

Gymnosperms of Laos

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The present review includes keys for identification and summary data on the nomenclature, morphology, ecology and distribution for all 33 species of gymnosperms hitherto recorded in the flora of Laos. They belong to 8 families and 15 genera. Important additions to these data were obtained during fieldwork in 2009–2013, when 58 localities containing 25 species from 14 genera and 8 families were explored and initially studied. Two species, *Cycas laotica* and *Pinus cernua*, are described as new species for science. Seven species, *Cycas dolichophylla*, *C. inermis*, *C. macrocarpa*, *C. micholitzii*, *C. nongnoochiae*, *C. petraea* and *Taxus wallichiana*, are found in Laos and represent new records for the flora of the country. Maps of the distribution and illustrations for the newly discovered gymnosperm species are provided. All observations, records and discoveries are based on reliable scientific literature and collected voucher herbarium specimens housed in main regional herbaria.

Gymnosperm plant species form a small relictual group of higher plants, representing the most sensitive ancient elements of modern tropical floras. Gymnosperms are highly vulnerable to numerous destabilizing factors presently affecting the Earth's biosphere. The largest representatives of gymnosperms, particularly conifers, appear as well recognizable indicators of primary plant communities, where they play roles as dominants or co-dominants of pristine 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. Today most gymnosperms are vulnerable, threatened or endangered species. Gymnosperms in primary forest are the first types of plants to disappear from a region once the habitat is degraded or destroyed. As a result, gymnosperm plants are recognized in botanical inventories and surveys as the most important 'key group' of plants having a clear and recognizable physiognomy and can be used as an indicator for the characterization of the flora and vegetation. This is particularly significant in nature protection and conservation activities.

Material and methods

All observations, records and discoveries reported herein are based on reliable scientific literature and on collected voucher herbarium specimens, duplicates of which are now housed: LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation (Hanoi), PanNature Herbarium (Hanoi) and VNU.

Schematic distribution maps of personally studied gymnosperm species are compiled and presented in Fig. 1–3. Locations of the newly discovered and studied species are marked on each map by dark red dots; territories within provinces where species were previously recorded before our explorations are marked by black-line shading.

Illustrations of almost all discovered and studied species are presented in Fig. 4–15. All photos were taken by L. V. Averyanov, S. K. Nguyen and V. T. Pham.

An annotated list of studied species and keys for their identification are presented below. National IUCN status of the studied species was preliminarily evaluated according to the last edition of red list categories and criteria (IUCN 2013).

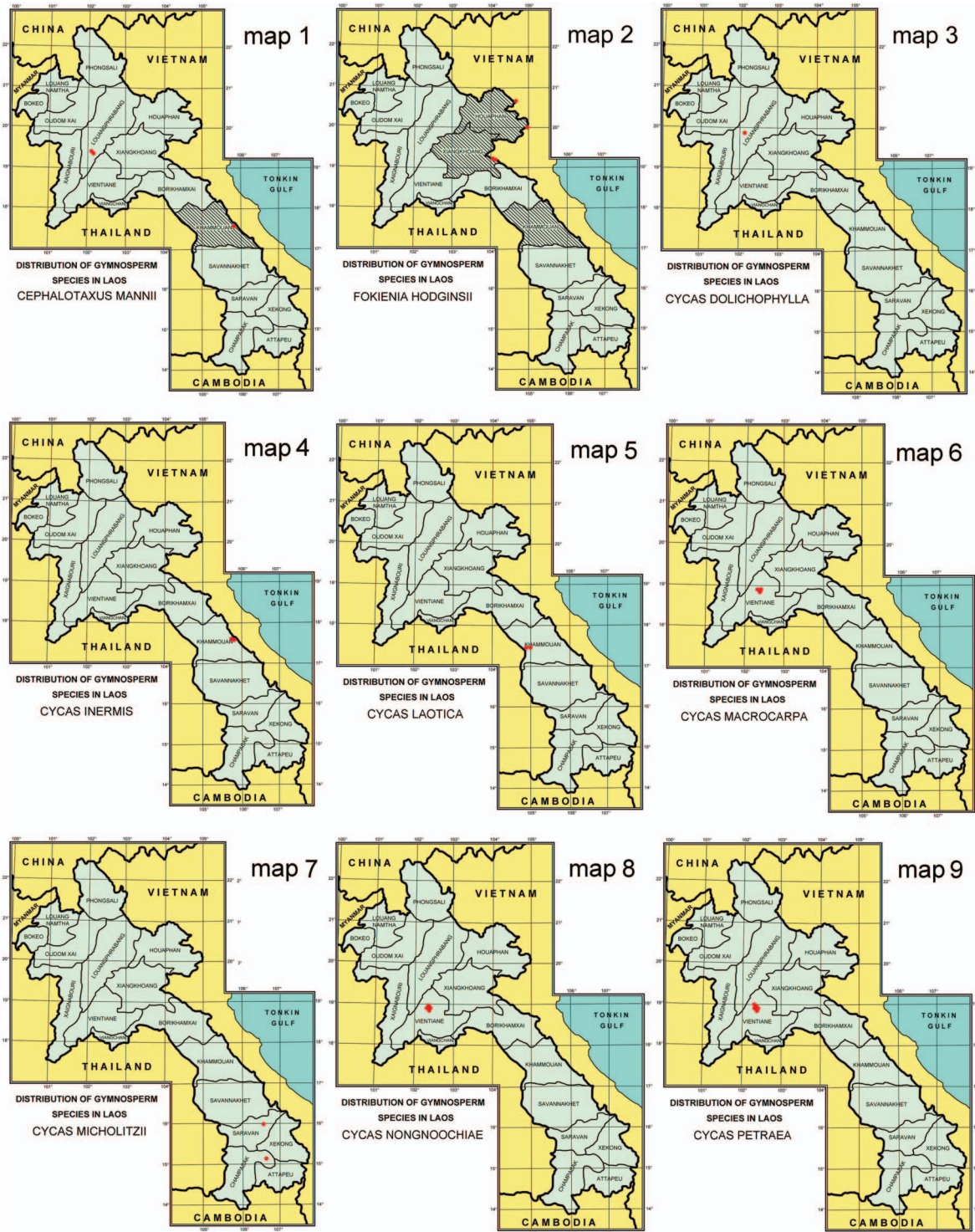


Figure 1. Maps of studied species distribution in Laos. 1 = *Cephalotaxus mannii*; 2 = *Fokienia hodginsii*; 3 = *Cycas dolichophylla*; 4 = *C. inermis*; 5 = *C. laotica*; 6 = *C. macrocarpa*; 7 = *C. micholitzii*; 8 = *C. nongnoochiae*; 9 = *C. petraea*. ▨ Tentative area of distribution according to earlier data. ● Presently discovered localities.

Main Results

Twenty-four gymnosperm species from 12 genera and 7 families were recorded from Laos in previous surveys (Nguyen and Vidal 1996, Newman et al. 2007, Thomas et al. 2007). The present review includes 33 species from 15 genera and 8 families. Important additions to previous data

were obtained in the course of four field trips during 2009–2013 when we studied 32 local floras within the 12 provinces of the country (Attapeu, Borikhamxai, Champasak, Houaphan, Khammouan, Louangphrabang, Phongsali, Saravan, Viangchan, Vientiane, Xekong, Xiangkhoang). In this work 58 new localities for 25 gymnosperm species from 14 genera and 8 families were discovered. These taxa are listed below.

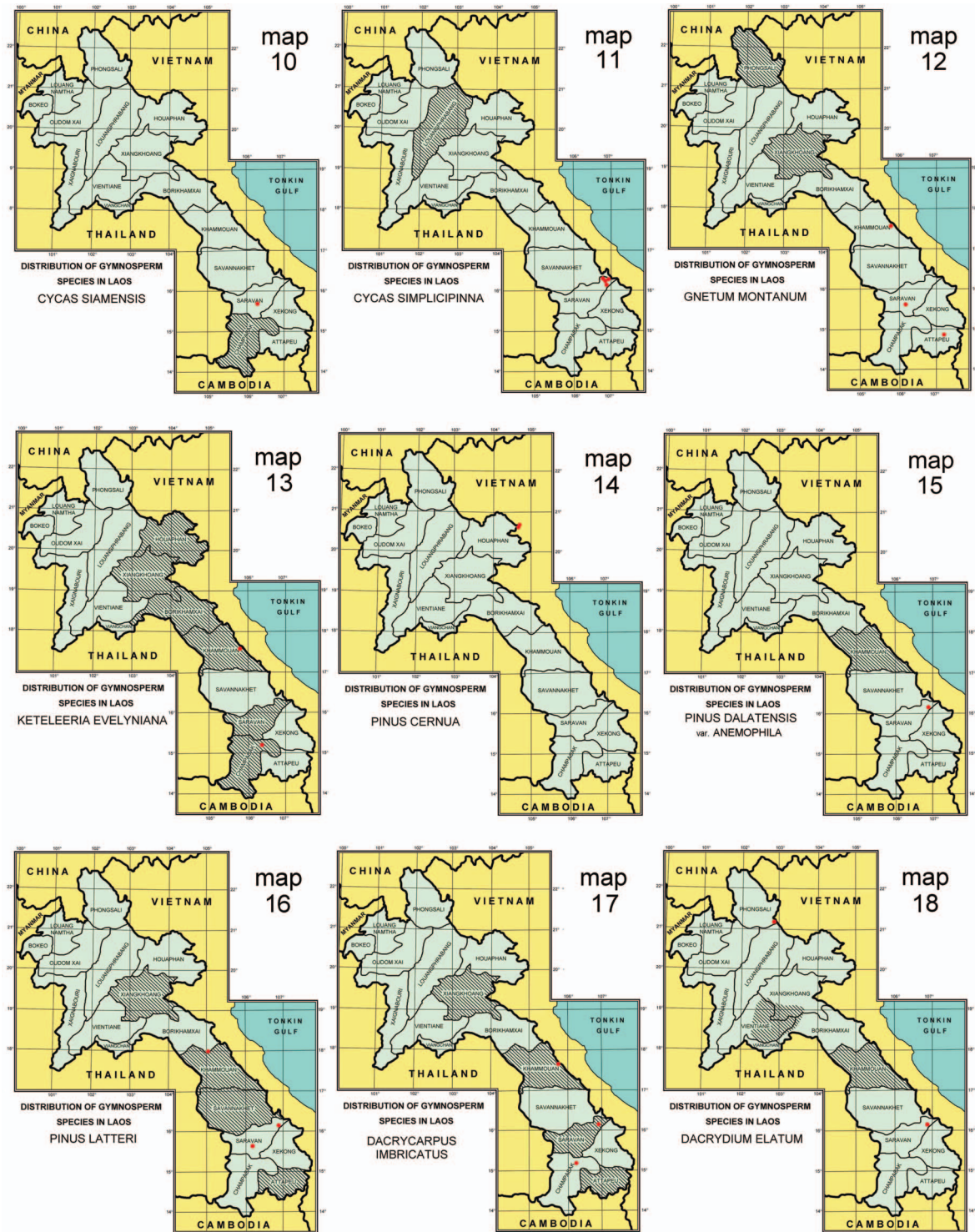


Figure 2. Maps of studied species distribution in Laos. 10 = *C. siamensis*; 11 = *C. simplicipinna*; 12 = *Gnetum montanum*; 13 = *Keteleeria evelyniana*; 14 = *Pinus cernua*; 15 = *P. dalatensis* var. *anemophila*; 16 = *P. latteri*; 17 = *Dacrycarpus imbricatus*; 18 = *Dacrydium elatum*. ■ Tentative area of distribution according to earlier data. ■ Presently discovered localities.

