: 270, fig. 731, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 32, Pl. 2, fig. 2, 1996; Fu *et al.*, Fl. China 4: 15, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1159, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 75, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 44, 2013b.

- *P. langbianensis* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 24: 25, 1944.

Vietnamese name: Thông ba lá (*Ngotrắng*).

Description: Straight–boled trees to 30 m, bole free of branches 20 m and more; trunk to 0.8–1 m d.b.h., sometimes greater. Crown large pyramidal, turning broadly domed shape when old. Bark brown, thick, irregularly reticulate and deeply fissured, flaking in thick pieces. Winter buds red–brown, conical, slightly resinous. Needles 3 per bundle, slender and flexible, 10–24 × 0.7–1 mm, base with 1.5–1.8 cm sheath, persistent. Pollen cones oblong. Seed cones ovoid to ovoid–conical when mature, usually solitary, paired, sometimes up to 3 together, 5–7.5 × 4.5–6 cm, pendulous, persistent for many years on trees after seed dispersal; seed scales narrowly suboblong, 2.5–3 × 1–1.5 cm; apophyses rhombic, ca. 0.8 × 0.8 cm, obviously transversal ridges; umbo small, transversally ellipsoid, slightly protruded into a stout, short (less than 1 mm), tiny recurved spine. Seeds brownish, slightly appressed, ellipsoid, ca. 7 × 5 × 3.5 mm; wing semitrullate, articulated to seed, 15–25 mm long, with seed ca. 22–32 × 6.5 mm.
Distribution: Vietnam (Ha Giang, Dien Bien, Thua Thien–Hue, Quang Nam, Kon Tum, Gia Lai, Dak Lak, Khanh Hoa, Ninh Thuan, Lam Dong and Dak Nong provinces) (Phan, 1984; Pham, 1991; Nguyen & Vidal, 1996; Nguyen & Thomas, 2004; Nguyen, 2004; Nguyen *et al.*, 2004; Phan *et al.*, 2010, 2011a, 2013b). India, Myanmar, Thailand, Laos, China, (?) Cambodia, Philippines (Phengklai, 1972; de Laubenfels, 1988; Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2014).
Phenology: Pollination mainly January–March; seed maturity about 16–18 months later, July–September in following year.
Ecology: Certainly originally occurred in primary closed evergreen mixed with broad–leaved forests on ridges of non limestone mountains, but subsequently occupying abandoned slash and burn areas on slopes at elevations 900–1400 m; regeneration by seeds is very abundant.
Use: Observed annual rings are 0.5 cm wide (voucher specimens–*P 10975*). One of most important timber sources; the wood has general purpose, used in construction, making mediocre furniture, partition houses, wrapping materials; oleoresin of good quality usually tapped from the trees before complete clearance for timber. One of several tree species largely cultivated in Vietnam (voucher photo: *P.K. Loc 18142).* Planted throughout the tropics.
Conservation status: LC (Nguyen *et al.*, 2004).
Specimens examined: – Ha Giang Prov., Hoang Su Phi (observation).–Dien Bien Prov.,*Aver. et al. CPC 2118* (CPC). – Thua Thien–Hue Prov., *V.X. Phương et al. HLF 939* (HN).–Quang Nam Prov., Nam Tra My, Tra Linh (observation).–Kon Tum Prov., *Aver. et al. VH 162* (HN, LE), *VH 1378* (HN, LE)*, D.K. Harder et al. DKH 4751.*– Dak Lak Prov., *Aver. et al. VH 6401.*– Lam Dong Prov., *Aver. et al. VH 3862* (HN, LE), *VH 4098 and HLF 5390, S.G. Wu et al. WP 1331.* –Dak Nong., *Aver. et al. HLF 5499 and HLF 5511.*

16. *Pinus krempfii* Lecomte (Fig. 3G)

Bull. Mus. Hist. Nat. (Paris) 27: 191,1921; Hickel, Fl. Gen. Indo-Chine 5: 1076, fig. 125, 1931; Phan, J. Biol. (Hanoi) 6 (4): 7, 1984; Pham, Ill. Fl. VietnamI, 1: 269, fig. 726, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 31, Pl. 2, fig. 1-2, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1160, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 77, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 44, 2013b.

– *Ducampopinus krempfii* (Lecomte) A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 24: 30, 1944; Orlova & Averyanov, Turzaninowia 7(2): 30–34, 2004.

Vietnamese name: Thông lá dẹt.

Description: Straight–boled trees to 30–35 m tall, bole up to 20–25 m or longer; trunk 1.4–1.8 m in d.b.h., sometimes greater; trunk slightly buttressed. Crown large oblate. Bark exudes milky resin, thin, dark brown–reddish. Leaves clustered on top of branchlets; base with sheath caducous. Leaves narrowly lanceolate on pollen cone and seed cone bearing branchlets 4–5 × 0.2–0.25 cm, on young and sterile branchlets bigger, 7–9 × 0.35–0.5 cm, thinner. Pollen cones cylindric. Seed cones tilt, solitary, oblong ovoid, when opening 6–9 × 3–4 cm; cones persistent on tree for many years after seed dispersal, seed scales in middle of cone 2.8–3.2 × 0.9–1.1 cm; oblong–hexagonal, keeled; two lateral sides parallel on most of its length, tapering at base, at apex cuneate thickened by two sides of apophyses, reddish brown at maturity; apophyses subrhombic, ca. 11 × 9 mm, obviously transversaly ridged; umbo dorsal, triangular, protruding, not terminating in a spine; peduncle ca. 1 × 0.4 cm. Seeds elliptic, ca. 4–6 × 2.5–3.5 mm; wings ca. 20–24 × 4–5 mm, semitrullate.
Distribution: Vietnam (local endemic, restricted in Lam Dong prov. and in some narrow adjacent areas of Dak Lak, Khanh Hoa and Ninh Thuan provinces) (Pham, 1991; Phan, 2001; Farjon, 2001; Nguyen & Vidal, 1996; Nguyen, 2004; Nguyen *et al.*, 2004; Orlova & Averyanov, 2004; Phan *et al.*, 2013b; Businský, 2013).
Phenology: Pollination probably April–June; seed maturity after ca. 14–16 months, July–November in following year.

Ecology: Grows in pure stands, emergent layer, on ridges of non limestone mountains, on deep, rich in humus and drained soils or mixed with other conifers such as *Pinus dalatensis* or *Fokienia hodginsii* on slopes of mountains, in primary closed evergreen at elevations 1000–1800 m. Regeneration by seeds is rather common, but saplings are rarely seen.
Use: Timber is good quality and large size, used in house contruction and making furniture.
Conservation status: VU (Nguyen *et al.*, 2004); protected in Chu Yang Sin, Bi Doup–Nui Ba and Phuoc Binh.
Specimens examined. – Dak Lak., *Aver. et al. VH 6343*. – Lam Dong Prov., *Aver. et al. VH 2842, VH 3794 and VH 4421, Aver., N.V. Duy HLF 5348, L.C.Doan et al. HLF 5381, T.T.T. Trang et al. HLF 5320 and HLF 5341, S.G. Wu et al. WP 1191 and WP 1432.*

17. *Pinus kwangtungensis* Chun and Tsiang (Fig. 3H, I)

Sunyatsenia 7: 113, 1948; Phan, J. Biol. (Hanoi) 6 (4): 7, 1984; Pham, Ill. Fl. VietnamI, 1: 270, fig. 730, 1991; Fu *et al.*, Fl. China 4: 25, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 79, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 44, 2013b.

– *Pinus wangii* Hu and W.C. Cheng var. *kwangtungensis* (Chun & Tsiang) Silba, Phytologia 68: 64, 1990; *Pinus wangii* subsp. *kwangtungensis* (Chun & Tsiang) Businský, Acta Pruhon. 68: 11, 1999.

Vietnamese name: Thông pà cò.

Description: Trees up to 20–25 m tall; trunk to 0.4–0.6 m d.b.h. or greater; bark brown, scaly exuding oleoresin; 1st year branchlets pale brown, pubescent, 2nd year branchlets glabrescent turning glabrous as older branchlets turn brown, glabrous. Winter buds black brown, slightly resinous. Needles 2–5 per bundle, 3.5–7 × 0.1–0.15 cm; basal with sheath shed; leaves 3–faced, concave; stomates in 4–5 lines on adaxial face. Seed cones usually solitary, pedunculate, erect or subhorizon, reddish brown at maturity, cylindric–oblong or cylindric ovoid, usually 6–12 × 3–5 cm, slightly resinous, opened at maturity, comprising 20–30 seed scales; cones persistent for many years after seed dispersal, peduncle 10–12 × 0.4 cm. Seed scales cuneate–obovate, 2.5–3.5 × 1.8–2.3 cm; apophyses rhombic, apex thin, straight or slightly incurved. Seeds ellipsoid or obovoid, 8–11 × 5–6 × 3.5–4 mm, oleoresin spotted abaxially; wings 16–20 × 7–8 mm, semitrullate; seeds with wing 20 mm, subequal to seed scale.
Distribution: Vietnam (Ha Giang, Cao Bang, Bac Kan, Son La, Hoa Binh and Thanh Hoa provinces) (Phan, 1984, 2001; Pham, 1991; Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Nguyen, 2004; Nguyen *et al.*, 2007; Phan *et al.*, 2007a, 2007b, 2009a, 2013b). China (Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001).
Phenology: Pollination February–April; seed maturity after ca. 18–20 months, August–October in the following year.
Ecology: Usually forms pure stands,sometimes scattered with some other conifer species in primary closed evergreen seasonal tropical forests on ridges of the highly eroded solid crystalline white limestone mountains at elevations 700–1300 m.
Use: Timber is of good quality, used in making local houses and quality furniture.
Conservation status: VU (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007); protected in Thang Heng, Nam Xuan Lac, Hang Kia–Pa Co, Pu Luong, Nam Dong.
Note: Hiêp and Vidal (l.c.) recognized *P. wangii*Hu and W.C. Cheng (*Bull. Fan Mem. Inst. Biol. Peiping* n.s. I: 191. 1948) for Vietnam based on *Chevalier 38353* (which we have not seen), stating that this species is very closely related to *P. kwangtungensis*. The identity of the Vietnamese record and the relationship of these two species requires further investigation. Also, the taxonomic status of *Pinus fenzeliana* Hand.–Mazz. (*Oesterr. Bot. Z.* 80: 337. 1931) which is treated above as a synonym of *P. armandii* subsp. *xuanhaensis*, needs to be reassessed in relation to *P.kwangtungensis*; *P.fenzeliana* is listed inFarjon 0(2001). Businský proposed *P. kwangtungensis* as a subspecies of *Pinus wangii* Hu and W.C. Cheng(Businský, 2013).
Specimens examined: – Ha Giang Prov., *N.T. Hiep et al. NTH 6053, P.K. Loc et al. CBL 1792, CBL 1895, HAL 1450 and HAL 8660.* – Cao Bang Prov., *Aver. et al. HAL 5470, Aver., N.T. Hiep VH 4957, N.S. Khang, N.M. Tam CB 03.* – Bac Kan Prov., *Aver. et al. HAL 4991, N.Q. Hieu et al. CPC 1249* (CPC). – Son La Prov., *L.T. Chan C 111, D.K. Harderet al. DKH 7334, P.K. Loc, Q.V. Quan P 10932.* – Hoa Binh Prov., *N.T. Hiep et al. HAL 823, P.K. Loc, N.H. Nga P 4482.* – Thanh Hoa Prov., *Aver. et al. HAL 3015.*

18. *Pinus latteri* Mason (Fig. 4A, B)

J. Asiat. Soc. Bengal. Sci. 18: 74, 1849; Fu *et al.*, Fl. China 4: 16, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 81, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 45, 2013b.

–*Pinus merkusii* Jungh. and de Vriese, Pl. Nov. Ind. Bot. 5, pl. 2, 1845; Hickel, Fl. Gen. Indo-Chine 5: 1077, fig. 126, 1931; Phengklai, Fl. Thail. 2(2): 193, 1972; de Laubenfels, Fl. Males. Ser. I, 10 (3): 451, 1988; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 35, Pl. 2, fig. 6-8, 1996.

–*Pinus tonkinensis* A. Chev., Rev. Int. Bot. Appl. Agric. Trop. 24: 29, 1944; *P. merkusii* var. *tonkinensis* (A. Chev.) Gaussen ex Bui, Adansonia, sér. 2: 336, 1962.

–*Pinus merkusiana* Cooling and Gaussen, Trav. Lab. Forest. Toulouse T. 1(8, 7): 5, 1970; Phan, J. Biol. (Hanoi) 6(4): 7, 1984; Pham, Ill. Fl. VietnamI, 1: 271, fig. 732, 1991.

Vietnamese name: Thông nhựa (*Thông hai lá*)

Description: Straight–boled trees to 30 m tall or higher, bole up to 20 m or longer; trunk to 1.4–1.8 m d.b.h., sometimes greater; bark gray–brown, thick, scaly; crown large pyramidal–cylindrical; branchlets of 1st year dark brown, glabrous; winter buds brown, cylindric. Needles 2 per bundle, 19–32 × ca. 0.15 cm; sheath ca. 2 cm long, persistent. Pollen cones cylindric, 3–3.5 cm long, brownish red. Seed cones solitary or group in two, red–brown at maturity, conical or ovoid cylindric, 7–13 × 5–7 cm; persistent for many years after seed dispersal; peduncle ca. 1 × 0.5 cm. Seed scales in middle of cones oblong, keeled, 2.9–3.5 × 1.2–1.5 cm; apophyses rhombic, ca. 1.3 × 1.3 cm, slightly swollen and recurved toward apex, flat toward base, obviously radially ridged; umbo small, transversally ellipsoid, slightly protruded into a stout, short (less than 1 mm) spine. Seeds gray–brown, slightly appressed, ellipsoid–ovoid, 6–9 × 3.5–4 mm; wing semitrullate, 22–27 × 8 mm including seed.

Fig. 1. Native conifer species in Vietnam: A, B – *Cephalotaxus mannii* (HAL 4292, 5377); C, D – *Calocedrusmacrolepis* var. *rupestris* (HAL 5441, 8548); E, F – *Cunninghamialanceolata* var. *konishii* (HLF 7056); G, H – *Fokienia hodginsii* (HAL 2430, 6933); I – *Glyptostrobus pensilis* (HAL 11349). Photos by Averyanov.

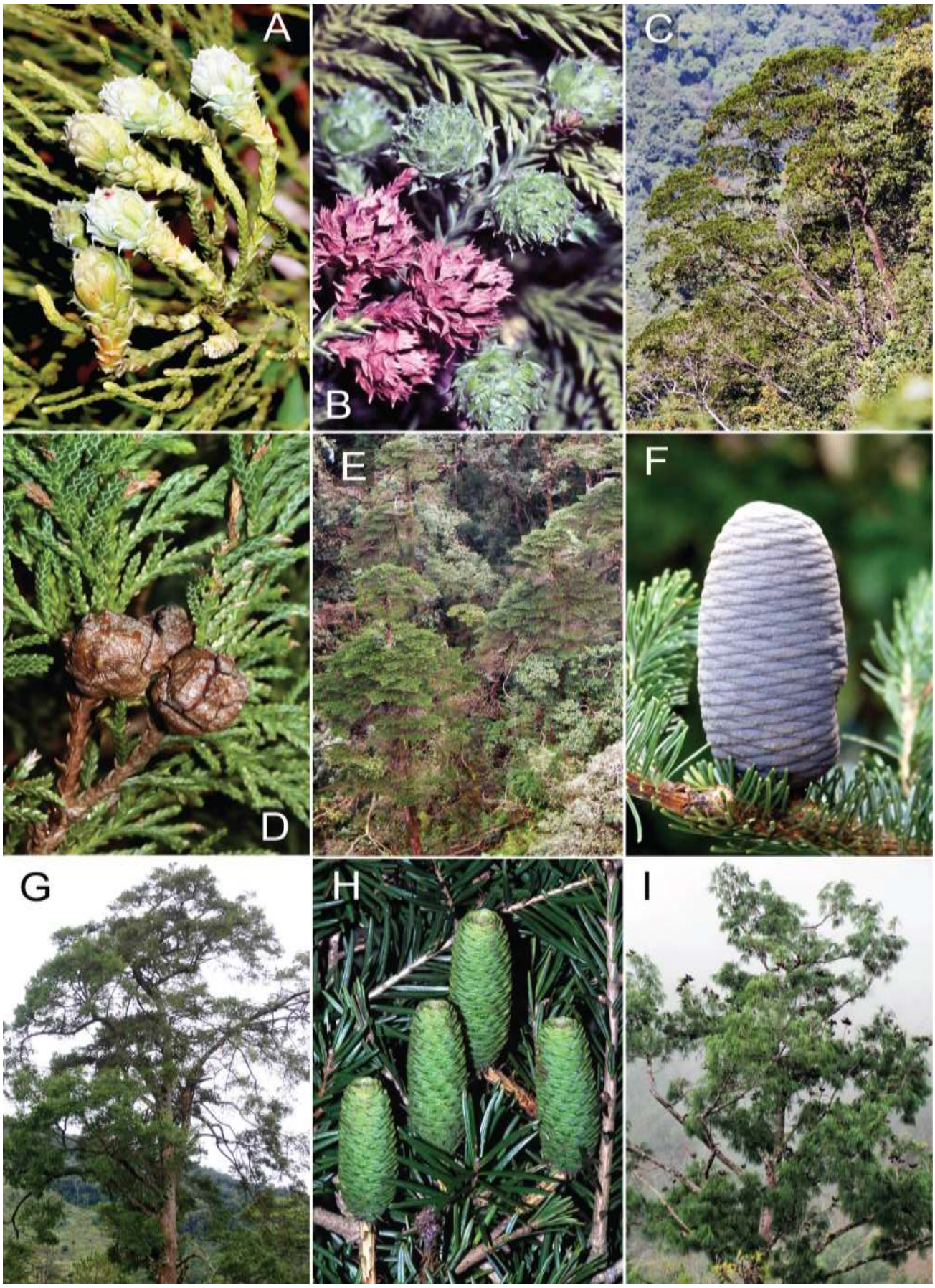

Fig. 2. Native conifer species in Vietnam: A, B – *Glyptostrobus pensilis* (HAL 11349, NTH 5184); C, D – *Xanthocyparisvietnamensis* (CPC 5292); E, F – *Abies delavayi* subsp. *fansipanensis* (P 11196); G, H – *Keteleeria evelyniana* (HLF 5373, 6550); I – *Pinus armandii* subsp. *xuanhaensis* (CPC 6992). Photos by Averyanov, except F by Phan Ke Loc.