Cephalotaxaceae: *Cephalotaxus mannii*.

Cupressaceae: *Calocedrus macrolepis*, *Fokienia hodginsii*.

Cycadaceae: *Cycas dolichophylla*, *C. inermis*, *C. laotica*, *C. macrocarpa*, *C. micholitzii*, *C. nongnoochiae*, *C. petraea*, *C. siamensis*, *C. simplicipinna*.

Gnetaceae: *Gnetum latifolium*, *G. leptostachyum*, *G. macrostachyum*, *G. montanum*, *G. parviflorum*.

Pinaceae: *Keteleeria evelyniana*, *Pinus cernua*, *P. dalatensis* var. *anemophila*, *P. kesiya*, *P. latteri*.

Podocarpaceae: *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Nageia fleuryi*, *N. wallichiana*, *Podocarpus nerifolius*, *P. pilgeri*.

Taxaceae: *Amentotaxus argotaenia*, *A. yunnanensis*, *Taxus wallichiana*.

Taxodiaceae: *Cunninghamia konishii*, *Glyptostrobus pensilis*.

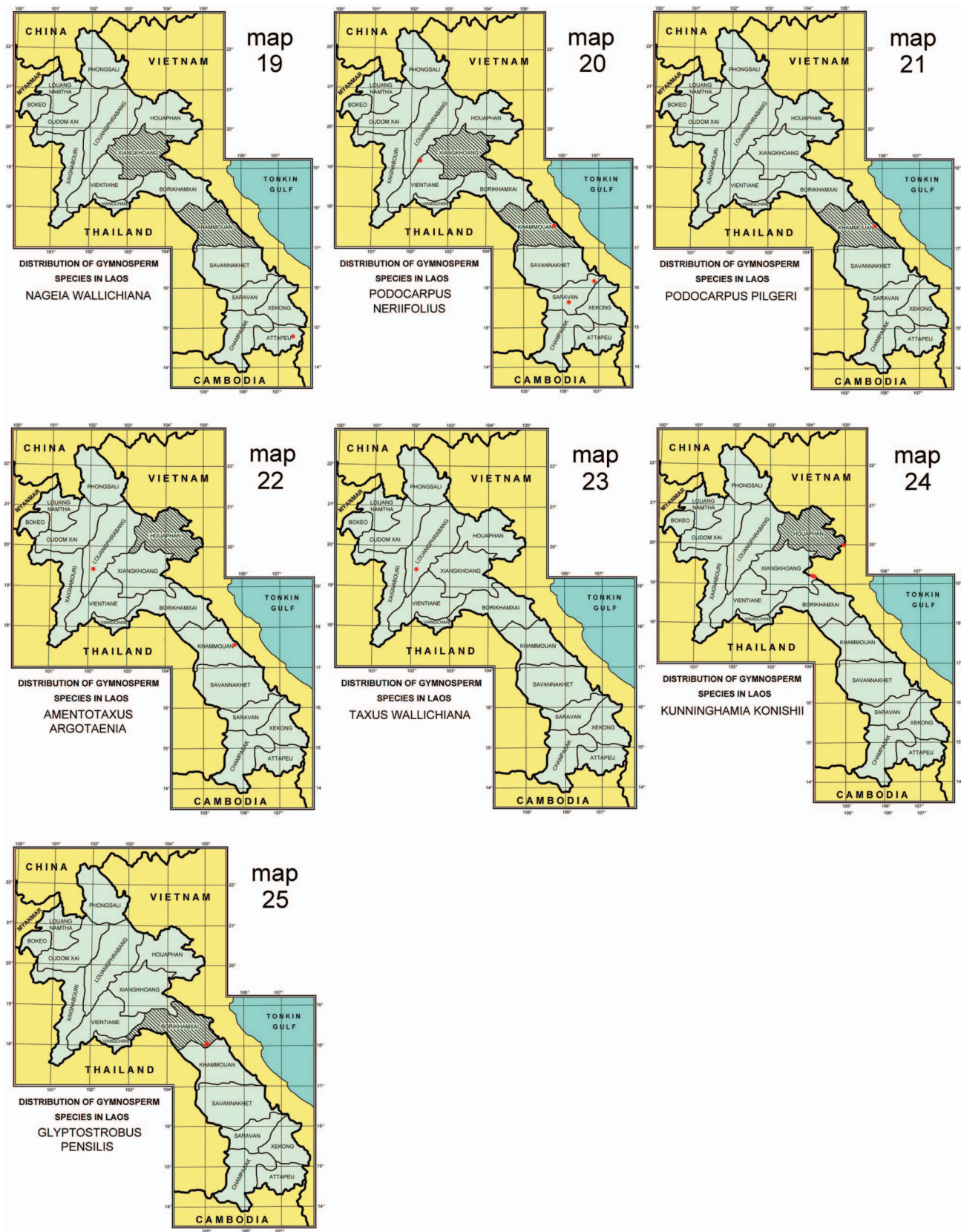


Figure 3. Maps of studied species distribution in Laos. 19 = *Nageia wallichiana*; 20 = *Podocarpus neriifolius*; 21 = *P. pilgeri*; 22 = *Amentotaxus argotaenia*; 23 = *Taxus wallichiana*; 24 = *Cunninghamia konishii*; 25 = *Glyptostrobus pensilis*. ▨ Tentative area of distribution according to earlier data. ● Presently discovered localities.



Figure 4. Studied species in native habitats. (a)–(b) *Cephalotaxus mannii* (LA-VN 279); (c)–(g) *Cycas dolichophylla* (L. Averyanov, P. V. The, CPC s.n.); (h)–(i) *C. inermis* (LA-VN 326).

Two species named *Cycas laotica* and *Pinus cernua* are described as new species for science.

Seven species, *Cycas dolichophylla*, *C. inermis*, *C. macrocarpa*, *C. micholitzii*, *C. nongnoochiae*, *C. petraea* and *Taxus wallichiana* represent new records for the flora of Laos.

It should be mentioned that our current checklist is still far from complete because the largest part of the country remains poorly botanically explored at present. Probably, such gymnosperm taxa as *Amentotaxus poilanei* (Ferré & Rouane)

D. K. Ferguson, *Calocedrus rupestris* Aver., T. H. Nguyễn & P. K. Lôc, *Pinus dalatensis* var. *dalatensis* Ferré, *P. wangii* Hu & W. C. Cheng var. *eremitana* (Businsky) Aver. comb. & stat. nov. (*Pinus eremitana* Businsky 2004, p. 234) and *Taxus chinensis* (Pilg.) Rehder are expected to occur in Laos, although they have not been yet recorded and confirmed by voucher herbarium collections. The provinces of Laos were these plants may reasonably be found due to analysis of their distribution in neighbour areas of Vietnam are listed in Table 2.

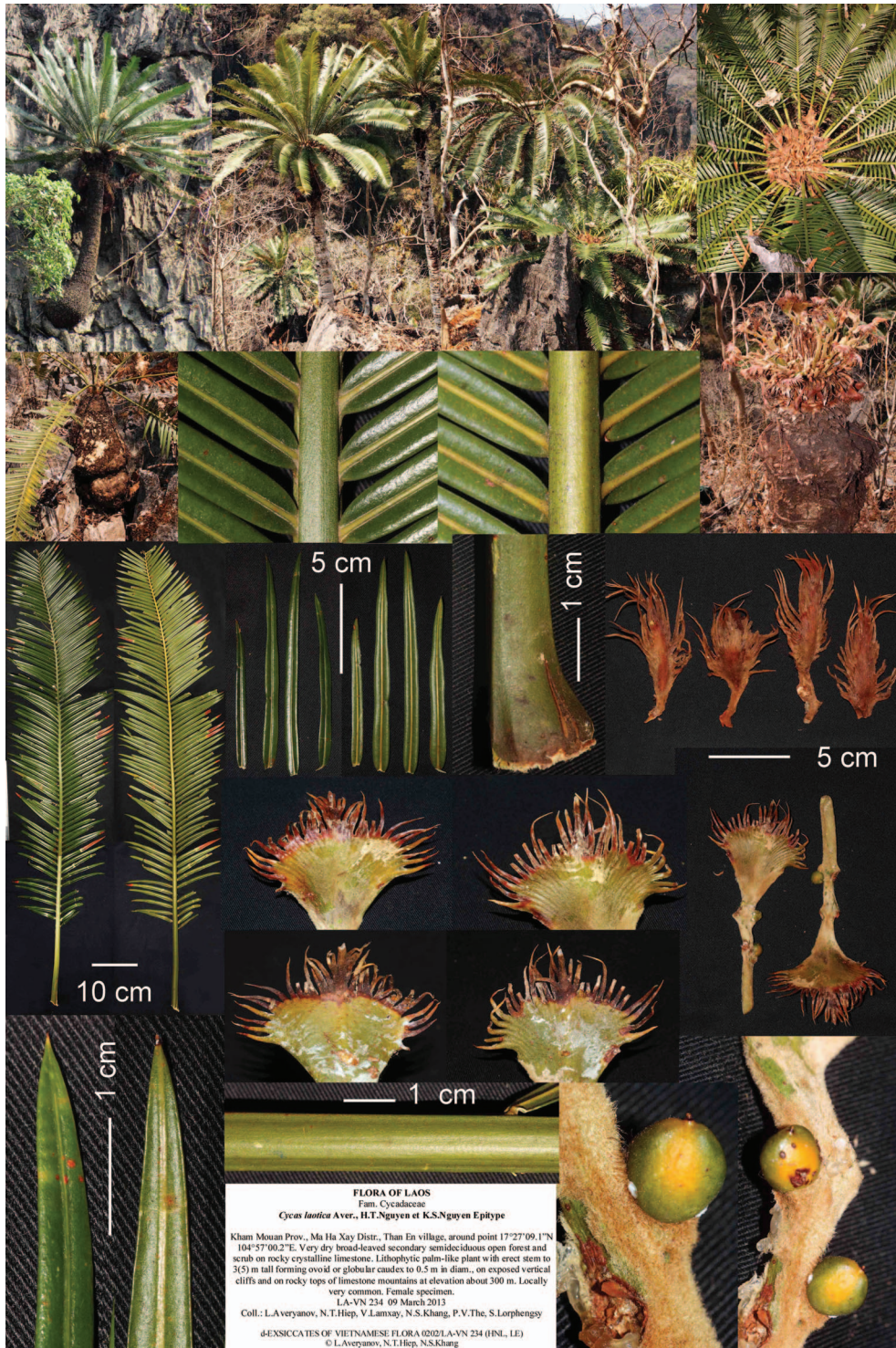


Figure 5. Digital herbarium sheet of *Cycas laotica* (LA-VN 234).

Annotated list of studied species

Designations and explanations: * = species newly recorded for the flora of Laos; ** = species proposed as new for science.