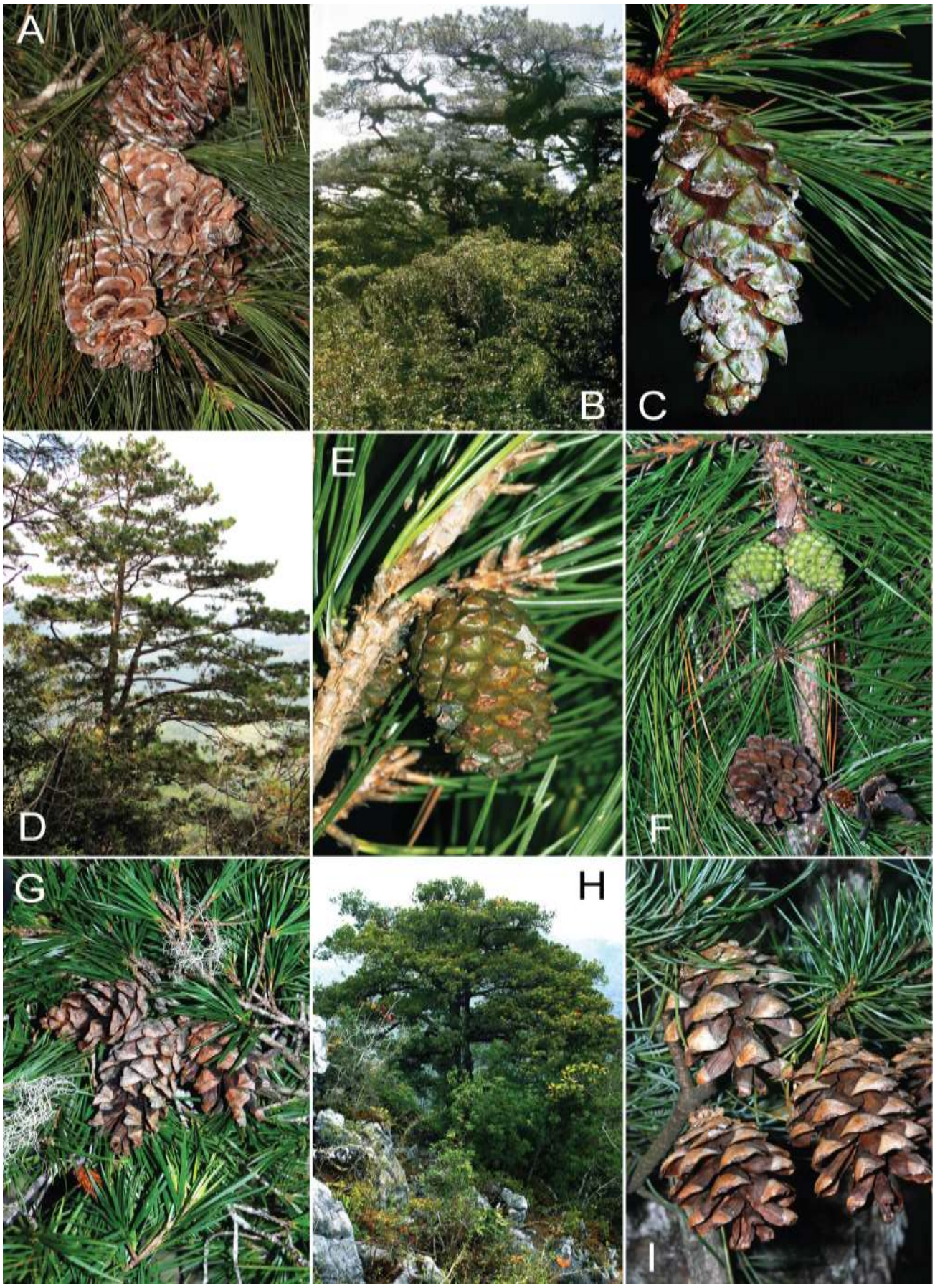

Fig. 3. Native conifer species in Vietnam: A – *Pinus armandii* subsp. *xuanhaensis* (CPC 6992); B, C – *Pinusdalatensis* (HLF 5318); D, E – *Pinus henryi* (CPC 7638); F, G – *Pinus kesiya* (HLF 5381, 5499); H, I – *Pinuskwangtungensis* (HAL 8595). Photos by Averyanov.

Distribution: Vietnam (Thanh Hoa, Nghe An, Ha Tinh, Kon Tum and Dak Lak provinces) (Phan, 1984, 2001; Pham, 1991; Nguyen & Vidal, 1996; Nguyen & Thomas, 2004; Nguyen, 2004; Nguyen *et al.*, 2004; Phan *et al.*, 2010, 2011a,, 2013b; Businský, 2013). Myanmar, Thailand, Laos, China, Cambodia (Phengklai, 1972; de Laubenfels, 1988; Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001).
Phenology: Pollination February–March (voucher from Nghe An); seed maturity after 18–20 months, around August–October in following year.
Ecology: Grows in primary mixed forests with *Dipterocarpus obtusifolius* on periodically inundated swamp forests or woodlands on foot of mountains or in pure stands on lower part of non limestone mountains. Regeneration by seeds is very common, on abandoned slash and burn areas on shallow, infertile, humus-poor, silicate soils.
Use: The timber is mediocre, used for construction, making furniture and wrapping materials; plantations in some areas are the most important source of oleoresin for industry; in the past it was sometimes cultivated around pagodas.
Conservation status: EN (Nguyen *et al.*, 2004). Habitat on foot hills were destroyed completely during the seventies and eighties of the past century for making permanent rice fields, stands on slopes were cut for timber, then replaced by other timber tree plantations such as *Acacia mangium, Eucalyptus* spp.
S**pecimens examined:** Thanh Hoa Prov., *P.K. Loc et al. HAL 11210 and HAL 11214.* – Nghe An Prov., *Aver. et al. HLF 7093.* – Ha Tinh Prov., *N.T. Hiep et al. VA 496.* – Kon Tum Prov., *Aver. et al. VH 2210, N.T. Hiep NTH 4674.* – Dak Lak Prov., *Aver. et al. HLF 5439*.

19. *Pseudotsuga sinensis* Dode (Fig. 4C, D)

Bull. Soc. Dendrol. France 7: 58, 1912; Fu *et al.*, Fl. China 4: 38, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 84. 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 46, 2013b.

– *Pseudotsuga brevifolia* W.C. Cheng and Fu, Acta Phytotax. Sin. 13 (4): 83, 1975.

– *Pseudotsuga sinensis* Dode var. *brevifolia* (W.C. Cheng & Fu) Farjon and Silba, Phytologia 68: 71, 1990.

Vietnamese name: Thiết sam giả (*Sá côống, Súa cúng*-HMông name)

Description: Trees to 20–25 × 0.5–0.7 m, occasionally larger; bark brown, irregularly and thickly scaly; crown domed shape; branchlets of 1st year usually glabrescent; of 2nd year and older glabrous. Leaves of pollen and seed–bearing cones branchlets pectinately arranged, linear, usually 2–3 × 0.2–0.25 cm, and two whitish–greenish stomatal bands on abaxial face, obtuse, rarelly emarginate at apex. Pollen cones axillary, solitary, pendulous, oblong–cylindric, 4–5 × 2.5–3.5 mm; peduncle 3–4 mm long, covered by scales. Seed cones developing from axillary buds near ends of 2nd year branchlets, maturing in 1st year, usually ovoid, 4–8 × 2.5–5.5 cm; seed scales in middle of cones variously shaped, semiorbicular, flabellate or reniform, convex, woody, margin rounded toward apex, 2.3–2.8 ×2.8–3.6 cm, rusty brown pubescent abaxially on exposed part, glabrous of nonexposed part as well as adaxial face; base broadly cuneate or almost truncate, concave at sides, persistent on trees for many years after seed dispersal; bracts exserted, reflexed, cusp narrowly triangular, ca. 3 mm, lateral lobes triangular, margin erose; seeds spotted with oleoresin glands; seeds borne in a shallow, membranous cup covering 1 side of seed, including wing up to 21–25 x 9–10 mm, semitrullate.
Distribution: Vietnam (Ha Giang, Cao Bang and Bac Kan provinces) (Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2009a, 2013a, 2013b; Nguyen *et al.*, 2011). China (Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001).
Phenology: Pollination March–May; seed maturity October–November.
Ecology: Forms pure stands, rarely mixed with other conifers such as *Keteleeria davidiana*, on narrow ridge-tops or cliffs of highly eroded solid crystalline white limestone mountains at elevations 700–1300 m.
Use: Timber is of good quality, used for local house construction and making furniture.
Conservation status: VU (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007); protected in some NR such as Bat Dai Son, Nam Xuan Lac, Kim Hy.
S**pecimens examined:** – Ha Giang Prov., *Aver. et al. HAL 8547, D.K. Harder et al. DKH 5166, N.T. Hiep NTH 5971, NTH 6029 and NTH 6034, P.K. Loc P 10914, P.K. Loc et al. CBL 1848, CBL 1881, HAL 1428 and HAL 11871, C.I. Peng et al. 19940.* – Cao Bang Prov., *Aver. et al. CBL 245, CBL 385, CBL 747, CBL 909, CBL 1052, CBL 1131, VH 2451 and HAL 5499* . – Bac Kan Prov., *Aver. et al. HAL 4917, S.K. Wu et al.WP 552*.

20. *Tsuga chinensis* (Franch.) E. Pritz. (Fig. 4E, F)

Bot. Jahrb. Syst. 29: 217, 1900; Phan, J. Biol. (Hanoi) 6 (4): 10, 1984; Fu *et al.*, Fl. China 4: 40, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 86, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 47, 2013b.

–*Abies chinensis* Franch., J. Bot. (Morot) 13 (8): 259, 1899.

– *Taxus celebica*auct. non (Warb.) H.S. Li; Pham, Ill. Fl. VietnamI, 1: 280, fig. 760, 1991.

Vietnamese name: Thiết sam đá vôi (*Súa chầy* – HMông name)

Description: Trees to 20–25 m tall; trunk to 0.6–0.8 m d.b.h., sometimes a bit more; bark dark gray, longitudinally fissured, flaking; crown hemispherical; branchlets brown–yellow in 1st year, turning reddish–brown in 2nd year old, glabrescent; leaves pectinately arranged, linear, 9–17 × 2–3 mm, abaxial with two greenish stomatal bands both sides of midvein, larger than marginal bands, apex obtuse or emarginate. Pollen cones solitary, in axil of leaves on the second year branchlets; oblong, 5–7 × 3–4 mm, peduncle thin, 3–5 mm long. Seed cones ovoid 1.4–2.6 × 1.4–3 cm when opened; persistent for many years after seed dispersal;seed scales at middle of cones square–orbicular or pentagonal–ovate, 1–1.4 × 0.8–1 cm, apex rounded, pubescent on covered parts abaxial; bracts cuneate–obovate, ca. 4 mm long, 2–lobed; seeds narrowly triangular, 3–4 × ca. 1.5 mm, covered by large oleoresin glands; seed with wing 10–12 × 3.5–4.5 mm, shorter than seed scale.

Distribution: Vietnam (Ha Giang and Cao Bang provinces) (Nguyen & Vidal, 1996; Phan, 2001; Nguyen *et al.*, 2004; Nguyen *et al.*, 2007; Phan *et al.*, 2007a, 2007b, 2009a, 2013a, 2013b). China (Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001).
Phenology: Pollination April–May; seed maturity October–December.
Ecology: Forms pure stands, sometimes mixed with other conifers such as *Pseudotsuga sinensis* in primary closed evergreen seasonal tropical conifer forests on narrow ridge-tops of highly eroded solid crystalline white limestone mountains at elevations 1400–1600 m; usually at slightly higher elevations than that of *Pseudotsuga sinensis.*
Use: Timber of good quality, used for building local houses and furniture making.
Conservation status: EN (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007); protected in Bat Dai Son nature reserve.
S**pecimens examined:** – Ha Giang Prov., *Aver. et al. HAL 8533*, *N.T. Hiep et al. NTH 6037, P.K. Loc P 10915, P.K. Loc et al. CBL 1733, CBL 1841, CBL 1885, HAL 1448, HAL 8589 and HAL 8663.* – Cao Bang Prov., *Aver. et al. CBL 156.*

21. *Tsuga dumosa* (D. Don) Eichl.

In Engler and Prantl, Nat. Planzenfam. 2 (1): 80, 1887; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 43, Pl. 3, fig. 1-8, 1996; Fu *et al.*, Fl. China 4: 40, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1161, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 88, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 47, 2013b.

– sub. *Tsuga yunnanensis* (Franch.) E. Pritz., Pham, Ill. Fl. VietnamI, 1: 272, fig. 736, 1991.

– *Pinus dumosa* D. Don, in Lamb.Descr. Pinus 2: 55, 1824.

Vietnamese name: Thiết sam núi đất.

Description: Trees to 25–30 m tall and to 0.9–1.2 m d.b.h., or greater; branchlets ridged and grooved. Leaves linear, 2.2–2.6 × 0.25–0.3 cm, apex obtuse. Seed cones maturing light brown, ovoid when opened, ca. 2.5–2.7 × 2.4–2.6 cm; persistent for many years after seed dispersal; seed scales obovoid, ca. 1.4 × 1 cm; bracts cuneate–rhombic, apex shallowly 2–lobed. Seeds obliquely, narrowly ovoid or triangular, with resin glands on all faces, ca. 6 × 2.5 mm; wing semitrullate, with seed ca. 12 × 4 mm.
Distribution: Vietnam (restricted only in Lao Cai province, especially on the highest granite mountain Fansipan) (Nguyen & Vidal, 1996; Phan, 2001; Nguyen *et al.*, 2004; Phan *et al.*, 2013b). India, Bhutan, Nepal, Sikkim, Myanmar, China (Fu *et al.*, 1999; Farjon, 2001).
Phenology: Pollination April–May; seed maturity October–November.
Ecology: Scattered at elevations 2400–2900 m, on slopes of non limestone mountains, at higher elevations than *Tsuga chinensis* and on different basement rocks. Rather common on slopes of Fansipan mt., mixed with *Abies delavayi* subspecies *fansipanensis*.
Use: The timber is occasionally used for construction and furniture if plants are not far from local villages; sometimes cut branches used as ornamental during lunar year holidays.
Conservation status: VU (Nguyen *et al.*, 2004); protected in Hoang Lien national park.
Note: Although *T. chinensis* and *T. dumosa* differ in their habitat preferences and geographic distribution, they are very similar morphologically (including seed cones). Further study is needed to clarify their phylogenetic relationship 0 (Fu *et al.*, 1999).
S**pecimens examined:** – Lao Cai Prov., *D.H. Thoi 3798, N.V. Dien 1964, D.T. Doan DT 001.*

4. Podocarpaceae

22. *Dacrycarpus imbricatus* (Blume) de Laub. (Fig. 4G, H)

J. Arnold Arbor. 50(3): 317, 1969; Phan, J. Biol. (Hanoi) 6 (4): 8, 1984; de Laubenfels, Fl. Males. Ser. I, 10 (3): 376, 1988; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 97, Pl. 7, fig. 6-7, 1996; Fu *et al.*, Fl. China 4: 79, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1161, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 90, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 38, 2013.