Key to families

1. Plants palm-like usually with unbranched stem; leaves pinnate **Cycadaceae**

– Plants not palm-like usually with branching stem; leaves simple 2
 2. Large woody lianas **Gnetaceae**
 – Trees and shrubs 3
 3. Seeds few to many, not arillate; ovuliferous scales form a dry dense woody cone 4
 – Seeds solitary or paired enclosed in fleshy aril and becoming berry- or drupe-like 6

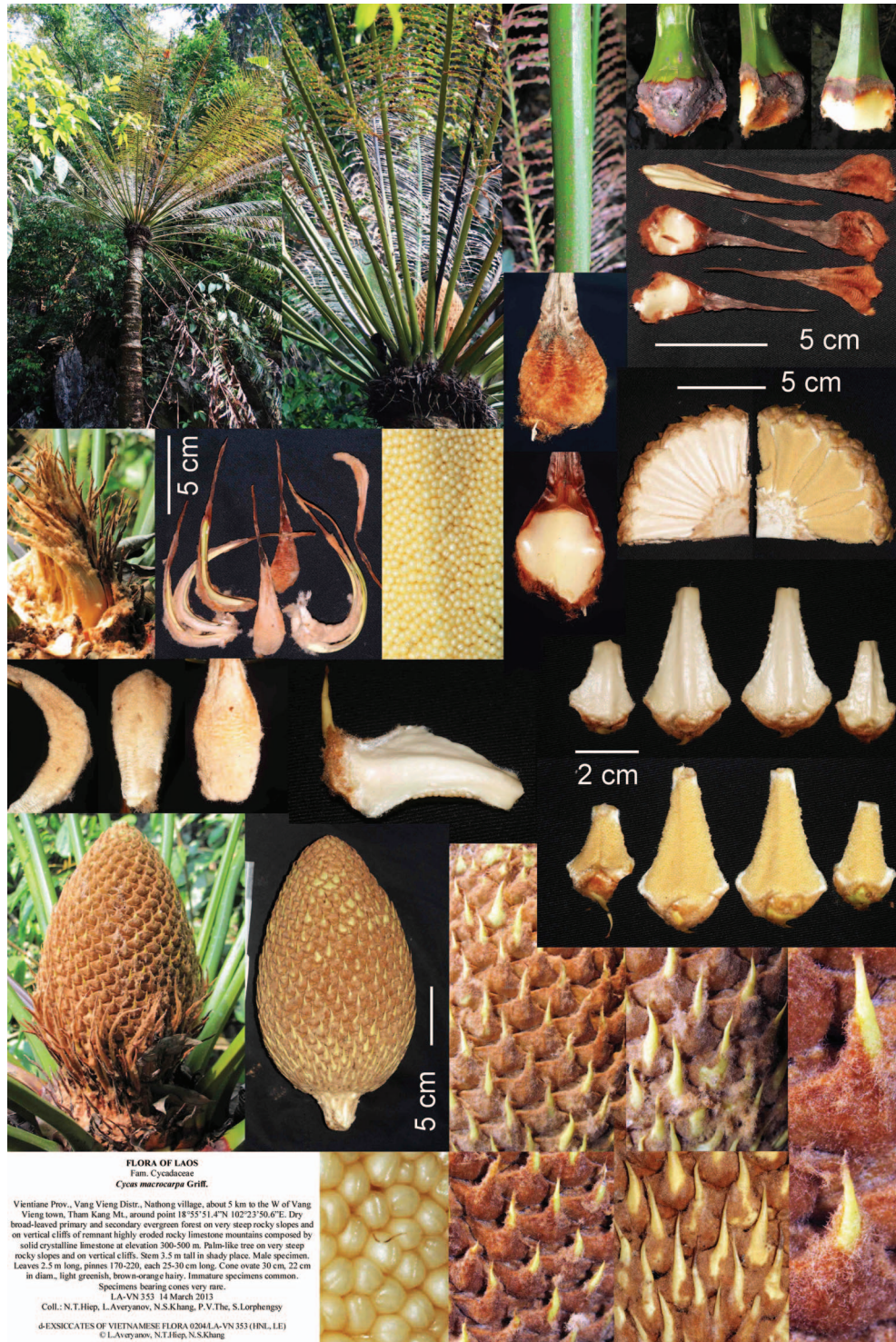


Figure 6. Digital herbarium sheet of *Cycas macrocarpa* (LA-VN 353).

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|--|--|
| <p>4. Leaves and cone scales opposite; all leaves triangular, scale-like, less than 8 mm long; ovules erect Cupressaceae
 – Leaves and cone scales spirally arranged; at least part of leaves narrowly lanceolate to linear or needle-like, longer than 8 mm; ovules inverted 5</p> | <p>5. Mature seed cones longer than 3 cm; cone scales and bracts distinct; each bract with 2 seeds; leaves needle-like, rather monomorphic Pinaceae
 – Mature seed cones less than 3 cm long; cone scales and bracts coalescent, indistinct, with 2–6 seeds; leaves dimorphic, scale-like or narrowly lanceolate Taxodiaceae</p> |
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Figure 7. Digital herbarium sheet of *Cycas macrocarpa* (LA-VN 350).

6. Basal bracts of seed bearing structure fused forming swollen, often juicy receptacle; microsporophyll with 2 pollen sacs; pollen grains winged **Podocarpaceae**
– Basal part of seed bearing structure not swollen; microsporophyll with 3–9 pollen sacs; pollen grains not winged 7

7. Microsporophyll with 3–9 pollen sacs; ovulate cones of a single terminal ovule **Taxaceae**
– Microsporophyll with 3 pollen sacs; ovulate cones consisting of several opposite pairs of scales with 2 axillary ovules **Cephalotaxaceae**



Figure 8. Studied species in native habitats. *Cycas inermis* (a) (LA-VN 326); *C. micholitzii*: (b) (LA-VN 209), (c) (LA-VN 136); *C. petraea*: (d)–(f) (LA-VN 496), (e) (LA-VN 568); *C. siamensis*: (g)–(i) (LA-VN 225).

Cephalotaxaceae

Cephalotaxus Siebold & Zucc. ex Endl.

C. matnii Hook. f. (1886, sine pag.)

Taxonomic synonym: *C. griffithii* Hook. f. (1888, p. 648).

Described from northeast India (“Inde, Mts Khasia”). Type (“G. Mann s.n.”) in P.

Description

Tree to 30 m tall and 1 m dbh. Bark light brown to reddish brown, leathery. Leaves dark green adaxially, linear-lanceolate, mucronate, 1.5–4.0 cm long, 2.5–4.0 mm wide, leathery, stomatal bands white, sometimes not clear, 0.7–1.6 mm wide. Pollen cones axillary, 6–8 together, pale yellow, globular, 4.0–4.5 mm across. Ovule structures 1–3 together on peduncles 6–10 mm long. Aril olive–brownish. Seeds



Figure 9. Digital herbarium sheet of *Cycas nongnoochiae* (LA-VN 460).

ellipsoid, 2.2–2.8 cm long, shortly mucronate. Pollination February–March, seeds August–October (Fig. 4a–b).

General distribution

Northeast India, northern Myanmar, south China, northern Thailand, Vietnam.

Distribution in Laos

Khammouan and Vientiane provinces (Fig. 1, Map 1).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007, Thomas et al. 2007). **Khammouan:** M. F. Newman LAO 1009 (E, FRCL, L, NUL, P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt 17°35'13.2"N, 105°47'49.8"E, 1425 m a.s.l., 9 Mar 2013, L. Averyanov



Figure 10. Studied species in native habitats. *Cycas siamensis*: (a)–(b) (LA-VN 226); *C. simplicipinna*: (c)–(e) (LA-VN 203), *Gnetum montanum*: (f) (LA-VN 119); *Keteleeria evelyniana*: (g) (LA-VN 240); (h)–(i) (LA-VN 142).

et al. LA-VN 279 (Fig. 4a–b). **Vientiane** Prov., Kasi Distr., Thong Mout village, 19°26'51.5"N, 102°07'45.8"E, 1550–1650 m a.s.l., 20 Mar 2013, N. T. Hiep et al. LA-VN 631. **Vientiane** Prov., Kasi Distr., Thong Mout village. 19°25'19.7"N, 102°08'32.7"E, 1550 m a.s.l., 20 Mar 2013, N. T. Hiep et al. LA-VN 680.

Ecology

Primary mixed and broad-leaved, evergreen, humid montane forests at elevations 1000–1700 m a.s.l. on silicate and

limestone soils. Low to middle natural regeneration. No data on cultivation.

Notes

A widespread, but rare species found scattered in primary forests on various types of soils. Also a shade tolerant indicator of intact habitats with full spectrum of native species and often associated with *Amentotaxus argotaenia*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Nageia wallichiana*, *Podocarpus neritifolius*, *Taxus wallichiana* and



Figure 11. *Pinus cernua* in natural habitats.

other rare conifers. Selective logging for high-quality timber and deforestation are the primary threats to these high-value timber trees throughout the entire area of its distribution. The species may be cultivated as an ornamental tree.

Conservation status

Globally, this species is considered as 'Vulnerable' (VU) due to the widespread reduction of forests under criteria A2cd (Liao and Yang 2013). Extant stands are restricted to

very small, severely fragmented populations as the mature trees are often targeted for their timber. In all explored localities (Fig. 1, Map 1), the species has been observed in very small populations, hence its IUCN status in Laos may also be estimated as 'VU'. The species may be effectively protected in the mountain forests of Hin Namno protected area (Khammouan province). Monitoring of all known populations may be important for species protection as a seed source for future introduction of this plant into cultivation.

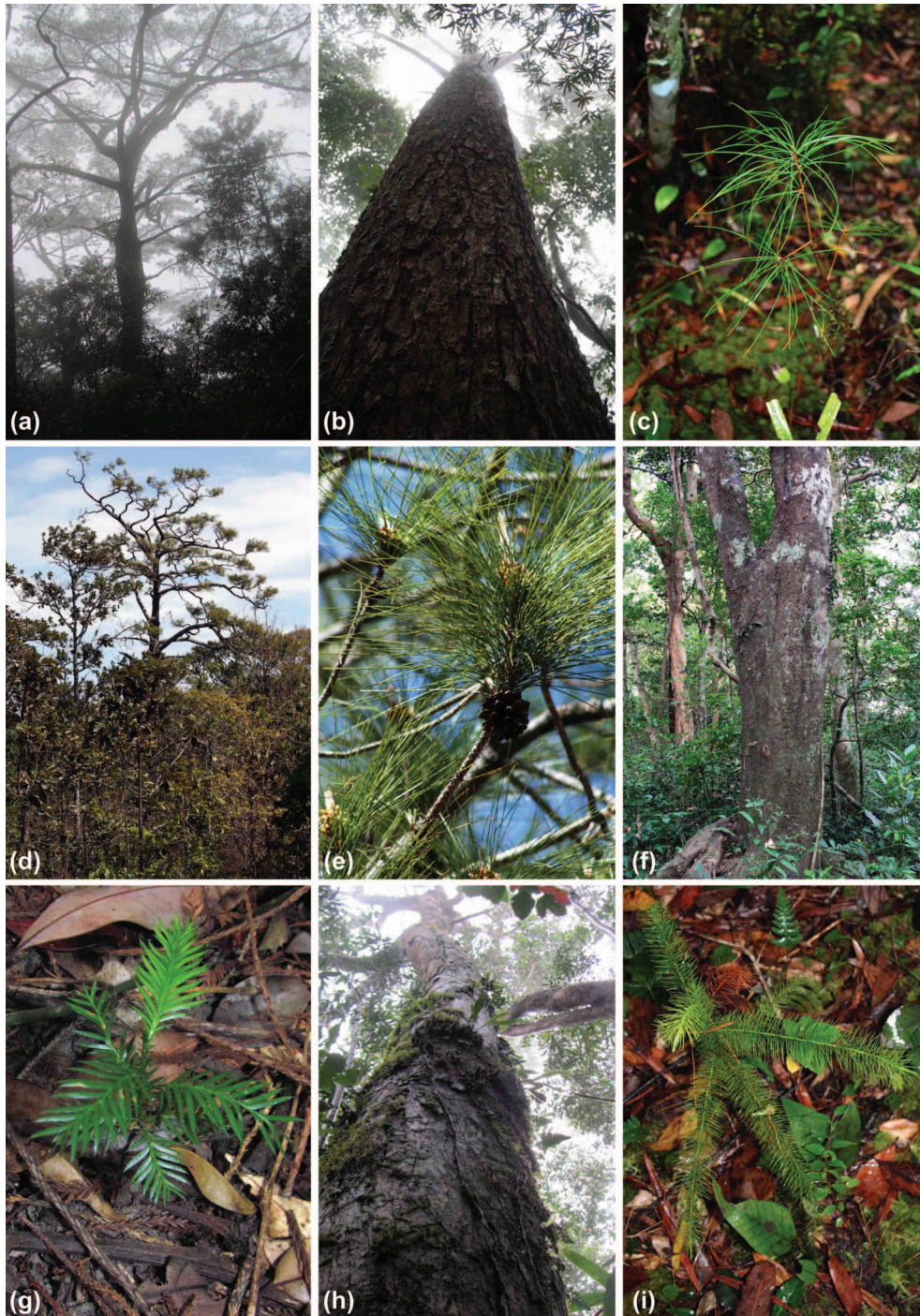


Figure 13. Studied species in native habitats. *Pinus dalatensis* var. *anemophila*: (a)–(c) (LA-VN 195); *P. latteri*: (d)–(e) (LA-VN 214); *Dacrycarpus imbricatus*: (f) (LA-VN 197), (g) (LA-VN 238); *Dacrydium elatum*: (h)–(i) (LA-VN 180).

Calocedrus Kurz

C. macrolepis Kurz (1878, p. 196)

Described from southwest China (“Chine, Yunnan, Hotha”).
Type (“Anderson s.n.”) in CAL, K.

Description

Tree 25–30 m tall and 1 m dbh. Bark fissured, grayish brown or reddish brown. Crown broad, branches spreading and ascending. Leaves dark green, imbricate, 2.5–5.0 mm long. Pollen cones yellow, ovoid to oblong, 4–8 mm long, microsporophylls with 4 pollen sacs. Seed cones dull brown,



Figure 14. Studied species in native habitats. *Nageia wallichiana*: (a) (LA-VN 107); *Podocarpus neriifolius*: (b) (LA-VN 239), (c) (LA-VN 152); *P. pilgeri*: (d)–(f) (LA-VN 257); *Amentotaxus argotaenia*: (g)–(i) (LA-VN 615).

1.0–1.5(2) cm long, 4–6 mm wide; scales flattened, woody, fertile scales 2-seeded. Seeds narrowly ovoid, 3–4 mm long with rhomboid wing 5–7 mm long, 4–5 mm wide. Pollination March–April, seeds September–October.

General distribution

Northern India, northeast Myanmar, south China, Taiwan, northeast Thailand, Vietnam.

Distribution in Laos

Khammouan, Vientiane provinces and Xaisomboun Special Area.

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007, Thomas et al. 2007). **Khammouan:** M. F. Newman LAO 1278, 1280, 1385, 1389 (E, FRCL, L,



Figure 15. Studied species in native habitats. *Amentotaxus argotaenia*: (a) (LA-VN 615); (b) (LA-VN 614), (c) (LA-VN 616); *Taxus wallichiana* (d)–(e) (LA-VN 630); *Glyptostrobuspensilis*: (f) (LA-VN 40), (g)–(i) (LA-VN 1).

Table 1. Morphological differences between *Pinus cernua* sp. nov. and the closest similar species, *P. fenzeliana*.

Character	<i>P. fenzeliana</i>	<i>P. cernua</i>
Needle length (cm)	4.0–12.5	12–22
Needle width (mm)	about 0.5	0.8–1.2
Seed strobils shape	narrowly ovoid	ovoid to broadly ovoid
Seed strobils size (cm)	6 × 3	8–11 × 5–7
Number of scales in seed cone	about 50	50–70
Scale of seed cone shape	broadly spatulate obovate	triangular deltoid
Scale of seed cone size (cm)	1.7 × 1.4–1.8	2.4–3.0 × 1.5–2.5

Table 2. Gymnosperms which are likely to occur in Laos and provinces where they may be found.

Plant name	Expected occurrence in Laos
<i>Amentotaxus poilanei</i> (Ferré & Rouane) D. K. Ferguson	Attapeu, Xekong
<i>Calocedrus rupestris</i> Aver., T. H. Nguyễn & P. K. Lóc	Borikhamxai, Houaphan, Khammouan, Xiangkhoang
<i>Pinus dalatensis</i> var. <i>dalatensis</i> Ferré	Attapeu, Xekong
<i>Pinus wangii</i> Hu & W. C. Cheng var. <i>eremitana</i> (Businsky) Aver.	Houaphan, Louangphrabang
<i>Taxus chinensis</i> (Pilg.) Rehder	Houaphan

NUL, P). **Vientiane:** J. E. Vidal (P). **Xaisomboun Special Area:** M. F. Newman LAO 1101 (E, FRCL, L, NUL, P).

Ecology

Primary mixed and broad-leaved, evergreen, humid sub-montane forests at elevations 800–1500 m a.s.l. on silicate derived soils. Good natural regeneration is recorded in Vietnam (Nguyen et al. 2004). No data on natural regeneration and cultivation in Laos.

Notes

A widespread, but rare light demanding species found in small groups in primary humid forests on silicate soils. Seedlings are mainly found in gaps but if shaded commonly die within 5 years. In native habitats often associated with *Dacrycarpus imbricatus*, *Dacrydium elatum* and *Keteleeria evelyniana*. Selective logging for high-quality timber and deforestation are the primary threats to the species throughout the entire range of its distribution. The species may be cultivated as an ornamental tree.

Conservation status

Globally, this species was recently assessed as 'Near Threatened' (NT) nearly meeting VU A2cd (Thomas et al. 2013a). Its national IUCN status in Laos may be estimated as 'Vulnerable' (VU) due to the widespread reduction of forests when remnant species populations are restricted to very small, severely fragmented localities. Monitoring of all known populations seems very important for species protection as a seed source for future propagation and cultivation.

Fokienia A. Henry & H. H. Thomas

F. hodginsii (Dunn) A. Henry & H. H. Thomas (1911, p. 67).

Based on the same type: *Cupressus hodginsii* Dunn (1908, p. 367).

Described from southeast China ("Chine, pres de Foochow, Fuzhou"). Lectotype ("Hodgins s.n. 27 avr. 1910") in HK, K, P (Nguyen and Vidal 1996).

Description

Tree to 30 m tall and 1.8 m DBH with broad round crown. Bark red-brown, smooth, becoming irregularly fissured. Leaves of adult plants scale-like, imbricate, 2–7 mm long, ridged, with a white, depressed stomatal band abaxially; leaves of young plants flat and distinctly larger. Pollen cones

apical, yellowish green to brown, ovoid to oblong, (2)3–5 mm long. Seed cones dark brown, subglobose, 1.5–2.2 cm in diameter. Seeds narrowly ovoid, 4–5 mm long, 3–4-ridged; larger wing ovate-dolabriform, 5 mm, smaller wing 1.5 mm. Timber light dull yellow-brown, fragrant. Pollination March–April, seeds October–November.

General distribution

South China, Vietnam.

Distribution in Laos

Houaphan, Khammouan and Xiangkhoang provinces (Fig. 1, Map 2).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007): **Houaphan:** M. F. Newman LAO 1122 (E). **Khammouan:** R. Timmins s.n. (BM). **Xiangkhoang:** A. F. G. Kerr 21014 (BM, P). New current records from Laos–Vietnamese border (LE, Herbarium of the Center for Plant Conservation, Hanoi): Northwest Vietnam, border area of **Houaphan** and **Son La** Prov.: Son La Prov., Van Ho Distr., Chieng Xuan Municipality, Co Hong village, territory of Xuan Nha natural reserve, Pha Luong Mountain. 20°41'40.5"N, 104°39'24.7"E. 1200–1400 m a.s.l., 13 Nov 2013, L. Averyanov et al. CPC 7032. Northwest Vietnam, border area of **Houaphan** and **Thanh Hoa** Prov.: Thanh Hoa Prov., Thuong Xuan Distr., Bat Mot Municipality, Vin village, Xuan Lien Natural Reserve. 19°58'18.2"N, 104°59'24.0"E, 1000–1200 m a.s.l., 2 Nov 2013, L. Averyanov et al. CPC 6620. Northwest Vietnam, border area of **Xiangkhoang** and **Nghe An** Prov.: Nghe An Prov., Ky Son Distr., Na Ngoi Municipality, eastern slopes of Phu Xai Lai Leng mountain system. 19°13'37.5"N, 104°06'11.8"E, 1900 m a.s.l., 20 Oct 2013, L. Averyanov et al. CPC 6011; 19°13'52.9"N, 104°05'30.5"E, 2100–2200 m, 27 Oct 2013, L. Averyanov et al. CPC 6389.

Ecology

Primary broad-leaved and coniferous, evergreen, humid montane forests at elevations 1000–2400 m a.s.l. on silicate and limestone derived soils, commonly along edges of ridges or on mountain summits. Sometimes occurring in nearly pure stands or scattered as individuals or small groups. In Vietnam often associated with gymnosperm species such as *Cunninghamia konishii*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Pinus dalatensis* and *Pinus wangii*. Oldest trees reach 1500 and more years.

Notes

In Lao PDR all known stands have already been severely depleted by logging. Tree felling and timber exploitation remains a major problem even within protected areas that make all known subpopulations highly fragmented and localized. Natural regeneration is occasional and unstable due to that mature trees have become very rare.

Conservation status

Globally, this species was recently assessed (Thomas and Yang 2013b) as 'Vulnerable' (VU) A2acd; B2ab(ii, iii, iv, v), taking into consideration its broad distribution in China.

Meanwhile, Laotian subpopulations certainly meet criteria A2cd and B2ab(i-v) and could be assessed as 'Nationally Endangered'. Declines and fragmentation of species subpopulations in Laos are still continuing despite protection measures. Organization of protected areas and their effective monitoring for termination of mature trees felling are promising ways for species protection.

Cycadaceae

Cycas L.