– *Podocarpus imbricatus* Blume, Enum. Pl. Javae 1: 89, 1827; Hickel, Fl. Gen. Indo-Chine 5: 1068, 1931; Phengklai, Fl. Thail. 2(3): 201, 1975; Pham, Ill. Fl. VietnamI, 1: 277, fig. 752, 1991.

Vietnamese name: Thông lông gà.

Description: Straight–boled trees to 30–35 m tall, bole up to 20–25 m or more; trunk to 1.5–2 m d.b.h. or greater; crown of old trees spreading, domed shaped. Bark superficially dark brown, reddish–brown, and granular fibrous within, flaking in thin and large strips; bark exuding reddish–brown resin. Leaves dimorphic: juvenile leaves two–ranked and forming an oblong branchlet outline, about 3–7 cm long; adult leaves scalelike, 1–1.5 × 0.4–0.6 mm, base keeled, apex acute or apiculate or base decurrent, apex obliquely incurved–apiculate; apiculus 0.2–0.3 mm. Pollen cones cylindric, 8–12 mm long. Seed–bearing structure terminal, and often borne on short, lateral branchlets, pedunculate, with appressed or spreading, bractlike leaves at base of peduncle; apical 1 or 2 bracts fertile; basal bracts fused to form a succulent, warty obovoid receptacle, bifacially slightly flattened, 0.9–1.1 × 1–1.2 × ca. 0.8 cm, at first green, turning yellowish, orange, red, finely reddish–brown; epimatium wholly enveloping seed covered by white powder layer, when ripe yellowish, turning brownish, finally brown. Seeds subglobose, 7–9 × 6–7 mm (*HLF 5294*).
Distribution: Vietnam (Ha Giang, Bac Giang, Quang Ninh, Lao Cai, Lai Chau, Son La, Hoa Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien–Hue, Da Nang, Quang Nam, Kon Tum, Gia Lai, Dak Lak, Lam Dong, Dak Nong and Kien Giang provinces) (Phan, 1984, 2001; Pham, 1991; Nguyen & Vidal, 1996 Nguyen, 2004; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2009a, 2010, 2011a, 2013b; Averyanov *et al.*, 2012). Myanmar,

Thailand, Laos, China , Cambodia, Malaysia, Philippines, Indonesia and many islands of Pacific Ocean (de Laubenfels, 1988; Phengklai, 1975; Sykes, 1991; Fu *et al.,* 1999; Farjon, 2001; Averyanov *et al.*, 2014).
Phenology: Pollination January–February; seed maturity September–November.
Ecology: Dominant in the highest storey of primary closed seasonal tropical evergreen mixed forests at 50–1800 m elevation, on non limestone mountains, rarely forms pure stands on ridge-tops of limestone mountains. Natural regeneration from seed is common.
Use: Important and good source of timber of high quality (fine, light, easily worked) used in making high quality furniture and for internal construction in house. Observed annual rings are 1.2–1.3 mm wide (voucher specimen-*HAL 11286*); density around 0.56.
Conservation status: VU (Nguyen *et al.*, 2004); protected in Bat Dai Son, Yen Tu, Hoang Lien, Phong Nha–Ke Bang, Bach Ma, Ba Na–Nui Chua, Chu Mom Ray, Chu Yang Sin, Bi Doup–Nui Ba and Ta Dung.
Specimens examined: – Ha Giang Prov., *Aver. et al. HAL 6410, N.S. Khang HAL 11944, N.Q. Hieu et al. CKF 071* (CPC), *N.T. Hiep et al. CPC 228* (CPC), *CPC 329* (CPC), *P.K. Loc et al. HAL 1475, HAL 6624, HAL 6631 and HAL 11137B.* – Bac Giang Prov., *DDTTNTV 3799* (HNU), *P.K. Loc P 3799 C* (P), *P.K. Loc, N.T. Vinh HAL 11228.* – Quang Ninh Prov., *P.K. Loc et al. HAL 11237.* – Lao Cai Prov., *D.K. Harder et al. DKH 6877, DKH 6878 and DKH 6882, N.Q. Hieu et al. CKF 252*(CPC) .–Lai Chau Prov., *N.T. Hiep et al. HAL 9794 and HAL 9859, P.K. Loc et al. HAL 8823.* – Son La Prov., *D.T. Mien 1701, N.T. Hiep et al. HAL 9713, P.K. Loc P 797, P.K. Loc et al. P 11076 and P 11083, P.K. Loc, N.T. Vinh HAL 11274, HAL 11276 and HAL 11286.* – Hoa Binh Prov., *N.T. Hiep et al. HAL 419.*–Thanh Hoa Prov., *Aver. et al. HAL 2976 and HAL 3078, P.K. Loc et al. HAL 11199 and HAL 11209.*–Nghe An Prov., *Vo Minh Son et al. HLF 3088.* –Ha Tinh Prov., *N.T. Hiep et al. VA 307*(HN).– Quang Binh Prov., *Aver. et al. HAL 6212, HAL 6245, HAL 11537, HAL 11669, HAL 11770, HAL 12258, HAL 12387 and HAL 12507, N.T. Hiep et al. CPC 3726 and CPC 4372* (CPC). – Quang Tri Prov., *P.K. Loc et al. HLF 6158.*–Thua Thien–Hue Prov., *Aver. et al. HAL 6905, HAL 7179, HAL 7552, HAL 8054, CPC 3080 and CPC 3133* (CPC), *N.T. Hiep et al. HLF 1038 and HLF 1696, J.C. Regalado et al. CFH–014.* –Da Nang City, *Aver. et al. CPC 3313*(CPC), *S.K. Wu et al. WP 241.*– Quang Nam Prov., *Aver. et al. HAL 11964.* –Kon Tum Prov., *Aver. et al. VH 1853, VH 2222 and VH 2329, N.H. Hien 572 and N.H. Hien 573, N.T. Hiep 4424, P.K. Loc P 7904, P 7903, P 8457 and P 10207.* – Gia Lai Prov., *P.K. Loc P 2808, P.K. Loc, L.X. Tham P 2808, T.T. Bach et al. KNP 123* (HN).– Dak Lak Prov., *Aver. et al. HLF 5420.* – Lam Dong Prov., *Aver. et al. VH 3758, VH 2535 and VH 2755, N.D. Chinh 905, N.M. Tam, V.D. Duy HT–DI 001, P.K. Loc P 2491 B, S.G. Wu et al. WP 1200 and WP 1356.*– Dak Nong Prov., *Aver. et al. HLF 5556 and HLF 5613, S.G.Wu et al. WP 1558.* – Kien Giang Prov., *Dang Minh Quan 21069* (private collection).

23. *Dacrydium elatum* (Roxb.) Wall. ex Hook. (Figs. 4I; 5A)

London J. Bot. 2: 144, tab. 2, 1843; Phengklai, Fl. Thail. 2(3): 201, 1975; Pham, Ill. Fl. VietnamI, 1: 279, fig. 758, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 92, Pl. 7, fig. 1-5, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1162, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 92, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 39, 2013b.

– *Dacrydium pierrei*Hickel, Bull. Soc. Dendrol. France 76: 74, 1930; Phan, J. Biol. (Hanoi) 6 (4): 8, 1984.

Vietnamese name: Thông đuôi chồn (*Hoàng đàn giả; Hồng tùng*)

Description: Big trees to 25–30 m tall; trunk to 1.2–1.8 m d.b.h., or more; crown of old trees spreading, domed shaped. Bark gray brown, reddish–brown, shallowly fissured, exuding resin; leaves dimorphic: juvenile leaves 12–17 × 0.4 mm, at first falcately curved forward, apex tapered, then spreading, not 2–ranked, linear to needlelike or subulate; adult leaves crowded, normally appressed, scalelike of subulate, ca. 1 mm, hard, changing abruptly from juvenile (intermediate leaves linear, quadrangular in cross–section, 2–5 mm). Pollen cones terminal on branchlets bearing intermediate leaves, solitary, cylindrical, 5–6 × 1.5 mm. Seed–bearing structures terminal, composed of several bracts, normally only one fertile, others (about 16–20) sterile, fleshy, swollen and brightly coloured at maturity (forming pseudo–receptacle becoming fleshy and brightly colored at maturity), 3–4 × 2 mm; seeds becoming inclined or inverted at maturity; in epimatium shallow cup (ca. 5–6 × 1–2 mm); seed narrowly ovoid, lustrous, 4–4.5 × ca. 3 mm, dark violet, finally blackish when ripe (voucher specimen: *HAL 12385*).
Distribution: Vietnam (Ha Giang, Tuyen Quang, Quang Ninh, Lai Chau, Ha Tinh, Quang Binh, Thua Thien–Hue, Da Nang, Kon Tum, Gia Lai, Dak Lak, Lam Dong and Kien Giang provinces) (Pham, 1991; Nguyen & Vidal, 1996; Phan, 2001; Nguyen, 2004; Nguyen *et al.*, 2004; Phan *et al.*, 2007a,, 2010, 2011a, 2013b; Averyanov *et al.*, 2012). Myanmar, Thailand, Laos, Cambodia, Malaysia, Indonesia (de Laubenfels, 1988; Sykes, 1991; Fu *et al.*, 1999; Averyanov *et al.*, 2014).
Phenology: Pollination January–February; seed maturity November–December.
Ecology: Grows in primary closed evergreen seasonal tropical mixed or forms pure stands on non limestone mountains, on deep, drained soils, at elevations 100–1400 m, rarely found on ridge-tops of highly eroded solid crystalline white limestone mountains. –
Use: Timber is water resistant and used for construction of boats, bridges, furniture and houses.
Conservation status: VU (Nguyen *et al.*, 2004); protected in Na Hang, Phong Nha–Ke Bang, Ba Na–Nui Chua, Kon Ka Kinh, Chu Yang Sin, Bi Doup–Nui Ba, Nui Chua, Phuoc Binh and Phu Quoc.
Note: A study of phylogenetic relationships between *D. elatum* and D. *pectinatum* de Laub. (from S China) is desirable to determine if they are specifically distinct (Fu *et al.*, 1999).
Specimens examined: – Ha Giang Prov., *D.K. Harder et al. DKH 4962.* – Tuyen Quang Prov., *Aver. and P.K. Loc HAL 1703, P.K. Loc et al. HLF 108, HLF 112, HAL 142, HLF 699 and HAL 1703*. – Quang Ninh Prov., *P.K. Loc et al. HAL 11852 B, HAL 11240.* – Lai Chau Prov., *N.T. Hiep et al. HAL 9988.* – Ha Tinh Prov., *N.T. Hiep et al. VA 61, L.V. Thuan C–7.* – Quang Binh Prov., *Aver. et al. VH*

4675, VH 4810, HAL 5999 and HAL 12385, N.T. Hiep et al. CPC 3727 (CPC). – Thua Thien–Hue Prov., *Aver. et al. HAL 7529, HAL 7553, HAL 7606, HAL 7645, HAL 8037 and HAL 11122, L.T. Cuc 1754; N.T. Hiep et al. CFH–343 and HLF 1015, P.K. Loc P 7860.* – Da Nang City, *Aver. et al. CPC 3265* (CPC), *P.V. The HAL 11945 A, B.* – Kon Tum Prov., *Aver. et al. VH 5055, L.K. Bien 892.* – Gia Lai Prov., *N.V. Du 406, LX–VN 678, Tran The Bach et al. KNP 268, V.X. Phuong 1243*. – Dak Lak Prov., *Aver. et al. HLF 5429*. – Lam Dong Prov., *Aver.* and *N.V. Duy HLF 5346 and VH 2616, S.G. Wu et al. WP 1409, T.T.T. Trang et al. HLF 5294, P.K. Loc P 2412.* – Kien Giang Prov., *Dang Minh Quan 10121030* (private collection).

24. *Nageia fleuryi* (Hickel) de Laub.

Blumea 32: 210, 1987; Nguyen, J.E. Vidal, Fl. Cambod., Laos, Vietnam 28: 102, Pl. 8, fig. 4-5, 1996; Fu *et al.*, Fl. China 4: 80, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 94, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 41, 2013.

- *Podocarpus fleuryi* Hickel, Bull. Soc. Dendrol. France 76: 75, 1930, *p.p.* quoad spec. Fleury in A. Chev. and Soc. For. In A. Chev. 8408; Fl. Gen. Indo-Chine 5: 1069, fig. 123, 1931; Phan, J. Biol.(Hanoi) 6 (4): 8, 1984.

– *Decussocarpus fleuryi* (Hickel) de Laub., Pham, Ill. Fl. Vietnam I, 1: 278, fig. 756, 1991.

Vietnamese name: Kim giao hạt to.

Description: Trees to 20–25 m tall; trunk to 0.7–0.9 m d.b.h. or greater. Bark brownish, smooth, peeling when old in thin flakes. Crown conical. Branchlets opposite. Leaves usually decussate, twisted 2–ranked with adaxial surface always uppermost; leaf blade green adaxially, paler or grayish green abaxially, ± lanceolate, straight 8–18 × 2.2–4 cm, thick and leathery, apex obtuse, acute or acuminate, sometimes truncate and blackened due to early shrivelling, break down and falling off, base acute, decurrent to end of short petiole, forming 4–8 mm, flat, winged twisted; stomate lines on both faces. Pollen cones in leaf axils of branchlets, 2.5–4 × 1.5–3 cm, 3–5–(–7)–branched, decussate; branches elongate–cylindric, rarely oblong, or narrow ovoid, 1.2–1.6 × 0.4–0.5 cm. Seed–bearing structure solitary in leaf axils of branchlets; structure each comprises a peduncle slender, not succulent, ca. 0.9–1.8 × 0.15–0.25 cm at seed maturity; bracts scattered along peduncle, early deciduous; scars protruding, horizontally elliptic; peduncle ending insingle seed, rarely two seeds in axils of subterminal bract, each seed subtended by a receptacle short and not swollen, 0.5–1 × 0.15–0.2 cm at seed maturity, the boundary between peduncle and receptacle can be recognized, only one ovule, very rare two ovules maturing; epimatium usually globose, 1.8–2.6 cm in diam., glaucous with dense white bloom when unripe, turning brown when ripe; shell leathery, 0.4–0.5 mm thick, seperated to stony endocarp, ca. 1 mm thick, sometimes with dense punctiform depressions; free naked seed, ivory color, ca. 1.6 × 1.3 × 1.2 cm.

Distribution: Vietnam (scattered but widespread, from lowland to beginning of montane belt in most forested areas in Ha Giang, Bac Giang, Quang Ninh, Son La, Phu Tho, Thanh Hoa, Quang Binh, Quang Nam, Dak Lak, Lam Dong and Khanh Hoa provinces) (Phan, 1984, 2001; Pham, 1991; Nguyen & Vidal, 1996; Nguyen, 2004; Nguyen *et al.*, 2004; Nguyen *et al.*, 2007; Phan *et al.*, 2007a, 2007b, 2009a, 2009b, 2010, 2011, 2013a, 2013b, 2015 ; Averyanov *et al.*, 2012). China, Laos, Cambodia, Indonesia (Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2014).

Phenology: Pollination March–April; seed maturity September–October (observed trees cultivated in Hanoi-*P.K. Loc P 11350*).

Ecology: Scattered or in small groups in primary, rarely secondary, closed evergreen, seasonal tropical broad–leaved forests, rarely mixed with other conifers on limestone and non limestone mts., extending from sea level to 1700 m elevation.–

Use: Wood bright brown, mediocre quality, not highly prized, used in small construction, manufacturing, house columns and partitions; sometimes cultivated as ornamental.

Conservation status: VU (Nguyen *et al.*, 2004); protected in Bat Dai Son, Cat Ba, Cuc Phuong, Phong Nha–Ke Bang.

Note: Phylogenetic relationships between this species and *N. nagi* require further study (involving morphology, DNA and distribution attributes); *N. wallichiana* is related to this pair, but is clearly distinct. These three species are similar in having stomata present on their leaves (see notes under *N. wallichiana* concerning stomata). *Nageia fleuryi* is further similar to *N. nagi* by its short, non-succulent receptacle (receptacle long, thick and very succulent in *N. wallichiana*) but differs in having larger leaves and seeds, and a wider geographic range. Receptacles are an easily recognized, good taxonomic character; they are never absent (except in sterile material), not as described by Fu *et al.* (1999). The description of pollen cones of *N. nagi* and *N. fleuryi* by Nguyen *et al.* (2004) and by Fu (1999) are vague and unclear. A few herbarium specimens currently called *N. fleuryi* belong to *N. nagi*.