Key to species

1. Leaflets dichotomously forked *C. micholitzii*
– Leaflets simple 2
2. Trunk of mature plants distinctly swollen at the base into ovate subterranean caudex to 0.4 m in diameter; petiole without spines *C. laotica*
– Trunk of mature plants not swollen at the base; petiole with more or less numerous spines 3
3. Trunk of mature plants usually subterranean, rarely to 1(1.5) m tall 4
– Trunk of mature plants erect, regularly higher than 1.5 m tall 6
4. Plants of open secondary, dry, semideciduous dipterocarp forests growing on poor lateritic soils; leaves subprostrate, 0.5–1.0 m long *C. siamensis*
– Plants of closed primary and secondary, humid, evergreen forests growing on non-lateritic soils; leaves suberect, 1.5–4.5 m long 5
5. Leaves 2.0–4.5 m long, more or less straight; petiolar spines 4–10 mm long *C. dolichophylla*
– Leaves 1.5–2.5 m long, arching; petiolar spines 1–3 mm long *C. simplicipinna*
6. Megasporophylls not pectinate *C. inermis*
– Megasporophylls pectinate 7
7. Cataphylls 8–17 cm long, rigid, pungent, densely rufous-tomentose; seeds 4.5–5.0 cm long *C. macrocarpa*
– Cataphylls about 9 cm long, soft or fleshy, not pungent, the tomentum loose or closely appressed, gray to orange brown; seeds less than 4 cm long 8
8. Lower trunk bearing thick, hard, corky bark with regular polygonal fracturing; crone with 30–40 leaves 0.8–1.4 m long; pinnae 2–8 cm long; pollen cones 15–22 cm long, 7–9 cm wide; megasporophylls 15–20 cm long, lamina 8–10 cm long, with 36–52 lateral spines *C. nongnoochiae*
– Lower trunk more or less smooth; crone with 50–100 leaves 1.3–2.0 m long; pinnae 10–12 cm long; pollen cones 30–40 cm long, 14–18 cm wide; megasporophylls 18–22 cm long, lamina 10–17 cm long, with 20–28 lateral spines *C. petraea*

**C. dolichophylla* K. D. Hill, H. T. Nguyen & P. K. Loc (2004, p. 157)

Described from northern Vietnam ("Tuyen Quang: Na Hang, Pu La Mountain ..."). Type ("2 Nov 1996, H. T. Nguyen 2124") in HN (holotype).

Description

Arborescent plant with stem to 1.5 m tall, 18–30 cm diameter and 8–40-leaved crown. Leaves glossy, 2.0–4.5 m long, flat in section, with 80–130 pinnae pairs, young with orange tomentum. Petiole 0.4–1.0 m long, glabrous, spinescent throughout. Cataphylls narrowly triangular, soft, pilose. Pollen cones fusiform, yellow–brown, 35–60 cm long. Microsporophyll lamina soft, 3.0–3.5 cm long, 1.0–1.3 cm wide, apical spine rudimentary or absent. Megasporophylls 1.5–2.5 cm long, brown-tomentose; ovules 2–4, glabrous; lamina orbicular, 5–12 cm across, deeply pectinate, with 16–26 soft spines 4–5 cm long, apical spine not distinct from lateral spines. Seeds yellow, flattened-ovoid, 4–6 cm long, 3.0–3.5 cm wide. Pollination during February–April, seeds September–November (Fig. 4c–g).

General distribution

South China, northern Vietnam.

Distribution in Laos

Louangphrabang province (Fig. 1, Map 3).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE – photos): **Louangphrabang** Prov., Luang Prabang City, cultivated plants of native origin. April 2011, L. Averyanov, P. V. The, CPC s.n., photos 25919–25934 (Fig. 4c–g).

Ecology

Primary and secondary lowland, broad-leaved, evergreen forests, secondary scrub and woodlands on silicate, sandstone, granite, shale, schist and limestone soils at elevations of 200–500 m a.s.l. Natural regeneration is more or less successful. This species is easily cultivated.

Notes

This species is reported as the most widespread and abundant cycad in northern Vietnam (Osborne et al. 2007, Hill 2008). Because the plant is particularly frequent in the northwestern part of northern Vietnam, its discovery in northern Laos was strongly expected (Fig. 1, Map 3). In Vietnam, this species occasionally forms natural hybrids with *C. bifida* (Dyer) K. D. Hill and *C. ferruginea* F. N. Wei.

Conservation status

This species was not considered to be at risk in Vietnam (Osborne et al. 2007), and assessed as 'Vulnerable' (VU) in China (Hill 2008). Presently it is assessed globally as 'Near Threatened' (NT) (Nguyen 2010a). In Laos, it was observed as a commonly cultivated ornamental plant within the proximity of numerous temples in Luang Prabang City (Fig. 1, Map 3, Fig. 4c–g). It is uncertain whether these plants were collected from the wild and the species may be fairly common in the valleys of the Mekong River and its tributaries in the northern part of the country. Based on our observations of this species, we recommend that the national status of the species be estimated as 'Data Deficient' (DD).

**C. inermis* Lour. (1790, p. 632)

Described from southern Vietnam ("Saigon"). Type ("1787, Loureiro 3") in BM (holotype).

Description

Arborescent plant with stem 1.5–4(8) m tall, 8–14 cm diameter and 6–35-leaved crown. Leaves deep glossy green, 2.2–3.0 m long, flat, with 60–110 pinnae pairs, young with white tomentum. Petiole 0.6–0.8 m long, glabrous, spinescent for 70–100% of length. Basal pinnae not gradually reducing to spines. Cataphylls linear, pungent, pilose, 4–5 cm long. Pollen cones ovoid, cream, 12 cm long, 8 cm in diameter. Microsporophylls firm, apical spine prominent, sharply upturned. Megasporophylls narrow, 20–30 cm long, gray tomentose; ovules 4–8, glabrous; lamina ovate to lanceolate, 5–10 cm long, 3.0–6.5 cm wide, regularly dentate, with 14–26 acute lateral spines 4–8 mm long, apical spine distinct. Seeds orange, oblong, 5–6 cm long, 4–5 cm wide. Pollination May–July, seeds September–October (Fig. 4h–i, 8a).

General distribution

South Vietnam.

Distribution in Laos

Khammouan province (Fig. 1, Map 4).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt 17°35'13.2"N, 105°47'49.8"E, 600 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 281; 200–400 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 282. **Khammouan** Prov., Bounlapha Distr., Nam Boua Sam village, Hin Namno protected area, Pu Pha Song Mt 17°33'43.6"N, 105°45'08.3"E, 230 m a.s.l., 10 Mar 2013, L. Averyanov et al. LA-VN 326 (Fig. 4h–i, 8a), LA-VN 327.

Ecology

Primary and secondary lowland, broad-leaved, evergreen and semi-deciduous open forests, secondary scrub and woodlands on sandy soils derived from metamorphic sandstone, granite and basalt substrates, often on steep rocky slopes at elevations 200–600 m a.s.l. Natural regeneration more or less successful, but formation of reproductive structures is certainly very rare. Plants are easily cultivated.

Notes

The species occurs widely on sea-facing slopes of hills and low ridges in central and southern Vietnam. There it is locally common in closed evergreen and semi-deciduous forests and scrub on rocky slopes composed of granite and basalt (Osborn et al. 2007). In our assessment the species was common on low, west-facing slopes of sandstone ridges along the Laos–Vietnamese border in the territory of Hin Namno protected area (Fig. 1, Map 4; Fig. 4h–I, 8a).

Some specimens here reach 8 m tall, but, even on these mature specimens, we never observed or found pollen or seed cones. In Laos, as well as in Vietnam, the distribution of subpopulations of the species needs verification as plants rarely form reproductive structures necessary for positive identification.

Conservation status

Globally this species was recently assessed as 'Vulnerable' (VU) under criteria A2acd. (Nguyen 2010b). Further studies of the species distribution in Laos are necessary for its assessment. Present recommended status is 'Data Deficient' (DD). Monitoring of known subpopulations and control of logging and forest degradation is important for continued protection of this species.

***C. laotica* Aver., T. H. Nguyen & S. K. Nguyen sp. nov.

Described from central Laos ("Khammouan province"). **Type:** ("L. Averyanov et al. LA-VN 234") in NUOL (holotype), LE, NHOL, Herbarium of the Center for Plant Conservation (isotypes).

Description

Acaulescent to arborescent plant with stem to 2(3) m tall and 10–20 cm in diameter swollen into ovate subterranean caudex to 0.4 m in diameter. Leaves glossy, 30–45, 0.6–1.4 m long, glabrous, flat, with 60–100 pinnae pairs. Pinnae linear acuminate, with revolute margin; basal pinnae (6)8–10 cm long, newer reducing into spines; medium pinnae 12–15 cm long. Petiole 10–15 cm long, glabrous, spineless. Cataphylls narrowly triangular, acute, orange–brown pilose, 3–5 cm long, persistent. Pollen cones unknown. Megasporophylls (8)14–16 cm long, dull brown to yellowish–white tomentose; ovules 4, glabrous; stalk 5–10 cm long, lamina obtriangular, 5.0–6.5 cm long and wide, deeply pectinate, with 24–34 more or less rigid spines 1.5–2.0 cm long, apical spine distinct. Seeds yellow, globose, 1.0–1.5 cm across. Pollination probably June–August, seeds April–May. Fig. 5.

General distribution

Endemic to central Laos.

Distribution in Laos

Khammouan province (Fig. 1, Map 5).

Data for species distribution in Laos

No previous data, new species for science. Current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Khammouan** Prov., about 10 km to the east from Thaket City. 17°26'53.3"N, 104°52'09.4"E, 150 m a.s.l. 6 Mar 2013, L. Averyanov et al. LA-VN 227. **Khammouan** Prov., Ma Ha Xay Distr., Than En village. 17°27'09.1"N, 104°57'00.2"E, 300 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 234 (Fig. 5).

Ecology

Primary and secondary dry semideciduous and deciduous broad-leaved forests, dense and open secondary scrub and

open rocky outcrops and cliffs of rocky highly eroded remnant limestone hills at elevation 150–400 m a.s.l., often in full sun. Natural regeneration is normal. No information on cultivation.

Notes

This species is very distinct in its lithophytic habit with a stem swollen into an ovate caudex. It may be close to *Cycas elephantipes* A. Lindstr. & K. D. Hill, *C. pachypoda* K. D. Hill and *C. siamensis* Miq. which also form inflated trunk bases. Meanwhile, it differs strikingly in developing large, straight, flat glossy leaves, with very short, unarmed petioles and in having broad obtriangular sterile lamina of megasporophylls with truncate pectinate apices with no distinct prominent apical spine. Older trees reach 2.0–2.5 m tall, however, sometimes plants reach reproductive maturity before any aerial stem is developed.

Conservation status

The status of this species has not yet been evaluated. According to this preliminary survey the proposed status may be 'Vulnerable' (VU) or 'Endangered' (EN) under criteria B1, B2ab(i–v). Though the two discovered subpopulations are fairly large and exhibit normal regeneration, the general distribution of the species is very limited (Fig. 1, Map 5). Its habitats may be easily altered or destroyed by forest fire, mining, road construction, land exploration and by commercial over-collection. The species certainly warrants full protection within its area of distribution as a beautiful tree and important indicator of habitats with very high plant diversity of native plant species. This species has outstanding prospects for cultivation as an ornamental palm-like treelet with an attractive leaf canopy.

**C. macrocarpa* Griff. (1854, p. 11)

Described from Malacca Peninsula ("Malacca at crew between Ayer Punnus and Tabong, near the Mahomedan tomb, ..."). Type ("Westerhout, East India Company, 6361) in K (holotype).

Description

Arborescent plant with stem to 12 m tall, 14–24 cm in diameter and 30–40-leaved crown. Leaves deep highly glossy green, 2.2–3.2 m long, young with orange-brown tomentum, flat in section, with 90–120 pinnae pairs; pinnae 15–25 cm long; basal pinnae not gradually reducing to spines. Petiole 0.4–0.8 m long, glabrous, spinescent. Cataphylls narrowly triangular, hard, pungent, brown–orange pilose. Pollen cones ovoid, yellow–orange, 16–22 cm long, 9–12 cm in diameter. Microsporophyll firm, 4–7 cm long, 1.4–2.0 cm wide, apical spine prominent to rudimentary, sharply upturned. Megasporophylls 10–20 cm long, brown-tomentose; ovules 2–4, glabrous; lamina lanceolate, 5–7 cm long, 1.7–3.5 cm wide, shallowly pectinate, with 10–22 pungent lateral spines 1.7–4.5 cm long; apical spine distinct. Seeds yellow, oblong ovoid, 4.5–5.0 cm long. Pollination June–July, seed February–March (Fig. 6–7).

General distribution

Peninsular Thailand, Malacca Peninsula.

Distribution in Laos

Vientiane province (Fig. 1, Map 6).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Vientiane** Prov., Vang Vieng Distr., Nathong village, about 5 km to the west of Vang Vieng town. 18°55'34.2"N, 102°22'58.4"E, 300 m a.s.l., 13 Mar 2013, N. T. Hiep et al. LA-VN 350 (Fig. 7). **Vientiane** Prov., Vang Vieng Distr., Nathong village, about 5 km to the west of Vang Vieng town, Tham Kang Mt. 18°55'51.4"N, 102°23'50.6"E, 300–500 m a.s.l., 14 Mar 2013, N. T. Hiep et al. LA-VN 353 (Fig. 6). **Vientiane** Prov., Vang Vieng Distr., Phol Xai village, about 8 km to the west of Vang Vieng town, Phar Poon Mt 18°56'11.5"N, 102°20'05.0"E, 800–900 m a.s.l., 15 Mar 2013, N. T. Hiep et al. LA-VN 462.

Ecology

The species was originally found in primary closed rain forest, in moderate to deep shade on well-drained, often sloping, deep, sandy, clay/loam soils (Hill and Yang 1999). In Laos it was observed as a lithophyte in primary and secondary lowland, broad-leaved, evergreen forests and in secondary scrub on rocky limestone at elevations 300–1000 m a.s.l. It also occasionally occurs in humid conditions in moderate shade. Natural regeneration of this species is more or less successful and it is easily cultivated.

Notes

Originally the species was recorded as a scattered plant, not forming dense stands. It occurs in inland forests of peninsular Thailand and on the Malacca Peninsula and is said to still occur on less-disturbed ridges in southern Thailand and northern Malaysia (Hill and Yang 1999). This species can survive in secondary plant communities after destruction of intact habitats. During our assessment, fairly large subpopulations were discovered within the limestone Vang Vieng massif (Fig. 1, Map 6; Fig. 6–7). This species warrants priority protection as a picturesque element of the flora and significant for eco-tourism landscapes. It is notable, that the discovered localities in Laos presented here are more than 1000 km to the north of the locality where the species was originally discovered. This fact makes the presence of a 'Malaysian' species in continental regions of northern Indochina doubtful. Continued exploration and study coupled with more collections within Indochina will allow verification of this observation.

Conservation status

Although the establishment and operation of rubber plantations have probably substantially reduced the range of this species, there is little continuing threat to the survival of the species in peninsular Thailand and Malaysia (Hill and Yang 1999). This species is not under immediate threat of extinction in the studied areas in Laos. We recommend,

however, that this species be assessed nationally as 'Vulnerable' (VU) on the basis of the continuing population decline that fits with its global assessment under criteria A2c (Hill 2010a).

**C. micholitzii* Dyer (1905, p. 142)

Described from south Vietnam ("Annam"). Type ("Micholitz s.n.") in K (holotype).

Description

Acaulescent plant with subterranean, swollen, obovoid caudex to 0.5 m in diameter. Leaves 3–8, flat, 1.5–3.0 m long; with 18–56 2-pinnate pinnae, petiole 0.5–1.5 m long, with sparse, short spines; leaflets dichotomously divided 2-linear, acuminate segments 10–35 cm long. Cataphylls triangular, 4–6 cm long, brown tomentose. Pollen cones fusiform, 15–20 cm long, 4–6 cm in diameter; microsporophylls 1.2–2.0 cm long, tomentose, acute. Megasporophylls 8–12 cm long, brown tomentose, sterile blade obovate, 4 cm long, deeply divided into 13–17 subulate lobes 1–2 cm long; ovules 1 or 2 on each side of stalk. Seeds yellowish, obovoid, 2.5–3.0 cm long. Pollination April–May, seeds October–November (Fig. 8b–c).

General distribution

South Vietnam.

Distribution in Laos

Champasak and Saravan provinces (Fig. 1, Map 7).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Champasak** Prov., Paxong Distr., Nam Tuot village, near Tod Katamtok Waterfall. 15°07'35.1"N, 106°38'16.1"E, 480 m a.s.l., 2 Mar 2013, L. Averyanov et al. LA-VN 136 (Fig. 8c). **Saravan** Prov., Ta Oy Distr., to the southwest of Sa Mouay town, Phou Ha Lak village. 15°58'17.9"N, 106°33'04.5"E, 4 Mar 2013, L. Averyanov et al. LA-VN 209 (Fig. 8b).

Ecology

Primary and secondary open semideciduous forests, scrubby woodlands, dense scrub at elevations 400–700 m a.s.l. on silicate alluvial soils. The species has low natural regeneration but is easily cultivated.

Notes

This species still has a broad distribution in lowland hilly areas of Vietnam. Plants are particularly common in southern Vietnam where they are most abundant and reach their best growth potential in secondary plant communities like dense dry scrub, scrubby savannas or scrubby woodlands, often with bamboo. In our survey the species was found in Champasak and Saravan provinces (Fig. 1, Map 7; Fig. 8b–c) in very similar ecological conditions. In particular in dry habitats it often grows as ephemeroïd herb developing an underground storage caudex and losing its leaves during the dry season. Though there are some uncertain earlier records of this species for eastern Laos

(Chen and Stevenson 1999, Osborn et al. 2007), we were unable to verify these earlier records and we did not find any specimens of this species in this region. A closely related species, *Cycas bifida* (Dyer) K. D. Hill replaces *C. micholitzii* in similar habitats in northern Vietnam and southern China (Hill 2008).

Conservation status

Populations of this species in Vietnam and Laos have been severely reduced by unrestrained agricultural land conversion and exploitation. Globally it was assessed as 'Vulnerable' (VU) under criteria A2c (Nguyen 2010c). The plant's unusual habit makes it attractive for cultivation as an ornamental plant. Due to its rarity and unregulated commercial collection, this species should be preliminarily assessed in Laos as 'VU' under criteria A2c, B1ab(i–v). Organizing and implementing effective protective conservation measures for this species within Tod Katamtok Waterfall tourist area may be possible.

**C. nongnoochiae* K. D. Hill (1999, p. 60)

Described from central Thailand ("Prov. Nakhon Sawan, Wat Suk Sum Ran, 5 km north of Tak Fa, ..."). Type ("29 Apr 1994, K .D. Hill 4643 & P. Vatcharakorn") in NSW (holotype), BKE, K (isotypes).

Description

Arborescent plant with stem to 5 m tall, 10–18 cm in diameter and 30–40-leaved crown. Leaves gray–green to bluish, semi-glossy, 0.8–1.4 m long, young with white (orange–brown in Laos specimens) tomentum, flat in section, with 60–100 pinnae pairs; pinnae 2–8 cm long; rachis consistently terminated by a spine 0.4–2.0 cm long. Petiole 0.20–0.35 m long, glabrous, spinescent. Basal pinnae gradually reducing to spines. Cataphylls narrowly triangular, 4–7 cm long, soft, orange–brown pilose. Pollen cones narrowly ovoid, pale yellow, 15–22 cm long, 7–9 cm in diameter. Microsporophyll firm, 2.2–3.0 cm long, 1.4–2.0 cm wide, apical spine prominent, sharply upturned. Megasporophylls 15–20 cm long, white to yellow tomentose; ovules 2–4, glabrous; lamina orbicular to ovate, 8–10 cm long, 6–7 cm wide, deeply pectinate, with 36–52 soft lateral spines 2.0–2.5 cm long; apical spine distinct. Seeds yellow, flattened-ovoid, 3.0–3.5 cm long. Pollination June–July, seed February–March (Fig. 9).

General distribution

Central Thailand.

Distribution in Laos

Vientiane province (Fig. 1, Map 8).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Vientiane** Prov., Vang Vieng Distr., Na Khun Village. 18°52'28"N, 102°24'21"E, 400–600 m a.s.l., 21 Jan 2009, O. Souliya et al. LA-VN 91. **Vientiane** Prov., Vang Vieng Distr., vicinity of Vang Vieng

town. 18°54'58"N, 102°24'52"E, 400–450 m a.s.l., 24 Apr 2011, (LE – photo), L. Averyanov, P. V. The, CPC 2441 ass. **Vientiane** Prov., Vang Vieng Distr., Phol Xai village, about 8 km to the west of Vang Vieng town, Phar Poon Mt, 18°56'11.5"N, 102°20'05.0"E, 800–900 m a.s.l., 15 Mar 2013, N. T. Hiep et al. LA-VN 460 (Fig. 9), LA-VN 461. **Vientiane** Prov., Vang Vieng Distr., Na Po village, about 12 km to the west of Vang Vieng town, Pa Nang Oua Mt, 18°55'44.9"N, 102°20'20.1"E, 600–900 m a.s.l., 17 Mar 2013, N. T. Hiep et al. LA-VN 547.

Ecology

Primary and secondary lowland, broad-leaved, evergreen and semideciduous forests and dense secondary scrub on rocky limestone at elevations 300–900 m a.s.l., often in crevices of open cliffs or rocky outcrops in full sun. Natural regeneration of the plant is more or less successful. This species is easily cultivated.

Notes

This species was originally known only from limestone outcrops in Tak Fa district, Nakhon Sawan province of central Thailand and was considered as a local endemic of hybrid origin combining morphological features of *C. siamensis* and *C. clivicola* (Hill and Yang 1999). In Laos, a number of fairly large subpopulations of similar looking plants were found during our assessment in Vang Vieng rocky limestone massif (Fig. 1, Map 8; Fig. 9). These plants appear quite stabilized and suggest that this taxon should be recognized as separate species, though further taxonomic studies of more material are necessary. This species can survive in secondary plant communities after destruction of intact habitats. Although its populations are continually being reduced, we observed large subpopulations in and around Vang Vieng. The protection of this plant is desirable because it is a picturesque element of the flora and significant for eco-tourism landscapes.

Conservation status

This species is not under immediate threat of extinction within the studied area. Its threat status in Laos may be assessed as 'Vulnerable' (VU) on the basis of the continuing population decline and the very limited area of its highly isolated populations. These data confirm the global assessment of the species as 'Vulnerable' (Hill 2010b) meeting criteria A2c, B1ab(i–v), B2ab(i–v).

**C. petraea* A. Lindstr. & K. D. Hill (2003, p. 299)

Described from northeast Thailand ("Loei: Phu Kradung, Ban Pong Khao, ..."). Type ("1 Feb 2000, K. D. Hill 5086 and P. Vatcharakorn") in BKF (holotype), K, NSW, NY (isotypes).