Specimens examined: – Ha Giang Prov., *P.K. Loc et al. P 11417*. – Quang Ninh Prov., *P.K. Loc, N.T. Vinh HAL 11231*. – Bac Giang Prov., *P.K. Loc, N.T. Vinh HAL 11227*.– Son La Prov., *P.K. Loc, N.T. Vinh HAL 11283*. – Hanoi., *P.K. Loc P 11350*. – Phu Tho., *P.K. Loc et al. HAL 11272*. – Thanh Hoa., *Aver. et al. HAL 3232*. – Quang Binh Prov., *Aver. et al. HAL 12420*. – Quang Nam Prov., *Aver. et al. HAL 11959*. – Dak Lak Prov., *Aver. et al. HLF 5432*. – Lam Dong Prov., *N.V. Duy, P.K. Loc NVD 01/01, P.K. Loc P 11334.* – Khanh Hoa Prov., *P.K. Loc P 11336*.

25. *Nageia nagi* (Thunb.) Kuntze

Revis. Gen. Pl. 2: 798, 1891; Pham, Ill. Fl. Vietnam I, 1: 227, fig. 909, 1991; Fu *et al.*, Fl. China 4: 80, 1999; Pham, 1999.

–*Podocarpus nagi* (Thunb.) Pilg., in Engler, Pflanzenr. 18, 4(5): 60. 1903: Luong *et al.*, 2010.

Vietnamese name: Kim giao hạt nhỏ.

Description: Trees to 20–25 m tall, trunk to 0.5–0.7 m d.b.h., stunted and twisted while growing on vertical cliffs

and steep slopes of limestone mountains, exposed to strong winds, on thin soil layer and discontinuous in pockets between rocks, dry. Bark brownish purple, smooth, later lumpy, peeling when old in thin flakes; inner bark reddish brown. Crown conical when young, turning rounded–conical when old. Branches and branchlets erect, ascending, spreading or ± pendulous, grayish to dark brown, stout; branchlets opposite, rigid, densely leafy. Leaves decussate, 2–ranked; petioles short, 3–6 mm, flat; leaves of seedlings and very young saplings thin leathery, lanceolate, 8–11 × 1.8–2.5 cm, apex caudate–acuminate, base acute decurrent along short and flat petiole; leaves of adult trees lanceolate or ovate, rarely narrow lanceolate, rather thick, leathery, 4.5–9 × 1.4–2.6 cm, apex obtuse, acute or acuminate, sometimes truncate and blackened due tovery early shrivel up, break down and fall off as in *N. fleuryi*, base acute, decurrent along petiole into widened, flattened and twisted petiole, 0.5–0.7 cm; leaf blades green and glossy adaxially, pale green abaxially; stomatal lines on abaxial face continuous, sometimes discontinuous on adaxial face. Pollen cones in leaf axils, 4–5 × 3–4 cm, branches up to 1.2–1.6 cm long. Seed–bearing structures in leaf axils; ovules 1 or 2, in axils of subterminal bract; peduncle 1–1.7 × 0.14–0.16 cm, with several scattered along, early deciduous bracts leaving protruding scars; receptacle consisting of few bracts, very short, 1–3 mm, slightly thickened at seed maturity; epimatium globose, 1.2–1.6 cm in diam., green with white bloom when young, dark purple with sparcer white bloom when ripe; shell 0.3–0.4 mm thick, seperated to stony endocarp, 0.8–1 mm thick; inside is globose naked seed, ca. 1–1.3 cm in diam.; base pointed, apex rounded.

Distribution: Vietnam (Ha Giang, Cao Bang, Bac Kan, Lang Son and Dak Lak provinces) (Phan *et al.*, 2015). Extreme S China (Guangxi, Guangdong and Hainan provinces) (Sykes, 1991; Fu *et al.*, 1999); sometimes cultivated as ornamental in Japan (Fu *et al.*, 1999).

Phenology: Pollination February–April; seed maturity around October–November.

Ecology: Scattered mainly in broad–leaved and mixed closed evergreen forests on ridges, steep slopes and vertical cliffs of limestone moutains, where soil accumulates in pockets between rocks, well drained, the winds are strong, rarely on non limestone sites, at elevations 300–1500 m.

Use: Timber is of small size, used in making utensils.

Conservation status: VU (*Phan K.L. proposed here*).

Note: This species was listed by Pham Hoang Ho (1999) following the "Cay Co Viet Nam: An Illustrated Flora of Vietnam" without citation of voucher specimens. Our data on the occurrence of this species in Vietnam is based on 15 well–documented specimens with pollen cones and seeds (including two with ripe or nearly ripe seeds), namely, *HAL 11219* and *VH 6227*. These data justify the recognition of *N. nagi* for Vietnam, however, as noted above, the phylogenetic relationship between this species and *N. fleuryi* requires further study.

Specimens examined: – Ha Giang Prov., *D.K. Harder et al. DKH 4962, N.S. Khang NSK 01 and HAL 11859A, P.K. Loc et al. HAL 1494, HAL 11317, HAL 11329 and HAL 11872, To. V.T 067 and To. V.T 093*. – Cao Bang Prov., *Aver. et al. CBL 901*. – Bac Kan Prov., *Aver. et al. HAL 4706 and HAL 4988*. – Lang Son Prov., *P.K. Loc et al. HAL 11219*. – Dak Lak Prov., *Aver. et al. VH 6227 and HLF 5489*.

26. *Nageia wallichiana* (C. Presl) Kuntze (Fig. 5B, C)

Revis. Gen. Pl. 2: 800, 1891; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 100, Pl. 8, fig. 1-3, 1996; Pham, Ill. Fl. Vietnam I: 227, fig. 908, 1991;Fu *et al.*, Fl. China 4: 80, 1999; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 96, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 41, 2013b.

– *Podocarpus wallichianus* C. Presl, Abh. Königl. Böhm. Ges. Wiss., ser. 5, 3: 540, 1846; Hickel, Fl. Gen. Indo-Chine 5: 1068, 1931;Phengklai, Fl. Thail. 2(3): 203, 1975; Phan, J. Biol. (Hanoi) 6 (4): 9, 1984.

– *Decussocarpus wallichianus* (C. Presl) de Laub., Pham, Ill. Fl. VietnamI, 1: 279, fig. 757, 1991.

Vietnamese name: Kim giao đế mập.

Description: Straight–boled trees to 30–35 m tall, bole up to 20–25 m long or more; trunk to 0.5–0.8 m d.b.h., sometimes greater; all plant parts glabrous; buttresses absent; crown pyramidal; bark smooth, dark brown, grey, usually a mottled colour, less than 20 mm thick, peeling in thin, large, irregular flakes; reddish purple within, exudate resinous, brownish red, scented. Leaves decussate, 2–ranked, turned so that those on 1 side of branchlet have adaxial surface uppermost, those on the other side abaxial surface uppermost. Leaf blade of seed–bearing branchlets leathery, lanceolate, rarely lanceolate–ovate, 4–7.2 (–8.5) × 1.5–2.5 (–3.0) cm, dark green adaxially, paler abaxially, stomatal lines present on both surfaces as in other species of the same genus. Pollen cones unknown. Seed–bearing structure with peduncle 0.9–1.4 × 0.2–0.35 cm, receptacle swollen, obovate, 1.8–2.4 × 1.5–1.8 cm, very succulent, clearly enlarged, plump, green initially, turning yellow, red, finelly reddish brown, and start to shrivel up, only one ovule, rarely two ovules maturing; epimatium globose, 1.3–1.5 cm diam., green with white bloom when young, turning violet–brownish or blackish, with sparse white bloom when ripe;epimatium, exocarp and mesocarp stuck together in shells, leathery, not hard, 0.3–0.4 mm thick, seperated to stony endocarp, ca. 1 mm thick; naked seeds spherical, 0.9–1 cm diam.

Distribution: Vietnam (Restricted until now only to Phu Quoc Island, Kien Giang Prov. (Pham, 1991; Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2013b, 2015). India, Bangladesh, Thailand, Laos, China, the Philippines, Malaysia, Indonesia, Papua–New Guinea (Fu *et al.*, 1999; Farjon, 2001).

Phenology: Pollination unknown; seed maturity February–March.

Ecology: Emergent, often large canopy tree scattered in small groups in primary closed evergreen seasonal subequatorial broad–leaved forest with the dominance of evergreen dipterocarps from near sea level to ca. elevation 530 m, on non–limestone basement rocks and with subequatorial climate; seeds germinate abundantly, but saplings rarely observed in nature.

Use: Wood is used for house construction, manufacture; oleoresin harvesting.

Conservation status: VU (Nguyen *et al.*, 2004), based on the populationin Phu Quoc National Park.

Note: Hitherto most specimens in Vietnamese herbaria attributed *N. wallichiana* have been wrongly identified due to the use of leaf stomata, a difficult to observe morphological character, to identify this species (Phan *et al.*, 2015). Traditionally, the distribution of stomata has been used to help distinguish *N. fleuryi*, *N. nagi* and N. *wallichiana*. These stomata were thought to be present on both faces of leaves in *N. wallichiana* but present on the abaxial face only in *N. fleuryi* and *N. nagi* (Fu *et al.*, 1999, Nguyen *et al.*, 2004). However, a detailed study of 86 collections made over the past 20 years (1996–2015) from various sites in Vietnam by the first author of this paper and colleagues have found that fresh leaves of all three species have stomatal–lines on both leaf faces (on the abaxial face these lines are mostly continuous but on the adaxial face they are sometimes discontinuous) (Phan *et al.*, 2015). A more reliable character is the receptacle of ripe seeds which enables the species to be divided into two groups, namely, *N. wallichiana* with a long, thick, succulent receptacle, and *Nageia fleuryi* and *Nageia nagi* with a very short, non–succulent receptacle (Phan *et al.*, 2015). It is now known that of the specimens examined with ripe seed–bearing cones, only some from Phu Quoc island in the extreme south of Vietnam belong to *N. wallichiana*; specimens collected elsewhere in mainland, more northerly sites are *N. fleuryi* or *N. nagi*.

Specimens examined: – Kien Giang Prov., *P.K. Loc et al. P 11331, N.H. Quan et al. P 11337, N.H. Quan et al. P 11473, N.H. Quan et al. P 11472, N.H. Quan et al. P 11475, N.H. Quan et al. P 11465, N.H. Quan et al. P 11474, N.H. Quan et al. P 11464*, *N.H. Quan et al. P 11421, N.H. Quan, P.K. Loc P 11422, N.H. Quan, P.K. Loc P 11424, N.H. Quan, P.K. Loc P 11425, N.H. Quan, P.K. Loc P 11426, N.H. Quan, P.K. Loc P 11427, N.H. Quan et al. P 11459, N.H. Quan et al. P 11462, N.H. Quan et al. P 11459 A, N.H. Quan et al. P 11460, N.H. Quan et al. 11462, N.H. Quan et al. P 11463*.

27. *Podocarpus neriifolius* D. Don

In Lamb., Descr. Gen. Pinus, 2: 21, 1824; Phengklai, Fl. Thail. 2(3): 199, 1975; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 105, Pl. 8, fig. 6-9, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1163, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 98, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 45, 2013b.

27.1. *Podocarpus neriifolius* var. *neriifolius* Fu *et al.*, Fl. China 4: 82, 1999(Fig. 5D, E)

– *P. annamiensis* auct. non N.E. Gray: Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 106, 1996.

Vietnamese name: Thông tre lá dài.

Description: Trees to 20–25 m tall; trunk to 0.2–0.3 m d.b.h., sometimes more; bole of trees in closed primary forest up to 10–20 m. Crown ± cylindrical. Bark grayish brown, thin, fibrous, peeling off in longitudinal flakes. Branches spreading or ascending. Leaf blade of pollen and seed–bearing cone branchlets lanceolate, usually slightly curved, mostly 7–15 × 0.9–1.3 cm, leathery, base cuneate into short petiole, apex tapered long acuminate. Pollen cones solitary, rarely in clusters of 2–3 in leaf axil, 2.5–5 cm long. Seed–bearing structures axillary, solitary; peduncle around 1–2 cm; receptacle obconical–ellipsoid, 8–10 × 5–8 mm, when ripe orange, red, turning violet, finally blackish, heo quat; epimatium purplish–red when ripe; seed ovoid or subglobose, ca. 8–13 mm.

Distribution: Vietnam (scattered but widespread, in Ha Giang, Bac Kan, Bac Giang, Lao Cai, Lai Chau, Dien Bien, Son La, Phu Tho, Hoa Binh, Ninh Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Da Nang, Quang Nam, Kon Tum, Gia Lai, Khanh Hoa, Lam Dong and Dak Nong provinces) (Hickel, 1931; Phan, 1984, 2001; Pham, 1991; Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2007b, 2009a, 2009b, 2010, 2011a, 2013b). Bhutan, Nepal, India, Myanmar, Thailand, Laos, China, Campuchia, Malaysia, Indonesia, Philippines, Papua–New Guinea, Pacific Islands (Sykes, 1991; Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2014)

Phenology: Pollination July–September, seed maturity March–May in the following year.

Ecology: Scattered in primary closed evergreen, mixed and broad–leaved forests, as well as secondary woodlands and scrubs, on a variety of basement rocks, from sea level to elevation 2000 m.

Use: Timber is of mediocre quality and usually small size, used in local house construction, making furniture and utensils.

Conservation status: LC (Nguyen *et al.*, 2004).

Specimens examined: – Ha Giang Prov., *Aver. et al. HAL 6621, C.I .Peng et al. 20133, P.K. Loc et al. HAL 11321, P.K. Loc, G.M. Hai P 11145*. – Bac Kan Prov., *Aver. et al. HAL 4966*. – Bac Giang Prov., *P.K. Loc, N.T. Vinh HAL 11229*. – Lao Cai Prov., *D.K. Harder et al. DKH 6746, N.Q. Hieu et al. CKF 124* (CPC) and *CKF 251* (CPC). – Lai Chau Prov., *N.T. Hiep et al. HAL 10215, P.K. Loc et al. HAL 8815*.– Dien Bien Prov., *Aver. et al. CPC 2256* (CPC), *P.V. The CPC 2385* (CPC). – Son La Prov., *D.K. Harder et al. DKH 5747 and DKH 7274, P.K. Loc et al. HAL 11278, HAL 11284 and HAL 11288*.– Phu Tho Prov., *Aver. et al. HAL 11256, P.K. Loc et al. HAL 11267*. – Hoa Binh Prov., *N.T. Hiep et al. HAL 321, Hiep, Chan 404*. – Ninh Binh Prov., *N.M. Cuong NMC 2123* (CPNP). – Thanh Hoa Prov., *P.K. Loc et al. HAL 11182 and HAL 11185*.– Nghe An Prov., *B.X. Dung et al. P 533* (PMNP).– Ha Tinh Prov., *N.T. Hiep et al. VA 59*. – Quang Binh Prov., *N.T. Hiep et al. CPC 4406* (CPC).– Quang Tri Prov., *Aver. et al. CPC 2866* (CPC). – Thua Thien–Hue Prov., *Aver. et al. HAL 7680 and HAL 10969*. – Da Nang City., *Aver. et al. CPC 3250* (CPC). – Quang Nam Prov., *Aver. et al. CPC 3564* (CPC). – Kon Tum Prov., *Aver. et al. VH 1865, P.K. Loc P 7904*. – Gia Lai Prov., *P.K. Loc et al. P 3901*.– Khanh Hoa Prov., *Aver. et al. VH 1443*. – Lam Dong Prov., *Aver. et al. VH 4256*. – Dak Nong Prov., *Aver. et al. HLF 5534*.

27.2. *Podocarpus neriifolius* var. *annamiensis* (N.E. Gray) L.K. Phan, comb. etstat. nov.

–*P. annamiensis* N.E. Gray, J. Arnold Arbor. 39: 451, 1958; Fu *et al.*, Fl. China 4: 83, 1999; Phan, Ecol. Econ. J. (Vietnam) 45: 45, 2013b.

Vietnamese name: Thông tre lá vừa.