Description

Arborescent plant with stem to 6 m tall, 15–20 cm in diameter and 50–100-leaved crown. Leaves bright glossy green, 1.3–2.0 m long, young with white or orange–brown tomentum, flat in section, with 70–120 pinnae pairs; pinnae 10–12 cm long; basal pinnae not reducing in size. Petiole

0.25–0.40 m long, glabrous, unarmed or spinescent. Cataphylls narrowly triangular, soft, pilose, 6–8 cm long. Pollen cones narrowly ovoid to ovoid, orange to brown, 30–40 cm long, 14–18 cm in diameter Microsporophyll firm, 4–5 cm long, 0.7–1.1 cm wide, apical spine prominent, sharply upturned. Megasporophylls 18–22 cm long, gray or brown tomentose; ovules 2–4, glabrous; lamina ovate to orbicular, 10–17 cm long, 4.5–9.0 cm wide, deeply pectinate, with 20–28 soft lateral spines 2–4 cm long; apical spine distinct. Seeds yellow, flattened-ovoid. Pollination June–July, seed February–March (Fig. 8d–f).

General distribution

Northwest Thailand.

Distribution in Laos

Vientiane province (Fig. 1, Map 9).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Vientiane** Prov., Vang Vieng Distr., Nathong village, about 5 km to the west of Vang Vieng town. 18°55'34.2"N, 102°22'58.4"E, 300 m a.s.l., 13 Mar 2013, N. T. Hiep et al. LA-VN 349. **Vientiane** Prov., Vang Vieng Distr., Nathong village, about 5 km to the west of Vang Vieng town, Tham Kang Mt, 18°55'51.4"N, 102°23'50.6"E, 300–400 m a.s.l., 14 Mar 2013, N. T. Hiep et al. LA-VN 416. **Vientiane** Prov., Vang Vieng Distr., Phol Xai village, about 8 km to the west of Vang Vieng town, Phar Poon Mt, 18°56'11.5"N, 102°20'05.0"E, 800–900 m a.s.l., 15 Mar 2013, N. T. Hiep et al. LA-VN 463. **Vientiane** Prov., Vang Vieng Distr., Na Po village, about 12 km to the west of Vang Vieng town, Pa Nang Oua Mt, 18°55'36.4"N, 102°20'44.6"E, 350–450 m a.s.l., 17 Mar 2013, N. T. Hiep et al. LA-VN 488, LA-VN 496 (Fig. 8d, f), LA-VN 498. **Vientiane** Prov., Vang Vieng Distr., Na Po village, about 12 km to the west of Vang Vieng town, Pa Nang Oua Mt. 18°55'44.9"N, 102°20'20.1"E, 600–900 m a.s.l., 17 Mar 2013, N. T. Hiep et al. LA-VN 541, LA-VN 543, LA-VN 546. **Vientiane** Prov., Vang Vieng Distr., Nam Pe village, about 12 km to the west of Vang Vieng town. 18°58'41.0"N, 102°18'54.1"E, 700 m a.s.l., 18 Mar 2013, N. T. Hiep et al. LA-VN 568 (Fig. 8e), LA-VN 579, LA-VN 580, LA-VN 581.

Ecology

Primary and secondary lowland, broad-leaved, evergreen forests and dense secondary scrub on rocky limestone at elevations 300–700 m a.s.l., commonly on shady steep slopes and cliffs. Natural regeneration is more or less successful. The plant is easily cultivated.

Notes

Prior to our work, this species was known only from Phu Kra Dung limestone massif in Loei province of northeastern Thailand. In its locus classicus it was reported growing among open scrub on steep to precipitous limestone outcrops without soil cover in association with *Dracaena*, *Euphorbia*, bamboos and numerous climbers (Lindström

and Hill 2002). A new locality in Laos was discovered about 200 km to the north from its known locality in Thailand (Fig. 1, Map 9; Fig. 8d–f). We discovered, in a number of fairly large subpopulations within the limestone Vang Vieng massif, that this species can survive in secondary plant communities after destruction of intact habitats. Although its populations here are continually being reduced, large subpopulations in Vang Vieng area still remain. The plant warrants priority protection as a picturesque element of the flora significant for eco-tourism landscapes.

Conservation status

In Laos this species is not under immediate threat of extinction within the areas studied. Meanwhile, on the basis of the continuing population decline and small isolated areas of its range in Laos, it may be assessed nationally as ‘Vulnerable’ (VU) under criteria A2c, B1ab(i–v), B2ab(i–v), C1, C2(ai). In Thailand this species is more localized, yet abundant in relatively inaccessible sites. The present range and population size in Thailand are relatively undisturbed. Hence there is little threat to the survival of the species outside Laos (Bösenberg 2010).

C. siamensis Miq. (1863, p. 334)

Described from Thailand (“Siam ...”). Type (“J. E. Teysmann s.n., Mar. 1862”) in U (holotype).

Description

Acaulescent to arborescent plant with stem to 1.5 m tall and 14–20 cm in diameter swollen into sub-globular subterranean caudex. Leaves semi-glossy, 0.6–1.0 m long, with white to orange–brown tomentum, flat, with 40–70 pinnae pairs. Petiole 10–30 cm long, pubescent, spinescent for 10–90% of length. Basal pinnae gradually reducing to spines. Cataphylls narrowly triangular, acute, pilose, 6–7 cm long, persistent. Pollen cones ovoid, yellow–brown, 10–20 cm long, 5–7 cm in diameter. Microsporophylls firm, 2–3 cm long, 1.0–1.5 cm wide, apical spine prominent, sharply upturned. Megasporophylls 6–10 cm long, brown tomentose; ovules 2, glabrous; lamina ovate, 6–11 cm long, deeply pectinate, with 22–50 soft lateral spines 8–35 mm long, apical spine distinct. Seeds yellow, sub-globose, 3.0–3.5 cm long. Pollination June–August, seeds April–May. (Fig. 8g–i, 10a–b).

General distribution

Myanmar, Thailand, Vietnam, Cambodia.

Distribution in Laos

Champasak and Saravan provinces (Fig. 2, Map 10).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Champasak:** J. F. Maxwell 98-480 (CMU). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Saravan** Prov., Saravan Distr., about 10 km from Saravan town to the NW, near Bane Ton Noy village. 15°42′12.4″N, 106°17′51.5″E, 200 m a.s.l. Male sample. 6 Mar 2013, L. Averyanov et al.

LA-VN 225 (Fig. 8g–i), female sample. 6 Mar 2013, L. Averyanov et al. LA-VN 226 (Fig. 10a–b).

Ecology

Primary and secondary, open, semi-deciduous, fire prone, seasonally wet dipterocarp forests and woodlands on lateritic, ferralitic soils at elevations 100–300 m a.s.l., often in full sun. Natural regeneration was observed as abundant and successful. This species is easily cultivated.

Notes

This species is abundant in many flat and lowland areas of Indochina covered by secondary monsoon, seasonally moist dipterocarp forests and woodlands, particularly in central Thailand and southern Vietnam (Tang et al. 1997, Hill and Yang 1999, Osborn et al. 2007). These habitats are characteristically seasonally wet and dry with the monsoon weather patterns of the region, with particularly pronounced and extended dry periods. The species warrants cultivation as an ornamental.

Conservation status

This species is widespread and locally common. Although its habitats are continually being reduced, large populations still remain in Thailand and Vietnam. Due to the fact there are very few known populations in Laos (Fig. 2, Map 10), this species may be assessed at the national level as ‘Vulnerable’ (VU) that fits with its global recent assessment under criteria A2cd (Nguyen 2010d). Special protection of a large discovered population in Saravan province may be desirable to ensure species protection in the country.

C. simplicipinna (Smitinand) K. D. Hill (1995, p. 150)

Based on the same type: *C. micholitzii* var. *simplicipinna* Smitinand (1971, p. 164).

Described from northwest Thailand (“Chiang Mai Province, Doi Suthep, alt.1100 m ...”). Type (“19 Jul 1958, Smitinand 4757”) in BKF (Lectotype designated by Hill 1995).

Description

Acaulescent plant with subterranean caudex to 40 cm in diameter. Leaves 2–5, glossy, 1-pinnate, 1.5–2.5 m long. Petiole, 35–120 cm long, with 10–25 spines; leaf flat with 35–90 pairs of acuminate pinnae. Cataphylls triangular, orange–brown tomentose, 4–5 cm long. Pollen cones fusiform, 15–30 cm long, 4–7 cm in diameter; microsporophylls cuneate, 1.2–1.4 cm long, pale brown tomentose, shortly acute, apical spine absent. Megasporophylls 5–15, 8–12 cm long, pale brown tomentose, lamina ovate, 4.5–5.5 cm long, deeply pectinate, with 10–14 subulate spines; ovules 2–3 on each side of stalk. Seeds yellow ovoid, 2.5–2.7 cm long. Pollination March–May, seeds September–November (Fig. 10c–e).

General distribution

Myanmar, southwest China, northern Thailand, Vietnam.

Distribution in Laos

Saravan province (Fig. 2, Map 11).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Louangphrabang:** Pottier 71A (P); A. de Rouw 263 (NUOL). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Saravan** Prov., Sa Mouay Distr., Lang Lac Hang village. 16°17'54.4"N, 106°55'54.3"E, 600 m a.s.l., 3 Mar 2013, L. Averyanov et al. LA-VN 143, LA-VN 144, LA-VN 146. **Saravan** Prov., Sa Mouay Distr., to the southeast of Sa Mouay town, Ta Oy village. 16°08'47.0"N, 106°52'35.4"E, 800 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 203 (Fig. 10c–e). **Saravan** Prov., Sa Mouay Distr., to the southwest of Sa Mouay town. 16°14'37.9"N, 106°49'36.5"E, 435 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 207, LA-VN 208.

Ecology

Primary and secondary evergreen broad-leaved woods, open degraded forests, secondary scrub on low alluvial slopes composed of silicate rock at elevations 400–800 m a.s.l. Natural regeneration is occasional. The species is easily cultivated.

Notes

This is a widespread species, with its main range comprising northern Myanmar, Yunnan, northern Thailand, northern Laos and central Vietnam (Hill and Yang 1999, Osborn et al. 2007, Nguyen 2010e). In this range, it was reported growing at elevations above 600 m a.s.l. in humid habitats under deep shade in tall, closed evergreen forests. Individuals are usually scattered and sporadic in occurrence, rarely forming dense stands. Large populations were found during our assessment in Xe Xap protected area in Saravan province (Fig. 2, Map 11; Fig. 10c–e). Here plants were observed on low hill and mountain slopes composed of alluvial soils based on shale at elevations 400–800 m a.s.l. Many mature specimens with pollen cones and numerous young plants provide evidence of good regeneration of the species in the studied area. It is remarkable that this species can easily survive in secondary plant communities after degradation of pristine vegetation in its primary habitats. This species can survive in secondary plant communities such as on highly degraded open forests and secondary scrub after degradation. The species warrants cultivation as an ornamental.

Conservation status

This species is widespread, though not usually forming large populations. Although its habitat is continually being reduced and degraded, many populations still remain in Myanmar and Thailand (Hill and Yang 1999). Hence it is regarded as not being under immediate global threat of extinction as 'Near Threatened' (NT) (Nguyen 2010e). However, due to very few known populations within Laos, the appropriate IUCN category should be preliminary estimated as 'Vulnerable' (VU) under criteria A2cd, B1ab(i–v), B2ab(i–v), C1. Large populations discovered in Saravan provinces within the mountain foothills in Xe Xap protected area (documented by collecting number (LA-VN 203, Fig. 10c–e) warrant special protection to ensure species conservation.