Description: Differs from type var. by adult leaf apex obtuse (vs. long acuminate). Trees to 17–25 m tall, bole up to 12 m and longer; trunk to 0.6–0.8 m d.b.h., sometimes greater. Leaves radially spreading; petiole 2–4 mm; leaf blades of pollen and seed–bearing cone branchlets elliptic–lanceolate, 5–10 × ca. 0.8 cm, thick, leathery, base attenuate, apex obtuse. Pollen cones solitary or clustered in 2–3, spikelike, 3–5 × ca. 0.5 cm (voucher specimen- *P 11093;* photos – *27011*).
Distribution: Vietnam (Ha Giang, Cao Bang, Quang Ninh, Son La, Phu Tho, Hoa Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Kon Tum and Dak Lak provinces) (Pham, 1991; Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2013b). Myanmar, China (Fu *et al.*, 1999).
Phenology: January–April; seed maturity probably September–October.
Ecology: Clustered in small groups in primary closed evergreen seasonal tropical forest on ridges of silicat mother rock with the dominance of *Pinus armandii* subsp. *xuanhaensis,* with other conifer species or broad–leaved ones, at 800–1200 m elevation.
Use: The wood is used for making local houses and furniture, for carving and making writing materials and musical instruments.
Conservation status: (2016) NT (*Phan K.L. proposed here*); protected Xuan Nha, Xuan Lien and Yen Tu Nature Reserves.
Note: In the protologue of *P. annamiensis* N.E. Gray emphasized that this species differed from *P. neriifolius* by the leaves being always shorter and possessing obtuse or acute (not long–acuminate) apices. However, following a comparison of leaves, pollen cones, receptacles and seeds of the type specimen of *P.annamiensis* (i.e. *Poilane 1561*) with *P. neriifolius* (but type not cited) Nguyen & Vidal (1996) treated *P.annamiensis* as a synonym of a highly variable *P. neriifolius*. Our examination of many specimens in Vietnamese herbaria identified as *P. annamiensis* has shown that many possess leaf size, form and apical characters identical to the *Poilane 1561* type, and which differed from those of *P. neriifolius*. Although these differences are diagnostic and stable we consider that they justify only infraspecific recognition and accordingly we have recognized it as *P. nariifolius* var. *annamiensis*. If this treatment is accepted by our peers, then many specimens identified as both *P. annamiensis* and *P. neriifolius* will need to be determined to include the varietal names as proposed above.
Specimens examined: – Ha Giang Prov., *Aver. et al., HAL 11131 B,N. Tap 33B.* – Cao Bang Prov., *Aver. et al. CBL 1183.* – Quang Ninh Prov., *P.K. Loc et al. HAL 11239.* – Son La Prov., *D.K. Harder et al. DKH 7072.* – Phu Tho Prov., *P.K. Loc et al. HAL 11232 and HAL 11267.* – Hoa Binh Prov., *N.T. Hiep et al. HAL 627.* – Thanh Hoa Prov., *Aver. et al. HAL 2963, HAL 2968 and HAL 3217.* – Nghe An Prov., *P.K. Loc et al. HLF 3135.* – Quang Binh Prov., *Aver. et al. HAL 6163, HAL 6244, HAL 11702 and HAL 11771.* – QuangTri Prov., *N.T. Hiep et al. HLF 5815a.* – Kon Tum Prov., *Aver. et al. VH* 5559. – Dak Lak Prov., *Aver. et al.* 1000–1400 m, *HLF 5434.*

28. *Podocarpus pilgeri* Foxw.

Phillip. J. Sci. 2: 259, 1907; Phengklai, Fl. Thail. 2(3): 201, 1975; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 109, Pl. 8, fig. 10-13, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1163, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 100, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 46, 2013b.

–*P. brevifolius* (Stapf) Foxw., Phillip. J. Sci. 6: 160, fig. 29, 1911; Phan, J. Biol. (Hanoi) 6 (4): 8, 1984; Pham, Ill. Fl. VietnamI, 1: 277, fig. 753, 1991.

Vietnamese name: Thông tre lá ngắn.

Description: Trees to 12–18 m tall; trunk to 0.3 m d.b.h., rarely more if growing in unexploited forests, or in the contrary 2–5 m if disturbed by cutting, much branched; branchlets usually opposite or ± whorled, erect–spreading, glabrous. Bark brown or reddish brown. Leaves in adult trees alternate, subopposite, or rarely ± whorled, crowded, dispersed ± evenly on branchlets; blade ± shortly linear (sun leaves) or ovate–oblong (shade leaves), apex acute or obtuse. Leaves alternate or subopposite, crowded or dispersed on branchlets; blades of pollen and seed–cone bearing branchlets ± short linear (sun leaves) or oblong–ovate (shade leaves), 2–5 × 0.8–1 cm; petiole ca. 2 mm, apex ± acute or rounded. Pollen cones axillary, solitary or borne in clusters of 2 or 3, cylindric, 1–3 × ca. 0.2–0.3 cm. Seed–bearing structure solitary; peduncle 0.5–1 cm; receptacle 0.5–1.2, obovate, when ripe at first orange, red, turning violet–brownish; epimatium dark violet when ripe, 0.8–0.9 × ca. 0.7 cm. Seed subglobose, ca. 8 mm.
Distribution: Vietnam (scattered but widespread in some provinces such as Ha Giang, Tuyen Quang, Quang Ninh, Lao Cai, Son La, Hoa Binh and Quang Binhprovinces) (Pham, 1991; Nguyen & Vidal, 1996; Nguyen, 2004; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2007b, 2009a, 2010, 2013b). Thailand, Laos, China, Philippines, New–Guinea (Sykes, 1991; Averyanov *et al.*, 2014).
Phenology: Pollination February–June (once pollination in October– voucher specimen: HAL 11236), seed maturity October–November.
Ecology: Scattered in the medium tree layer, but more common in the shrub storey of heavily disturbed primary closed evergreen seasonal tropical conifer or mixed forests on limestone mts., rarely on non limestone moutains., on slopes and ridges at elevations 700–1500 m.
Use: Timber is hard but usually of small size, used in local house construction and for making domestic utensils; during the first decade of this century entire plants were removed from nature illegally exported to China as ornamental treelets.

Conservation status: VU (Nguyen *et al.*, 2004); due to the mass export to China some sub-populations on the limestone areas bordering with China (mainly from Ha Giang province) should have been assessed as Critical Endangered (CR), but species in general is assessed as VU in Vietnam.
Note: Study of phylogenetic relationships with some other species such as *P. wangii* (see note above under *P. kwangtungensis*) and *Podocarpus brevifolius* (which is here treated as a syonym of *P. piligeri*) would be desirable (Fu *et al.*, 1999)**.**
Specimens examined: – Ha Giang Prov., *Aver. et al. HAL 8500, D.K. Harder et al. DKH 5181 and DKH 6194, N.T. Hiep et al. NTH 6033, N.T. Hiep et al. CPC 213* (CPC), *P.K. Loc P 10913, P.K. Loc, G.M. Hai P 11107, P 11108, P 11122, P 11132, P 11134, P 11135, P 11137, P 11144,P 11147 and P 11149*, *P.K. Loc et al. HAL 11322, C.I. Peng 20133, To Van Thao, ToVT 063 and ToVT 077*. – Tuyen Quang Prov., *P.V. The et al. CPC 4524* and CPC 4562 (CPC). – Quang Ninh Prov., *L.K. Bien 5882, N.T. Vinh HAL 11852, P.K. Loc et al., HAL 11236.* – Lao Cai Prov., *N.Q. Hieu et al. CKF 177* (CPC).–Son La Prov., *Aver. CPC 1854* (CPC), *D.K. Harder DKH 7341, N.T. Hiep et al. HAL 9316.* – Hoa Binh Prov., *N.T. Hiep et al. HAL 771, P.K. Loc and B.D. Binh P 4508*, *P.K. Loc et al. P 11044.* – Quang Binh Prov., *Aver. et al. HAL 11729 and HAL 12386.*

5. Taxaceae

29. *Amentotaxus argotaenia* (Hance) Pilg.

Bot. Jahrb. Syst. 54: 41, 1917; Phan, J. Biol. (Hanoi) 6 (4): 9, 1984; Pham, Ill. Fl. VietnamI, 1: 281, fig. 765, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 123, Pl. 10, fig. 1, 1996;Fu *et al.*, Fl. China 4: 93, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1164, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 102, 2004; Phan *et al.* Ecol. Econ. J. (Vietnam) 45: 35, 2013b.

– *Podocarpus argotaenia* Hance, J. Bot. 21: 357, 1883.

Vietnamese name: Sam hoa bông sọc hẹp.

Description. Trees up to 25–30 m tall with 0.6–0.8 m d.b.h., sometimes more (as in *P 11050* và *HAL4106*) occurred in remote places far from villages; plants described as shrubs or small trees less than 7 m are in fact trees regenerated from stump shoots; stomatal bands on abaxial face of leaves white, narrower than marginal ones (voucher specimens:*HAL 4101, HAL 4114, ToVT 023, P 11062, HAL 6776*). Seeds pendulous, brown when ripe, narrowly obovoid–ellipsoid, ca. 19–25 x 10–13 mm covered by aril at first bright red turning reddish brown when ripe.
Distribution: Vietnam (scattered but widerspread in Ha Giang, Cao Bang, Bac Kan, Lang Son, Thai Nguyen, Lai Chau, Dien Bien, Son La, Phu Tho, Hoa Binh, Thanh Hoa, Quang Binh and Quang Tri provinces) (Pham, 1991; Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2007b, 2009a, 2013a, 2013b). Laos, China (Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2014).
Phenology: Pollination probably February–April; seed maturity October–November, once seen in March.
Ecology: Scattered in primary closed evergreen seasonal tropical broad–leaved forests on cliff slopes and ridges of limestones mountains, rarely on non limestone mountains, mainly at elevations 700–1600 m.
Use: Trees grow slowly; timber is of good quality and used for local construction, furniture, handicrafts because it is strongly resistent to rot and is not eaten by termites.
Conservation status: VU (Nguyen *et al.*, 2004).
Note: Based on a DNA study of *Amentotaxus* Gao *et al.* (2017) proposed that *A. argotaenia* does not exist in either Vietnam and Laos, and that trees under this name in these countries belong to an as–yet undescribed species that they called *Amentotaxus* nov. sp. Although we have not accepted that conclusion here, and to recognize it further study is required. In particular there is a need to collect more fertile specimens with pollen and seed cones to critically assess and clarify the lesser known morphological characters that may help to resolve this matter.
Specimens examined: – Ha Giang Prov., *N.Q. Hieu et al. CKF 043* (CPC), *P.K. Loc et al. P11316, T.V. Thao ToVT 023 and ToVT 030.* – Cao Bang Prov., *Aver. et al. CBL 1252, DDTTNTV–2352* (HN). – Bac Kan Prov., *Aver. et al. HAL 4747, N.Q. Hieu et al. CPC 1200* (CPC). – Lang Son Prov., *Aver. et al. HAL 6776.* – Thai Nguyen Prov., *Aver. et al. VH 5021, B.K. Khe 65, LX–VIỆT NAM 3871* (LE). – Lao Cai Prov., *Aver. HAL 2375a, D.T. Doan HAL 2478, N.Q. Hieu et al._CKF 250* (CPC), *V.V. Chi 2902*. – Dien Bien Prov., *Aver. CPC2275* (CPC), *P.V. The CPC 2409* (CPC). – Son La Prov., *L.T. Chan C 136a and C 159, D.K. Harder et al. DKH 7275, DKH 7348 and DKH 7478*. – Phu Tho Prov., *P.K. Loc et al. HAL 11264.* – Hoa Binh Prov., *N.T. Hiep et al. HAL 361 and HAL 713, N.Q. Hieu et al. CPC 541* (CPC) and *CPC 1995* (CPC), *P.K. Loc, N.H. Ha, L.T. Chan and C.D. Nguyen P 4960*a and *P 6993*. – Thanh Hoa Prov., *Aver. et al. HAL 3959, HAL 4101 and HAL 4114, P.K. Loc et al. P 11050*, *P 11052, P 11062, P 11067, HAL 11160 and HAL 11176.* – Quang Binh Prov., *Aver. et al. HAL 11538 and HAL 12508.* – Quang Tri Prov., *N.T. Hiep et al. HLF 5946 and HLF 6549.*

30. *Amentotaxus poilanei* (Ferré & Rouane) D. K. Ferguson

Bull. Mus. Natl. Hist. Nat., B, Adansonia, sér. 4, 11 (3): 316, 1989; Pham, Ill. Fl. VietnamI, 1: 282, fig. 766, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 126, Pl. 10, fig. 3-5, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1164, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 106, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 35, 2013.

–*A. yunnanensis* H.L. Li var. *poilanei*Ferré and Rouane, Trav. Lab. Forest. Toulouse T. 1 (9, 1): 3, 1978.

Vietnamese name: Sam hoa bông ngọc pan (*Dẻ tùng ngọc linh*)

Description: Trees up to 15–20 m tall, trunk to 0.3–0.4 m d.b.h.; crown large conic.– Some more description is needed.

Distribution: Endemic to Vietnam (Ngoc Linh mt. range and nearby areas, Kon Tum provinces) (Pham, 1991;

Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2010, 2013b).
Phenology: Pollination December; seed maturity probably September–November.
Ecology: Scattered in undisturbed primary closed evergreen seasonal tropical broad–leaved forests at elevations 1800–2300 m, on granite-derived soils that are deep, rich in humus, humid, drained, rarely in heavily disturbed broad-leaved forests mixed with bamboo.
Use: Unknown.
Conservation status: VU (Nguyen *et al.*, 2004).
Note: A poorly known species for which there is a need for more collections of fertile specimens with ripe pollen and seed cones**.**
Specimens examined: – Kon Tum Prov., *Aver. et al. VH 774, VH 802, VH 879 and VH 1317*.

31. *Amentotaxus yunnanensis* H.L. Li (Fig. 5F, G)

J. Arnold Arbor. 33: 197. 1952;Pham, Ill. Fl. VietnamI, 1: 282, fig. 767, 1991; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 125, Pl. 10, fig. 2, 1996; Fu *et al.*, Fl. China 4: 92, 1999;Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1165, 2001; Nguyen *et al.*, Vietnam Conifers: Conservation Status 2004: 108, 2004; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 35, 2013b.

–*A. yunnanensis* auct. non H.L. Li: Phan, J. Biol. (Hanoi) 6 (4): 9, 1984.

–*A. argotaenia* (Hance) Pilg. var. *yunnanensis* (H.L. Li) P.C. Keng.

–*A. hatuyenensis* T.H. Nguyen, Fl. Cambod., Laos, Vietnam 28: 126, Pl. 10, fig. 6-8, 1996; P.K.Loc, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1164, 2001; N.T. Hiep *et al.*, Vietnam Conifers: Conservation Status 2004: 104, 2004.

Vietnamese name: Sam hoa bông sọc rộng.

Description: Trees up to 25–30 m with 0.8–1 m d.b.h. (voucher– *NDT Luu 024* coll.) On east slope Pha Luong mt., Son La prov.), sometimes up to 1.4 m d.b.h. (*HAL4216*). Described in published literature in fact from heavily cut trees with regenerated branches, therefore size is reported astoo small. Leaves of pollen and seed cones bearing structure branchlets subleathery, lanceolate–elliptic, usually straight, 5–11 × 0.9–1.1 cm, apex acute, not longer with long caudate as in leaves of vegetative, young branchlets; stomatal bands on abaxial face at least 2 x as wide as marginal bands, with their colour not constant, but depending on the age (from whitish or yellowish white in very young leaves to yellowish/brownish in old leaves) and state (from yellowish white in fresh leaves to brownish in air–dried leaves). Pollen–cones borne on top of 1st year branchlet, 4–6 racemes together, 7–10 cm long (voucher specimens– *DKH 4970; PKL Sa Pa, CPC 211*), pendulous as seed cones; aril at first slightly white powdery then,smooth, ca. 1.8–2.8 x 0.8–1.2 cm, dark red purple when ripe, turning brownish red; peduncle 1.5–2 cm; seeds inside, ca. 16–26 × 7–11 mm (*WP 626; HAL 6413; NTH 6004, HAL 6203, HAL 8405*).

Distribution: Vietnam (Ha Giang, Bac Kan, Tuyen Quang, Lao Cai, Lai Chau, Son La, Hoa Binh, Thanh Hoa, Nghe An and Quang Binh provinces) (Pham, 1991; Nguyen & Vidal, 1996; Phan, 2001; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2009a, 2009b, 2013a, 2013b; Nguyen *et al.*, 2011). China (Fu *et al.*, 1999; Farjon, 2001; Averyanov *et al.*, 2014).
Phenology: Pollination February–March; seed maturity October–December, sometimes ripe seeds observed till March in following year (*HAL 6413, Peng 19934).*
Ecology: Scattered individuals or in small groups within primary closed evergreen seasonal tropical mixed broad–leaved forests, sometimes on cliff slopes or ridge-tops of limestone and non limestone mountains, at elevations 900–1600 m.
Use: Trees grow slowly; timber is of good quality, used for construction and furniture because it is strongly resistant to rot and is not eaten by termites.
Conservation status: VU (Nguyen *et al.*, 2004); protected in Bat Dai Son, Na Hang, Nam Xuan Lac, Hoang Lien, Xuan Nha, Hang Kia–Pa Co, Pu Luong, Pu Huong and Pu Mat.
Note: Following Phan *et al.* (2014a) we hereby regard *A.hatuyenensis* as a synonym of*A. yunnanensis*. The main diagnostic morphological character of *A. hatuyenensis* was regarded as the color of the stomatal bands on the abaxial face of its leaves. However, it is now known that this is not a constant or reliable character. Furthermore, the DNA (ITS1) results in Phan *et al.* (2014b) clearly provide further evidence supporting the treatment of *A.hatuyenensis* as a synonym of *A. yunnanensis* (Phan *et al*., 2014a).
Specimens examined: – Ha Giang Prov., *Aver. et al. CBL 1773, Aver. et al. HAL 6413 and HAL 8405, D.K. Harder et al. DKH 4970, DKH 5056 and DKH 6158, N.T. Hiep NTH CPC 169* (CPC) and *NTH 6059, N.T. Hiep et al. NTH 3299, NTH 3452, NTH 6004 and CPC 211* (CPC), *C.I. Peng et al. 19934, P.K. Loc et al. CBL 193, HAL 1512, HAL 8656 and HAL 8641, P.K. Loc, G.M. Hai P 11120, P 11131, P 11133, P 11139, P 11140, P 11142, P 11143, P 11151, P 11152, P 11154, P 11155, P 11157 and P 11158, Vu Xuan Phuong 329* (P), *To Van Thao, ToT 060 and ToT 078, S.K. Wu et al. WP 626.* – Bac Kan Prov., *P.K. Loc et al. HLF 828* (CPC). – Tuyen Quang Prov., *P.K. Loc et al. P 10613.* – Lao Cai Prov., *N.Q. Hieu et al. CKF 144* (CPC). – Lai Chau Prov., *N.T. Hiep et al. HAL 10018, P.K. Loc et al. HAL 8754 and HAL 8784*. – Sơn La Prov., *Le Tran ChanC 136 a*, *D.K. Harder et al. DKH 5856, N.T. Hiep et al. HAL 9513*. –Thanh Hoa Prov., *Aver. HAL 4029* and *HAL 4216*. – Nghe An Prov., *V.M. Sơn and N.T. Vinh HLF 3128, P 607* (PMNP). – Quang Binh Prov., *Aver. et al. HAL 6108 and HAL 6203*.

32. *Taxus chinensis* (Pilg.) Rehder (Fig. 5I, H)

J. Arnold Arbor. 1: 51, 1919; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 131, Pl. 10, fig. 13-16, 1996; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1165, 2001; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 47, 2013.

– *T. wallichiana* Zucc. var. *chinensis* (Pilg.) Florin, Acta Horti Berg. 14 (8): 355, 1948; Fu *et al.*, Fl. China 4: 91, 1999.

Vietnamese name: Thông đỏ đá vôi (*Thông đỏ bắc*)

Description: Trees rarely exceeding 20–25 m with 0.5–0.7 m in d.b.h. All plant parts glabrous. Bark of old trees cracking and fallingoff as thin scales. Leafy branchlets more or less flat in living state, 2–9 × 1.5–6 cm in outline. Leaves of pollen and seed–bearing branchlets linear, straight, rarely to distally falcate, usually 1.5–2.2 × 0.25–0.3 cm (mean ratio leaf length/width 5.8), thick textured, midvein of same colour as stomatal bands, densely and evenly papillate, larger than marginal bands, acuminate at apex. Pollen cones solitary in leaf axil of 2nd year branchlet, shortly pedicellate (less than 1 mm), overlapping bracts at base, subglobose, 4–5 × 3 mm at maturity. Seed–bearing structure borne toward distal end of 2nd year branchlet axis. Aril red to orange, succulent when ripe, around 6 × 7 mm; seeds ovoid, acuminate at apex, brownish, finely turning brown at maturity, around 7 × 5 mm.
Distribution: Vietnam (Ha Giang, Cao Bang, Tuyen Quang, Lao Cai, Son La, Hoa Binh and Thanh Hoa provinces) (Phan, 1984, 2001; Nguyen & Vidal, 1996; Nguyen *et al.*, 2004; Phan *et al.*, 2007a, 2007b, 2009b, 2013b). China (Fu *et al.*, 1999).
Phenology: Pollination January–March; seeds maturity September–November, sometimes observed ripe fruits in April.
Ecology: Grows in small groups or as scattered individuals in primary closed evergreen seasonal tropical forests along ridges of the highly eroded solid crystalline white limestone mountains in mixed conifer forests dominated by *Pseudotsuga chinensis, Xanthocyparis vietnamensis, Tsuga chinensis*, at elevations 900–1500 m. Natural regeneration by seeds observed. Observed annual rings are 0.8–1 mm wide to ca. 1.6 mm wide (voucher specimen- *HAL 11318*).
Use: Timber is used in building construction andfurniture making.
Conservation status: VU (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007); protected in many Bat Dai Son, Nam Xuan Lac, Na Hang, Hang Kia–Pa Co, Pu Luong, Pu Mat and Pu Huong as well as in the newely established Nam Dong species and habitat protected area (Thanh Hoa province).
Notes: Based on a combination of morphological and molecular data Möller *et al.*, 2013 considered that most of subpopulations of this taxon found on limestone areas in N Vietnam belonged to a new species, *Taxus calcicola* L.M. Gao & M. Möller (Möller *et al.*, 2013). This finding requires further investigation.
Specimens examined: – Ha Giang Prov., *Aver. et al. HAL 6469, HAL 8483 and HAL 8566*, *L.K. Bien 381*, *D.K. Harder et al. DKH 4979, DKH 5059, DKH 5189 and DKH 6071*, *N.Q. Hieu et al. CKF 004* (CPC) and *CKF 034* (CPC), *N.T. Hiep et al. NTH 3285, NTH 3373, NTH 5969 and NTH 6054*, *CPC 141 and CPC 212* (CPC), *P.K. Loc P 10912, P.K. Loc et al. HAL 8642 and HAL 8685*, *P.K. Loc, G.M. Hai P 10917, P 11101, P 11112, P 11121, P 11130, P 11146, P 11159, P 11318, P 11870, P 11913, HAL 1519 and HAL 11326*, *N. Tap et al.* 36a, *ToVT 095*. – Cao Bang Prov., *N.S. Khang, N.M. Tam CB 05*. – Tuyen Quang Prov., *P.V. The et al. CPC 4535* (CPC). – Lao Cai Prov., *N.Q. Hieu et al. CKF 172, CKF 2074* (CPC), *CKF 4535* (CPC). – Son La Prov., *Aver. et al. CPC 1857* (CPC), *D.K. Harder et al. DKH 7125, DKH 7168 and DKH 7340*, *N.T. Hiep et al. HAL 9319 and HAL 9522*, *P.K. Loc, H.V. Thien P 10934*, *P.K. Loc et al. DKH 7503*. – Hoa Binh Prov., *N.T. Hiep et al. HAL 345 and HAL 626, P.K. Loc, N.H. Nga P 4468, N.N. Thin NT 1151*, *P.K. Loc and V.D. Duy P 11040*. – Thanh Hoa Prov., *Aver.et al. HAL 3284, P.K. Loc et al. P 11051, P 11053*, *P 11054 and P 11055*. – Nghe An Prov., *P 640*, (PMNP), *V.M. Son and N.T. Vinh HLF 3128B*.

33. *Taxus wallichiana* Zucc.

Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 3: 803, t. 5, 1843; Phan, J. Biol. (Hanoi) 6(4): 10, 1984; Nguyen and Vidal, Fl. Cambod., Laos, Vietnam 28: 130, Pl. 10, fig. 10-12, 1996; Fu *et al.*, Fl. China 4: 90, 1999; Phan, Gymnospermae. Checkl. Pl. Sp. Vietnam I: 1165, 2001; Phan *et al.*, Ecol. Econ. J. (Vietnam) 45: 47, 2013.

–*Taxus baccata* subsp. *wallichiana* (Zucc.) Pilg., Farjon, World Checklist Bibliogr. Conif., 2nd.: 300. 2001; Pham, Ill. Fl. VietnamI, 1: 279, fig. 759, 1991.

Vietnamese name: Thông đỏ nam (*Thông đỏ núi đá không vôi*)

Description: Upright tree up to 30–35 m tall with bole up to 25–30 m long; trunk 1–1.5 m in d.b.h. or more; all plant parts glabrous. Bark of old trees cracking and fallingoff as thin scales. Branches spreading; crown pyramidal. Leaves of seed–bearing branchlets linear, around 1.5–2.8 × 0.25–0.3 cm straight, gradually tapered distally in S–shape, texture thinner in comparison to *T. chinensis*. Seed–bearing structure borne toward distal end of 2nd year branchlet axis. Aril red to orange, succulent when ripe, around 8 × 7 mm, covered almost all seed except its apex; seeds ovoid, acuminate at apex, brownish, finely turning dark brown at maturity, around 8 × 5 mm.
Distribution: Vietnam (restricted in Lam Dong province only) (Pham, 1991; Nguyen & Vidal, 1996; ; Phan, 2001; Nguyen *et al.*, 2004; Phan *et al.*, 2013b). India, Bhutan, Sikkim, Myanmar, China (Fu *et al*., 1999; Averyanov *et al.*, 2003).
Phenology: Pollination unknown; seed maturity October–December.
Ecology: Grows in primary closed evergreen seasonal tropical forests, usually in pure stands or mixed with broad-leaved species along rivulets running down non limestone mountains at 900–1600 m elevation, the slopes dominated by broad–leaved closed evergreen forests. Observed annual rings are around 1.7 mm wide (voucher specimen- *P 10972*).
Use: Timber is of good quality, used for building construction (making houses) and furniture**.**
Conservation status: EN (Nguyen *et al.*, 2004); VU (MOST & VAST, 2007); protected in Bidoup–Nui Ba National Park and in some sites around Da Lat City.
Specimens examined: – Lam Dong Prov., *Aver. et al. HLF 5251 B, LX–VIỆT NAM 1522* (LE), *N.M. Tam and V.D. Duy HT 32*, *HT 38, NV 11, P.K. Loc, L.C. Doan P 10972, P.K. Loc et al. HLF 5191*.

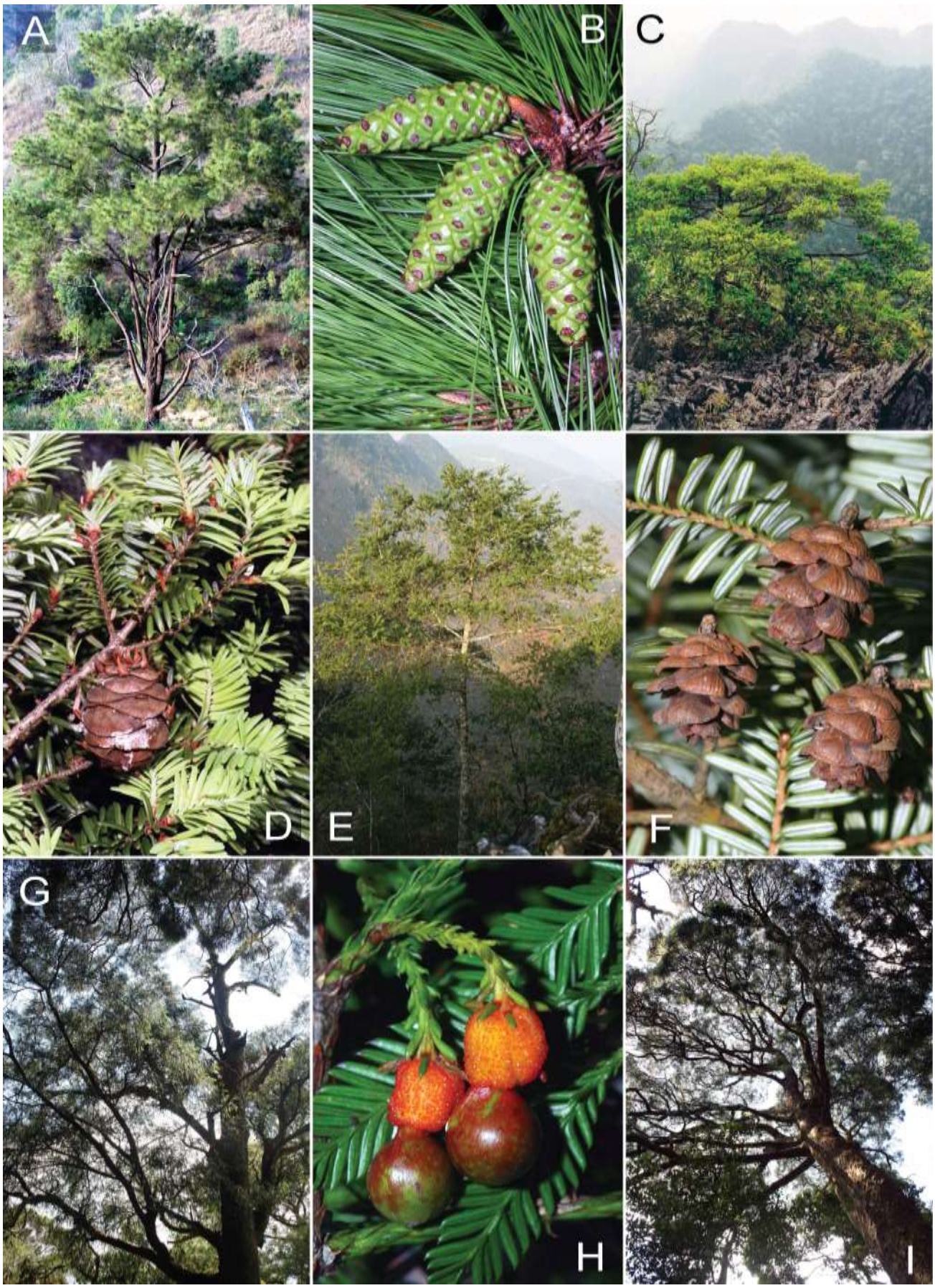

Fig. 4. Native conifer species in Vietnam: A, B – *Pinuslatteri* (HLF 5439, 7093); C, D– *Pseudotsuga sinensis* (HAL 1548, 5499); E, F– *Tsuga chinensis* (HAL 8533); G, H – *Dacrycarpus imbricatus* (CPC 3726, HLF 5294); I – *Dacrydium elatum* (CPC 3727). Photos by Averyanov.

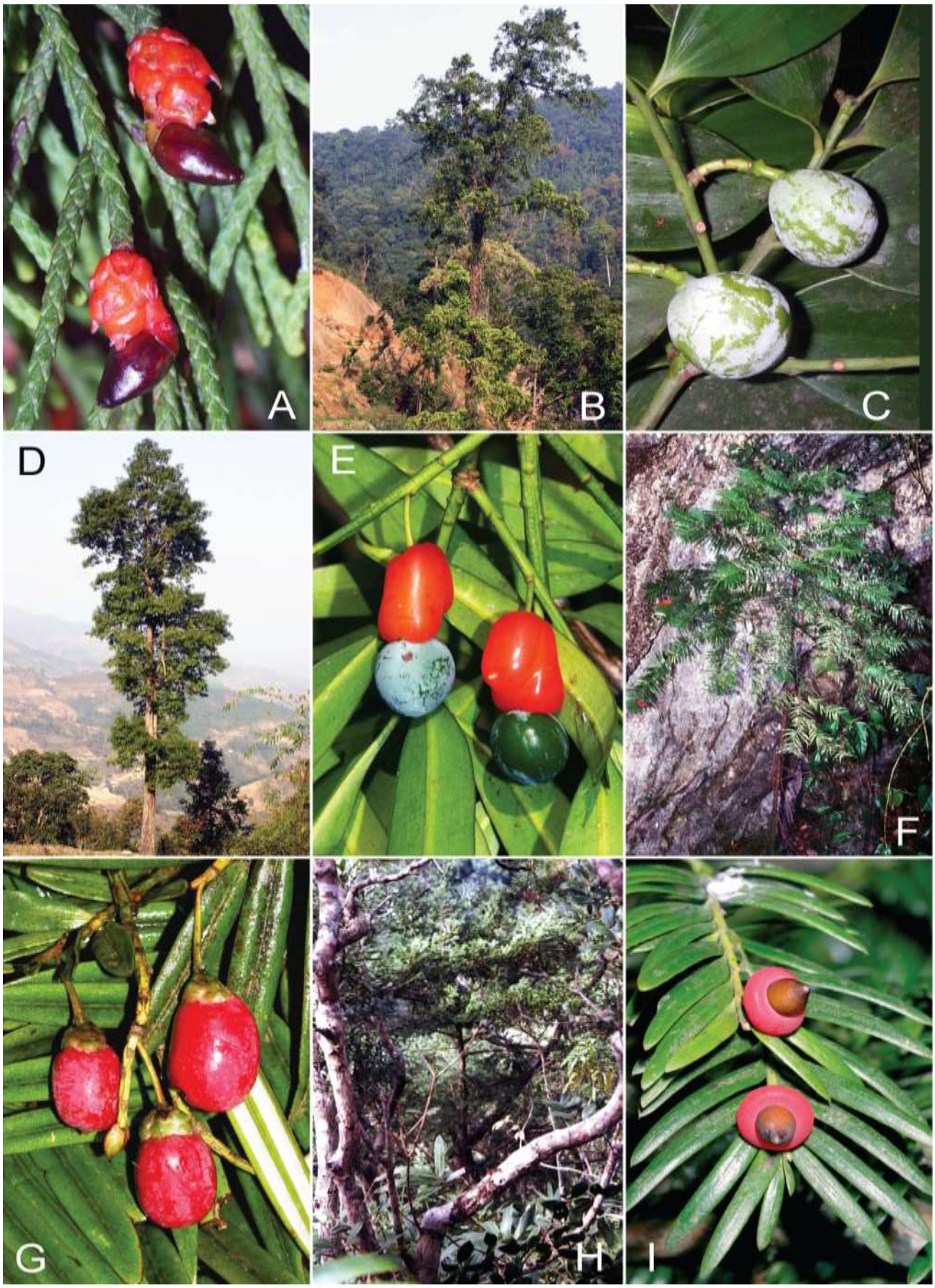

Fig. 5. Native conifer species in Vietnam: A – *Dacrydium elatum* (HLF 5346); B, C – *Nageiawallichiana* (HAL 7052, 8153); D, E– *Podocarpus neriifolius* var. *neriifolius* (HAL 6621); F, G – *Amentotaxusyunnanensis* (CBL 1256, HAL 6413); H, I– *Taxus chinensis* (HAL 3284, 9522). Photos by Averyanov.

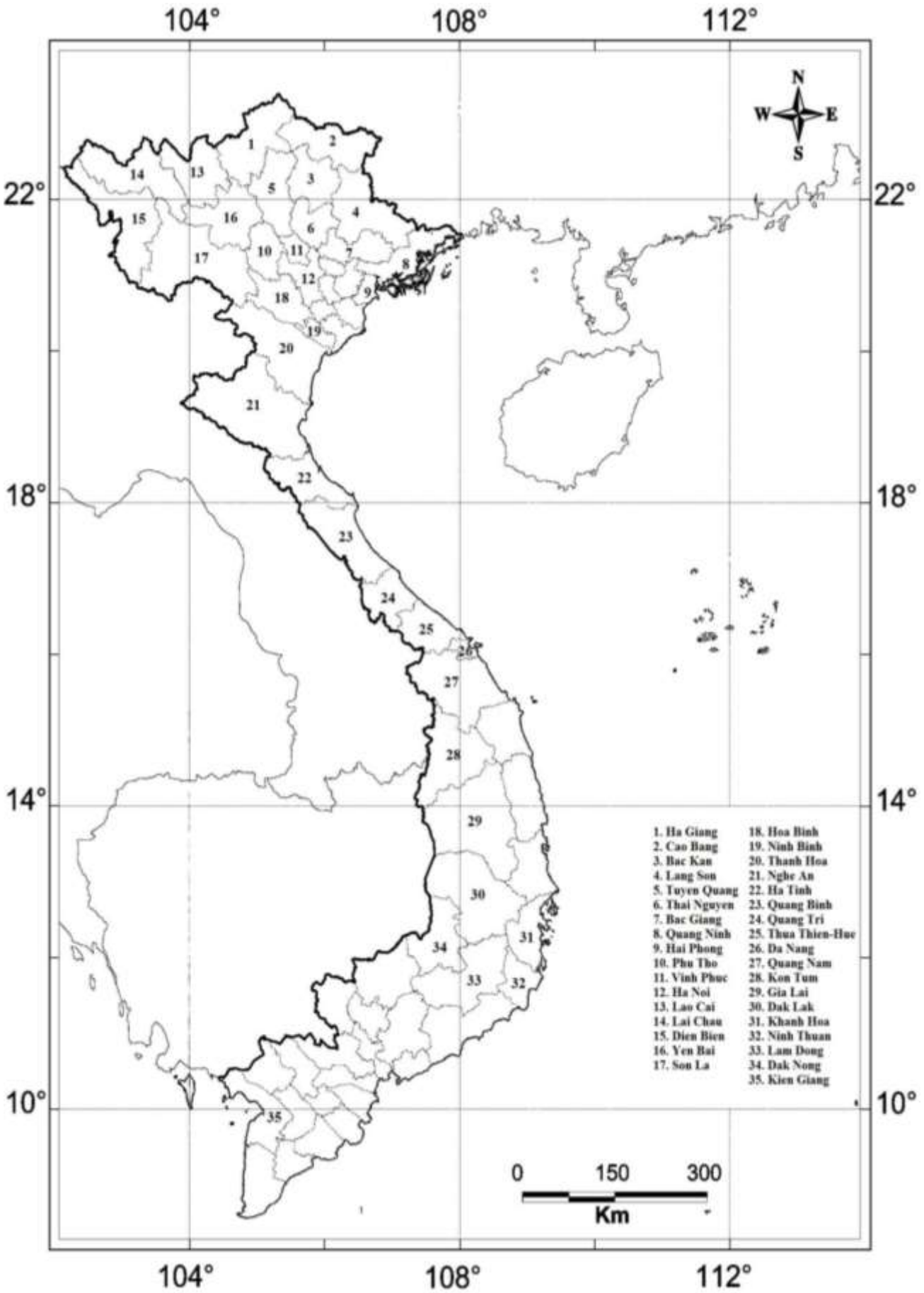

Fig. 6. List of provinces where studied specimens collected.

Discussion

This review recognizes 33 species of conifers for Vietnam; these species are accommodated in 19 genera belonging to 5 families. The largest family is Pinaceae which includes 13 species and 5 genera followed by Cupressaceae (7 species and 7 genera), Podocarpaceae (7 species and 3 genera), Taxaceae (5 species and 2 genera) and Cephalotaxaceae (1 species and genus). Most accepted taxa (30 taxa, representing 90% of the total) have been assessed as nationally threatened. Among them 3 as CR (*Cupressus tonkinensis, Glyptostrobus pensilis* and *Xanthocyparis vietnamensis*), 8 as EN (*Abies delavayi* subsp. *fansipanensis, Fokienia hodginsii, Keteleeria davidiana, Pinus armandii* subsp. *xuanhaensis, P. henryi, Taxus wallichiana, Tsuga dumosa*, *Xanthocyparis vietnamensis*) and 19 others as VU. The major threats are the overexploitation of timber and the clearing of habitats for agriculture.

Within Vietnam there are 6 floristic provinces. The Sizang-Yunnan province belonging to the Holarctic Kingdom includes the highest mountain range, Fansipan, and surrounding areas. Two species (*Taxus dumosa* and*Taiwania cryptomerioides*) and one subspecies (*Abies delavayi* subsp. *fansipanensis*) occur only in this province. There are 5 other provinces belonging to the Paleotropical Kingdom. *Nageia wallichiana* occurs only in the South Indochinese province, the southernmost floristic province of Vietnam. The Vietnamese Northeastern-South Chinese floristic province is the most diverse and interesting. In this area nine species are restricted to limestone mountains, namely *Calocedrus macrolepis* var. *rupestris, Cupressus tonkinensis, Keteleeria davidiana, Pinus henryi, Pinus kwangtungensis, Pseudotsuga sinensis, Taxus chinensis, Tsuga chinensis* and *Xanthocyparis vietnamensis*). These species form primary pure stands on narrow ridge tops from about 700 m ascending toabout 1500 m elevation. Ten others species occur mainly on limestone mts. Furthermore, apart from three local endemics, *Cupressus tonkinensis*, *Xanthocyparis vietnamensis, Calocedrus macrolepis* var. *rupestris*, the remaining 16 species in this province also occur in the south of Guangxi Zhuangzu Zizhiqu (China). This is easy to explain because the environment and habitats are similar in these two areas, and there are no barriers that prevent the spread of the species.

Endemism in conifers is relatively low with only seven of the 33 species (21%) are confined to Vietnam. Endemic taxa with very restricted distributions include *Cupressus tonkinensis*, *Xanthocyparisvietnamensis*, *Amentotaxuspoilanei*, *Abiesdelavayi* subsp. *fansipanensis* and *Pinusarmandii* subsp. *xuanhaensis*. Endemics with rather wide distributions include *Pinuskrempfii* and *Calocedrusmacrolepis* var. *rupestris*.

All native conifers in Vietnam are found only in primary closed evergreen seasonal tropical forests. Species can be observed from sea level to nearly the highest point of Fansipan, around 3100 m. *Abies delavayi* subsp. *fansipanensis* grows at the highest elevation, mainly 2600-3100 m. *Dacrycarpus imbricatus* occurs at 50–1800 m elevation.

Slash and burn agriculture which has operated for centuries and is still practiced today, has had the most devastating effect on the largest areas of primary forests in Vietnam. As a result of this practice many indigenous species and communities have been severely impacted or lost completely. In abandoned secondary regenerated communities, woodlands or scrubs, only threeindigenous conifer species namely *Keteleeria evelyniana, Pinus kesiya* and *P. Latteri* are able to regenerate.

Concluding remarks

It should be noted that this updated checklist is still far from complete because many mountain regions of Vietnam remain poorly explored botanically, and because many existing specimens lack fertile parts that are needed for correct identification. Moreover, a more complete understanding of the taxonomic status and phylogenetic relationships of some closely related taxa requires further critical morphological study and the use of molecular cladistic methodology (Phan *et al.,* 2013b). These related taxa include the following: *Keteleeria davidiana* and *Keteleeria evelyniana, Nageia fleuryi* and *Nageia nagi, Taxus chinensis* and *Taxus wallichiana, Tsuga chinensis* and *Tsuga dumosa, Podocarpus annamiensis* and *Podocarpus neriifolius, Pinus dalatensis* and *Pinus anemophila, Pinus kwangtungensis* and *Pinus wangii, Pinus armandii* subsp. *xuanhaensis* and *Pinus fenzeliana.*

Acknowledgements

Field explorations were possible by grants during the last 20 years from the following sources: Basic Research Program in Natural Sciences, Viet Nam and National Foundation for Science and Technology (NAFOSTED) of the Ministry of Science and Technology, Vietnam (grants #106.11.20.09 and 106.11-2012.30 to Phan Ke Loc), U.S. National Geographic Society (grants #9129-12, #9141-12 and #9584-14 to L.V. Averyanov), American Orchid Society (grants to L.V. Averyanov), Henry Luce Foundation (grants to the Missouri Botanical Garden, 2002-2008), John D. and Catherine T. MacArthur Foundation (grant to the Missouri Botanical Garden, 2003-2005). The authors would like to express their thanks to the above-cited donors.

References

Averyanov, L.V., K.L. Phan, T.H. Nguyen and D.K. Harder. 2003. Phytogeographic review of Vietnam and Adjacent Areas of Eastern Indochina. *Komarovia*, 3: 1-83.

Averyanov, L.V., K.L. Phan, T.H. Nguyen, S.K. Nguyen, T.V. Nguyen and T.D. Pham. 2009. Preliminary Observation of Native *Glyptostrobus pensilis* (Taxodiaceae) Stands from Vietnam. *Taiwania*, 54(3): 191-212.

Averyanov, L.V., T.H. Nguyen, D.K. Harder and K.L. Phan. 2002. The History of Discovery and Natural Habitats of *Xanthocyparis vietnamensis* (Cupressaceae). *Turczaninowia,* 5(4): 31-39.

Averyanov, L.V., T.H. Nguyen, K.L. Phan, S.K. Nguyen and V.T. Pham. 2012.*Flora and Vegetation of Areas Allied to Phong Nha – Ke Bang National Park (Northern Vietnam)*. Saarbrucken. Lambert Academic Publishing. 224 pp.

Averyanov, L.V., T.H. Nguyen, L.K. Phan andV.T. Pham. 2008. The Genus *Calocedrus* (Cupressaceae) in the Flora of Vietnam. *Taiwania,* 53: 11-22.

Averyanov, L.V., T.H. Nguyen, S.K. Nguyen, V.T. Pham, V. Lamxay, S. Bounphanmy, S. Lorphengsy, K.L. Phan, S. Lanorsavanh and K. Chantthavongsa. 2014. Gymnosperms of Laos. *Nord. J. Bot.*, 32: 765-805.

Beissner, L. 1891. *Handbuch der Nadelholzkunde: Systematik, Beschreibung, Verwendung und Kultur der Freiland-Coniferen, für Gärtner, Forstleute und Botaniker*. P. Parey, 424: f. 117

Bentham, G. 1880. *Libocedrus macrolepis*. In: (Eds.): Bentham, G. and J. D. Hooker. Gen. Pl. 3(1). Reeve & Co. London, p. 426.

Blume, K.L. 1827. Coniferae. *Enum. Pl. Javae* 1: 89.

Bui, N.S. 1962. Matétiaux pour la flore du Cambodge, du Laos et du Viêt Nam. Les Abiétacées. *Andansonia*, 2: 329-342, illus.

Businský, R. 1999. Taxonomic revision of *Eurasian pines* (genus *Pinus* L.): survey of species and infraspecific taxa according to latest knowledge. Towards a monograph of pines in the Old World. *Acta Pruhon.* 68: 7-86.

Businský, R. 2010. A new species of soft pine from the Vietnamese border of Laos. *Acta Pruhoniciana*, 96: 5-13.

Businský, R. 2011. *Pinus fenzeliana* Hand.-Mazz. (Pinaceae) still misinterpreted? *Phyton (Horn, Austria)*. 51(1): 77-87.

Businský, R. 2013. Taxonomic Revision and Conspectus of *Pinus* in Vietnam. *Phyton*, 53(2): 241-264.

Cheng, W.C., L.K. Fu and C.Y. Cheng. 1975. Gymnospermae sinicae. *Acta Phytotax. Sin*. 13(4): 56-89.

Chevalier, A. 1944. Notes sur les Conifères de l'Indochine. *Chev., Rev. Int. Bot. Appl. Agric. Trop*., 24: 7-34

Chun, W.Y. and Y. Tsiang. 1963. Materials for the Flora of Hainan (I). *Acta Phytotax. Sin*. 8(3): 259-278.

Cooling, E. and H. Gaussen. 1970. In Indochina: *Pinus merkusiana* sp. nov. et non *P. merkusii* Jungh. et de Vriese. *Trav. Lab. Forest. Toulouse* T. 1(8, 7): 5.

de Ferré, Y. 1960. Une nouvelle espèce de pin au Viet-nam, *Pinus dalatensis*. *Bull. Soc. Hist. Nat. Toulouse*, 95: 178.

de Laubenfels, D.J. 1988. *Podocarpaceae and Pinaceae. Flora Malesiana*. Ser. I, 10(3): 376-452.

de Laubenfels, D.J. 1969. A revision of the Malesian and Pacific rainforest conifers, I. Podocarpaceae, in part. *J. Arnold Arbor.,* 50(3): 315-369.

Don, D. and A.B. Lambert. 1824. *Cupressus torulosa; Pinus dumosa; Podocarpus neriifolius.* In: (Ed.): Lambert, A.B., Descr. Pinus 2. London :J. White, pp. 18, 21, 55.

Dode, L.A. 1912. Deux genres nouveaux pour la Chine. *Bull. Soc. Dendrol. France*., 7: 58-61.

Dunn, S.T. 1908. A Botanical Expedition to Central Fokien. *Dunn, J. Linn. Soc. Bot*., 38: 367.

Eichler, E.W.

Hooker, W.J. 1827. *Cunninghamia lanceolata*. In: (Ed.): Curtis,W., Bot. Mag. 54. Sherwood, Neely, & Jones, London, pl. 2743.

Farjon, A. 2001. *World Checklist and Bibliography of Conifers Second edition*. The Royal Botanic Gardens, Kew, 309 pp.

Farjon, A., T.H. Nguyen, D.K. Harder, K.L. Phan and L.V. Averyanov. 2002. A new genus and species in cupressaceae (Coniferales) from Northern Vietnam, *Xanthocyparis vietnamensis. Novon*, 12(2): 179-189.

Ferguson, D.K. 1989. On Vietnamese *Amentotaxus* (Taxaceae). *Bull. Mus. Nation. Hist. Nat., B, Adansonia,* sér. 4, 11(3): 315-318.

Florin, R. 1948. Enumeration of gymnosperms collected on Swedish expeditions to western and northwestern China in 1930-1934. *Acta Horti Berg.* 14(8): 343-384.

Foxworthy, F.W. 1911. Bedaru and Billian: Two Important Borneo Timber Trees. *Phillip. J. Sci*., 6: 160.

Franchet, A. 1884. Conifae. *Nouv. Arch. Mus. Hist. Nat.*, sér. 2, 7: 95.

Franchet, A. 1899. Plantarum sinensium ecloge tertia. *J. Bot. (Morot),* 13(8): 255-260.

Fu, L.G., R.R. Mill and N. Li. 1999. Pinaceae, Cupressaceae, Taxodiaceae, Podocarpaceae, Cephalotaxaceae and Taxaceae. In: (Eds.): Wu, Z.Y. and P.H. Raven. *Flora of China*. Beijing and St. Louis, 4: 11-96.

Fujita, D. 1932. Trans. Nat. Hist. Soc. Form.22: 49: p. 476.

Gao, L.M., Y. Li, K.L. Phan, L.J. Yan, P. Thomas, K.L. Phan, M. Möller and D.Z. Li. 2017. DNA barcoding of East Asian *Amentotaxus* (Taxaceae): Potential new species and implications for conservation. *J. Sys. & Evol.,* 55(1): 16-24.

Gordon, G. 1840. Report on the new species and varieties of hardy trees and shrubs raised in the Horticultural Society's gardens since the last report made in October, 1838. *Gard. Mag. and Reg. Rural Domest. Improv*., 6: 8.

Gray, N.E. 1958. A taxonomic revision of *Podocarpus* XI. The South Pacific species of section *Podocarpus*, subsection B. *J. Arnold Arbor.,* 39(4): 424-477.

Hance, H.F. 1883. Spicilegia florae sinensis: Diagnoses of new, and habitats of rare or hitherto un-recorded, Chinese plants.-VIII. *J. Bot*., 21: 357.

Hayata, B. 1906. On *Taiwania*, a new genus of Coniferae from the island of Formosa. *J. Linn. Soc., Bot.,* 37(260): 330-331.

Hayata, B. 1908. *New or noteworthy plants, new conifers from Formosa.* Gard. Chron., ser. 3, 43: 194.

Hickel, P.R. 1930. *Bull. Soc. Dendrol. France*., 76: 74-75.

Hickel, P.R. 1931. Conifères. *In*: Lecomte, M.H. (Ed.),*Flore Générale de L'Indochine.* Paris, 5, 1068-1084.

Henry, A. and H.H. Thomas. 1911. *New or noteworthy plants, a new genus of coniferae.* Gard. Chron., ser. 3, 49: 66-68.

Hooker, W.J. 1843. Brief descriptions, with figures, of *Juniperus bermudiana*, the Pencil-Cedar Tree; and of the *Dacrydium elatum*, Wall.*London J. Bot*. 2: 144, tab. 2: 141-145.

Hooker, J.D. 1886.*Cephalotaxus mannii*. In: Hooker, J.D. (Ed),*Hooker's Icones Plantarum 16*. Williams andNorgate, London, plate-1523.

IUCN Standards and Petitions Subcommittee. 2016. *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 12. Prepared by the Standards and Petitions Subcommittee. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf.

Junghuhn, F.W. and W.H. de Vriese. 1845. Pl. Nov. Ind. Bot. 5, pl. 2.

Koch, K.H.E. 1873. *Dendrologie 2 (2)*. Erlangen: Ferdinand Enke, p. 191.

Kuan, C.T. 1983. Flora Sichuanica:(Gymnospermae), 2: 113.

Kuntze, C.E.O. 1891. *Revis. Gen. Pl. 2*. Leipzig :A. Felix, pp. 798-800.

Kurz, S. 1873. On a few new plants from Yunnan. *In:* Trimens, H. (Ed.),*J. Bot.* 11, p. 196, t. 133.

Lambert, A.B. 1828. Descr. Pinus, ed. 2, 2: 115.

Le, T.T., T.T. Nguyen and K.L. Phan. 2015. Additions to the Morphology of the Genus *Keteleeria* Carrière (Pinaceae) in Vietnam. *Proceedings 6th National Scientific Conference on Ecology and Biological Resources*, Hanoi, 21 October 2015. Agric. Publ. House, 338-344 (in vietnamese).

Lecomte, H. 1921. Un pin remarquable de l'Annam. *Bull. Mus. Natl. Hist. Nat*., 27, 191-192.

Li, H.L. 1952. The genus *Amentotaxus*. J. Arnold Arbor., 33(2), 192-198.

Little, D.P., P. Thomas, T.N. Hiep and K.P. Loc. 2011. Before It Had A Name: Diagnostic Characteristics, Geographic Distribution, and The Conservation of *Cupressus tonkinensis* (Cupressaceae). *Brittonia,* 63(2), 171-196.

Luong, V.H., V.K. Huynh, L.T. Nguyen, K.L. Phan and T.H. Nguyen. 2010. Discovering of New Distribution Site of *Pinus dalatensis* Ferré at Bach Ma National ParkThua Thien-Hue Province. *Vietnam Ecol. Econ. J.*, 34, 4-7.

Mason, F. 1849. The pine tree of the Tenasserim Provinces. *J. Asiat. Soc. Bengal. Sci.*, 18(1): 74-75.

Masters, M.T. 1898. De Coniferis quibusdam sinicis vel japonicis adnotationis quaedam porrigit. *Bull. Herb. Boissier* 6 : 270.

Masters, M.T. 1902. Coniferae. *J. Linn. Soc., Bot.,* 26: 550.

Masters, M.T. 1903. Chinese conifers. *Gard. Chron.*, ser. 3, 33: 194.

Merrill, E.D. 1907. The Flora of mount Halcon, Mindoro. *Phillip. J. Sci.,* 2: 259

Möller, M., L.M. Gao, R.R. Mill,J. Liu, D.Q. Zhang,R.C. Poudel and D.Z. Li. 2013. A Multidisciplinary Approach Reveals Hidden Taxonomic Diversity In The Morphologically Challenging *Taxus wallichiana* Complex. *Taxon*, 62: 1161-1177.

MOST (Ministry of Science and Technology) and VAST (Vietnamese Academy of Science & Technology). 2007. *Vietnam Red Data Book. Part II- Plants*. Nat. Sci. and Techn. Publ. House, Hanoi.

Nguyen, D.T.L. and P. Thomas. 2004. *Conifers in Vietnam, Illustration guide*. World Publ. House, Hanoi (in Vietnamese).

Nguyen, H.N. 2004. *Conifers in Vietnam*. Agric. Publish. House, Hanoi (in Vietnamese).

Nguyen, S.K., T.H. Nguyen, V.T. To, V.T. Pham, K.L. Phan and L.V. Averyanov. 2007. The Diversity of the Flora of Vietnam 25. Additional Data on the Composition and the Distribution of Conifers in the Northeastern Limestone Areas of Ha Giang Province. *Genetics and Appl,*1: 24-28 (in Vietnamese).

Nguyen, T.H. and J.E. Vidal. 1996. *Flore du Cambodge, du Laos et du Vietnam 28*. Paris: Museum National d'Histoire Naturelle.

Nguyen, T.H., K.L. Phan, D.T.L. Nguyen, P.I. Thomas, A. Farjon, L.V. Averyanov and J.R.Jr. Regalado.2004. Vietnam Conifers: Conservation Status Review 2004. Fauna and Flora International, Vietnam Program, Hanoi, 174 pp.

Nguyen, T.H., Q.H. Nguyen, K.L. Phan, T.D. Pham, S.K. Nguyen and D.C. Nguyen. 2009a. Primary Results on Conservation of *Taiwania cryptomerioides* in Nam Co Commune, Mu Cang Chai District, Yen Bai Province. *Proceedings of the 3rd National Scientific Conference on Ecology and Biological Resources*, Hanoi,521-526. Agric. Publ. House, Hanoi (in Vietnamese).

Nguyen, T.H., T.D. Do, K.L. Phan and L.V. Averyanov. 2002. The Diversity of the Flora of Vietnam 9. *Taiwania* Hayata and *T. cryptomerioides* Hayata (Fam. Taxodiaceae), Genus and Species New Occurrence for the Flora. *Genetics & Appl.*, 1, 32-40 (in Vietnamese).

Nguyen, T.P.T., M.T. Nguyen, K.L. Phan and L.K. Phan. 2009b. Contribution to the Study of the Systematic Relationship Between *Cunninghamia lanceolata* and *Cunninghamia konishii* (Cupressaceae) in Vietnam Based on the 18S-rDNA Sequence data.*Vietnam J. Biotechnol.*, 7, 85-92 (in Vietnamese).

Nguyen, T.P.T., V.S. Nguyen, N.H. Truong, K.L. Phan and M.T. Nguyen. 2011. Taxonomic Position of *Cunninghamia lanceolata* (Lamb.) Hook., 1827. *Proceedings of the 4th National Scientific Conference on Ecology and Biological Resources*, Hanoi, 21 October 2011,417-422. Agric. Publish. House, Hanoi (in Vietnamese).

Orlova, L.A. and L.V. Averyanov. 2004. On the Taxonomical Position of *Ducampopinus krempfii*(Pinaceae). *Turzaninowia*, 7(2), 30-34.

Pilger, R.K.F. 1903. Taxaceae. *In:* Engler, A. (Ed.), *Pflanzenr*, 18: 4(5): 60.

Pilger, R.K.F. 1917. Kritische Ubersicht uber die neuere Literatur betreffend die Familie der Taxaceae. *Bot. Jahrb. Syst*. 54: 41

Pham H.H. 1991. Cay Co Viet Nam: An Illustrated Flora of Vietnam I (1). Montréal.

Pham H.H. 1999. Cay Co Viet Nam: An Illustrated Flora of Vietnam I. Tre Publishing House, Ho Chi Minh city, Vietnam, pp. 227.

Pham, V.T., H.T. Tran and T.H. Nguyen. 2009. Some additional data on the ecology and conservation status of Cupressus tonkinensis Silba. in Huu Lien Natural Reserve, Huu Lung district, Lang Son Province. *Proceedings 3rd National Scientific Conference on Ecology and Biological Resources*, Hanoi, October 2009. *Agric. Publ. House*, 1660-1667. (in Vietnamese).

Pham, V.T., K.L. Phan, T.H. Nguyen and J. Silba. 2013. The Status of Wild and Cultivated Populations of *Cupressus tonkinensis* Silba in Vietnam. *Bulletin Cupressus Conservation Project*, 2(1), 10-16.

Phan, K.L. 1984. Conifer Species in the Flora of Vietnam. *VietnamJ. Biol.,* 6(4), 5-10 (in Vietnamese).

Phan, K.L. 2001. Gymnospermae. In: *Checklist of Plant Species of Vietnam I.* Published by VNU'CRES (Center for Resources and Environmental Study). Agric. Publ. House, Hanoi, 1149-1166 (in Vietnamese).

Phan, K.L., K.L. Phan, T.M.L. Le and G.S. Nguyen. 2014a. Molecular Characterization of *Amentotaxus hatuyenensis*N.T. Hiep (Taxaceae) Based on ITS1 Partial Sequence. *VNU J. of Sci.: Natural Sci. & Technol.*, 30(3S), 46-52.

Phan, K.L., T.H. Nguyen andL.V. Averyanov. 2010. Continuing Study Conifer Diversity, Their Distribution and Assess Their Conservation Value in Kon Tum Province. *Vietnam Ecol. Econ. J.*, 37: 42-48 (in Vietnamese).

Phan, K.L., T.H. Nguyen, L.V. Averyanov, S.K. Nguyen and V.T. Pham. 2011a. Conifers in Central of Vietnam- Species Composition, Distribution and Actual Conservation. *Vietnam Ecol. Econ. J.*, 40, 9-17 (in Vietnamese).

Phan, K.L., T.H. Nguyen, S.K. Nguyen, L.V. Averyanov and J.C. Regalado. 2008. The Diversity of the Flora of Vietnam 30.*Pinus tabuliformis*Carrière aff. var. *henryi* (Mast.) C.T. Kuan, New Occurrence for the Flora. *Genetics & Appl.*, 1-4, 44-48 (in Vietnamese).

Phan, K.L., T.H. Nguyen, S.K. Nguyen, V.T. Pham and L.V. Averyanov. 2007b. Results of the Inventory of Conifer Species and Distribution and the Assessment of Their Conservation Value in Cao Bang Province. *Genetics & Appl.*, 3+4, 68-72 (in Vietnamese).

Phan, K.L., T.H. Nguyen, S.K. Nguyen, V.T. Pham, V.T. To, L.V. Averyanov, J.C. Regalado, and X.C. Lenh. 2007a. The Diversity of the Flora of Vietnam. Results of the Inventory of the Diversity, the Distribution and Assess its Its Conservation Value of Conifers in Ha Giang Province. *Genetics & Appl.*, 3+4, 60-67 (in Vietnamese).

Phan, K.L., T.H. Nguyen, S.K. Nguyen, V.T. To, V.T. Pham, L.V. Averyanov, D.K. Harder and J.C.Jr. Regalado. 2009b. The Diversity of the Flora of Vietnam 33. Continuing Contribution to the Enumeration of Conifer Species, Their Distribution and Assessment of Their Conservation Value in Son La Province. *Genetics & Appl.*, 2009, 43-49 (in Vietnamese).

Phan, K.L., T.H. Nguyen, T.D. Do, S.K. Nguyen, T.S. Le, D.H. Nguyen, V.H. Le, L.V. Averyanov and J.C. Regalado. 2009a. Continuing Contribution to the Enumeration of Conifers, Their Distribution and Assessment of Their Conservation Value in Thanh Hoa Province. *Genetics & Appl.*, 1, 22-28 (in Vietnamese).

Phan, K.L., T.T. Le, A.V. Tran, H.Q. Nguyen and T.C. Nguyen. 2015. Results of the Identification of New Collections of the Genus Nageia Gaertn. in Vietnam. *Proceedings 6th National Scientific Conference on Ecology and Biological Resources*, Hanoi, 21 October 2015. *Agric. Publ. House,* 214-220 (in Vietnamese).

Phan, K.L., T.T. Nguyen, L.V. Averyanov and K.L. Phan. 2011b. Molecular Characterization of *Calocedrus rupestris* Aver., H.T.Nguyen and L.K.Phan. 2008. (Cupressaceae) Based on ITS1 Partial Sequence. *Genetics & Mol. Res.*, 10, 3702-3711.

Phan, K.L., V.T. Pham, L.V. Averyanov and T.H. Nguyen. 2013a. Assess the Conservation Value of Plants and Their Communities in Na Hang Nature Reserve and in Two Neighbouring Sites, Na Hang Distr., Tuyen Quang prov. *Proceedings of the 5th National Scientific Conference on Ecology and Biological Resources*, Hanoi, 18 October 2013. Agric. Publ. House, 556-562 (in Vietnamese)

Phan, K.L., V.T. Pham, S.K. Nguyen, T.T.H. Nguyen and L.V. Averyanov. 2013b. Native Conifers of Vietnam- Updated Checklist 2013. *Vietnam Ecol. Econ. J.*, 45: 33-50 (in Vietnamese).

Phan, K.L., V.T. Phan, C.L. Ha and D.T.L. Nguyen. 2014b. *Pinus armandii* subsp. *xuanhaensis* (Pinaceae), A New Subspecies of Pine from Vietnam. *VNU J. of Sci.: Natural Sci. & Technol.*, 30(3S), 53-60.

Phengklai, C. 1972. Pinaceae/Cephalotaxaceae/Cupressaceae. *Fl. Thail*. 2(2). Applied Scientific Research Corporation of Thailand, Bangkok, pp.193-196.

Phengklai, C. 1975. Podocarpaceae. *Fl. Thail*. 2(3). Applied Scientific Research Corporation ofThailand, Bangkok, pp. 197-203.

Presl, K. B. 1844. Botanische Bemerkungen. *Abh. Königl. Böhm. Ges. Wiss.,* ser. 5, 3: 540

Pritzel, E. 1900. Gymnospermae. *In*: Diels, L. (Ed.), *Die Flora von Central-China*. Mit Taf. II-V, Karten-Skizzw und 5 Fig. Im Text. Bot. Jahrb. Syst., 29: 217.

Rehder, A. 1919. New species, varieties and combination from the herbarium and the collections of the Arnold Arboretum.*J. Arnold Arbor*., 1: 44-60.

Rushforth, K. 1999. Taxonomic notes on some Sino-Himalayan conifers. *Int. Dendrol. Soc. Yearb*. 1998: 60-63.

Silba, J. 1990. A supplement to the international census of the Coniferae: 2. *Phytologia*, 68(1): 7-78.

Silba, J. 1994. The trans-Pacific relationship of *Cupressus* in India and North America. J. *Int. Conif. Preserv. Soc.*1: 23.

Sykes, W.R. 1991. Gymnospermae of Guangxi, South China. *Guihaia,* 11(4), 339-377.

Tsiang, Y. 1948. A new pine from south China. *Sunyatsenia*, 7: 111-114.

Xiang, Q. P. 1997. *Abies fansipanensis* - A new species of the genus Abies from Vietnam. Acta Phytotax. Sin. 35(4): 356.

Zuccarini, J.G. 1843. Beiträge zur Morphologie der Coniferen (Vol. 3). *Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss*. 803, t. 5.

(Received for publication 17 September 2016)