Gnetaceae

Gnetum L.

Key to species

1. Fructifications pedicellate, with distinct pedicel 0.2–2.5 cm long; microsporophyll bearing structure branching, with 50–70(80) microsporophylls in each involucre collar ***G. latifolium***
– Fructifications sessile or subsessile; microsporophyll bearing structure branching or simple, with 20–100 microsporophylls in each involucre collar 2
2. Sporophylls immersed in dense involucre tufts of basal hairs 3
– Sporophylls with no or few and inconspicuous basal hairs 4
3. Sporophyll bearing structures branched; microsporophylls 30–40 per involucre collar; fructifications oblong ovoid, 3 cm long, 1.7 cm across ***G. leptostachium***
– Sporophyll bearing structures simple; microsporophylls 20–35 per involucre collar; fructifications ovoid, 2 cm long, 1.2 cm across ***G. macrostachium***
4. Microsporophylls 20–30 per involucre collar; fructifications 2.0–2.5 cm long, 1.0–1.3 cm across; leaves 7–15(20) cm long, 4–8 cm wide ***G. montanum***
– Microsporophylls 40–50 per involucre collar; fructifications 1.3–1.5 cm long and about 0.6 cm across; leaves 6–8(12) cm long, 3–4(5) cm wide ***G. parvifolium***

***G. latifolium* Blume (1834, p. 162)**

Described from Java ("Java"). Type ("*Blume* s.n.") in L.

Taxonomic synonyms: *G. minus* Foxw. (1911, p. 176) – *G. latifolium* f. *longipes* Markgr. (1930, p. 459) – *G. latifolium* var. *funiculare* Markgr. (1930, p. 463) – *G. latifolium* var. *minus* (Foxw.) Markgr. (1930, p. 463) – *G. latifolium* var. *longipes* (Markgr.) T. H. Nguyen (1996, p. 142).

Description

Large woody vine. Leaves petiolate, petiole 1 cm long; leaf blade leathery, oblong lanceolate to elliptic, acute, (5)10–20 cm long, (3)5–8 cm wide. Pollen cones terminal, green, cylindrical, rachis once or twice branched, spikes with 12–15 involucre collars, each with 50–70 microsporophylls and 10–15 sterile megasporophylls. Female strobils axillary, spikes with collars 6–10 mm apart. Fructifications pink to orange, ellipsoid, acute, 2–3 cm long on stipe 0.2–2.5 cm long. Pollination (February) March–June, seeds December–February.

General distribution

Tropical Asia from India to Philippines, New Guinea, Bismarck Archipelago and Solomon Islands.

Distribution in Laos

Champasak, Khammouan, Louangphrabang, Savannakhet and Xiangkhoang provinces.

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Champasak:** F. J. Harmand 1082 (P). **Khammouan:** M. F. Newman LAO 87, LAO 326, LAO 1493 (E). **Louangphrabang:** E. Poilane 20209 (P). **Savannakhet:** E. Poilane 12054 (P). **Xiangkhoang:** E. Poilane 20062 (P).

Ecology

Primary and secondary closed humid forests of any kind, preferably on acidic or neutral soils at elevations 400–1800 m a.s.l. There is no verified data on natural regeneration. There is no data on cultivation.

Notes

A widespread and common species within primary and secondary lowland, submontane and montane forests. It may be threatened in some areas of its distribution by local use and loss of habitats due to deforestation. Habitat loss caused by deforestation is the main threat to the species in all areas of its distribution including Laos.

Conservation status

In Laos the species is recorded from a number of localities and is probably fairly common in the country. It has been globally assessed as 'Least Concern' (LC) (Baloch 2011a) which agrees with our preliminary assessment of its status in Laos. The species can survive in secondary, particularly riverine forests and presently needs no special action to enable its protection.

***G. leptostachyum* Blume (1848, p. 5)**

Taxonomic synonym: *G. leptostachyum* var. *elongatum* Markgr. (1930, p. 686).

Described from Kalimantan ("In montosis orae australis Borneo"). Type in L?

Description

Woody vine 20–40 m long. Leaves shortly petiolate, coriaceous, ovate to elliptic, obtuse, 7–15 cm long, 4–7 cm wide. Pollen cones green, cylindrical, 3–6 cm long, 3–4 mm in diameter, with 12–15 involucre collars, each with 30–40 microsporophylls immersed in a dense hair tuft and 8–10 sterile megasporophylls, on branching rachis to 30 cm long. Female strobils 10 cm long, on similar rachis, megasporophylls 6 in each collar, immersed in dense hair tufts, globose, 3 mm in diameter. Fructifications pink, ellipsoid, 2 cm long. Pollination (February) March–May, seeds (July) August–October.

General distribution

Thailand, Vietnam, Cambodia, Kalimantan, Java.

Distribution in Laos

Champasak, Louangphrabang and Savannakhet provinces.

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Champasak:** E. Poilane 15646 (P).

Louangphrabang: Pedrono 158 (P). **Savannakhet:** E. Poilane 12014 (P).

Ecology

Lowland mixed dipterocarp forests, often along rivers or on steep slopes, as well as montane dense humid forests on any kind of soils at elevations up to 1500 m a.s.l. There is no data about natural regeneration or cultivation.

Notes

A relatively widespread species with fairly wide ecological amplitude. Sometimes it is used locally for rope handicraft and as crop plant for edible seeds. It is threatened in some areas of its distribution by loss of habitats due to deforestation which represent the main threat to the species. Meanwhile, the species can survive in secondary plant communities and does not need special protection.

Conservation status

The species was globally assessed as 'Least Concern' (LC) (Baloch 2011b) which agrees with our preliminary assessment of its status in Laos.

***G. macrostachyum* Hook. f. (1888, p. 642)**

Described from Singapore ("Singapour"). Type ("Hullett 834") in K, SING.

Description

Large woody vine. Leaves shortly petiolate, coriaceous, glossy green, elliptic, acuminate, (6)10–20 cm long, 4–6 cm wide. Pollen spikes green, cylindrical, 5–7 cm long, 5–7 mm in diameter, with 7–12 involucre collars, each with many microsporophylls on short unbranching rachis. Female strobils to 10 cm long, 1.5–2.0 cm wide, megasporophylls (2)4–6 in each collar, immersed in dense hair tufts, collars close together, separated only by hair tufts. Ovules acuminate, glabrous. Fructifications reddish, ovoid, 2 cm long, 1.2 cm across. Pollination February–December, June–July, seeds May–July, October–December.

General distribution

Myanmar, Thailand, Vietnam, Cambodia, Malacca Peninsula, Singapore, Indonesia, Papua New Guinea.

Distribution in Laos

Champasak and Savannakhet provinces.

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Champasak:** F. J. Harmand (P). **Savannakhet:** E. Poilane 28084 (P).

Ecology

Lowland and submontane primary and secondary dense humid forests on neutral soils, particularly within riverine thickets along river valleys at elevations 200–900 m a.s.l. No data exists about natural regeneration or cultivation.

Notes

A widespread species that can survive in lowland secondary plant communities. It is sometimes used locally for ropes handicraft and as crop plant for edible seeds. Deforestation and habitat degradation are main threats to the species. The species probably does not need special protection apart from conservation of forest areas.

Conservation status

The species was globally assessed as 'Least Concern' (LC) (Baloch 2011c) which agrees with our preliminary assessment of its status in Laos.

G. montanum Markgr. (1930, p. 466)

Described from northern Myanmar ("Arracan"). Lectotype ("1833 Wallich 138") in P.

Description

Woody vine to 40 m long and 10 cm in diameter. Leaves petiolate, leathery, oblong to elliptic, acute, 10–25 cm long, 4–10 cm wide. Pollen cones green, cylindrical, 2–3 cm long, on rachis to 6 cm long, once or twice branched. Female strobiles lateral, solitary or fascicled, rachis with 3 or 4 pairs of branches; peduncle 2–3 cm; cones to 10 cm long. Fructifications subsessile, reddish, ellipsoid, 1.2–1.5 cm long. Pollination April–June, seeds August–October (Fig. 10f).

General distribution

Northern India, Bhutan, Nepal, Myanmar, southern China, Thailand, Vietnam.

Distribution in Laos

Attapeu, Khammouan, Phongsali, Saravan and Xiangkhoang provinces (Fig. 2, Map 12).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Phongsali:** E. Poilane 26105 (P). **Xiangkhoang:** C. J. Spire 421 (P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Attapeu** Prov., Saysettha Distr., Dong Am Pham National protected area, Paosamphanmixay village. 14°51'53.4"N, 107°11'38.2"E, 178 m a.s.l., 28 Feb 2013, L. Averyanov et al. LA-VN 119 (Fig. 10f). **Saravan** Prov., Ta Oy Distr., to the southwest of Sa Mouay town, Thong Hang. 15°37'30.9"N, 106°12'26.5"E, 650–700 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 211. **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt, 17°35'13.2"N, 105°47'49.8"E, 1350 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 253.

Ecology

Primary and secondary forests of any kind, preferably on acidic or neutral soils at elevations 150–1500 m a.s.l. This species has normal natural regeneration. There is no data on cultivation.

Notes

A widespread species, not rare within primary and secondary lowland and montane forests of mainland tropical southeast

Asia and estimated globally as 'Least Concern' (LC) (Baloch 2011d). However, the species may certainly be threatened in some areas of its distribution. Surveys and monitoring in these regions are encouraged. Habitat loss caused by deforestation is the main threat to the species in all areas of its distribution.

Conservation status

The species was observed in a number of studied localities during our assessment (Fig. 2, Map 12; Fig. 10f). It can survive in secondary forests, particularly in shady thickets along humid stream valleys. Based on our observations in Laos its status coincides with the global species assessment as 'Least Concern' (LC) (Baloch 2011d).

G. parviflorum (Warb.) C. Y. Cheng (1964, p. 386)

Based on the same type: *G. scandens* var. *parviflorum* Warb. (1900, p. 196) – *G. montanum* f. *parvifolium* (Warb.) Markgr. (1930, p. 468).

Described from southeast China ("Chine, Futschou"). Type ("Warburg, 5953") in B.

Description

Thin, weak vine to 12 m long. Leaves shortly petiolate, leaf blade leathery, ovate to elliptic, acute to attenuate 2.5–10.0 cm long, 1.5–4.0 cm wide. Rachis bearing male cones simple or once branched, spikes 0.8–1.5 cm long, 2–3 mm in diameter, involucrell collars 5–10, each collar with 40–70 microsporophylls and 10–12 sterile megasporophylls. Rachis of female cones simple or once branched, 10–15 cm long; female spikes with involucrell collars 6–9 mm apart, nodes each with 5–8 megasporophylls, basal hairs brown. Fructifications subsessile, red, ellipsoid, 1.5–2.2 cm long, shortly apiculate. Pollination April–July, seeds July–November.

General distribution

South China, Vietnam.

Distribution in Laos

Louangphrabang.

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Louangphrabang:** E. Poilane 26190 (P).

Ecology

Lowland and submontane shady moist forests on neutral sandy soils, often in dense riverine thickets along streams at elevations about 500 m a.s.l. There are no data about natural regeneration or cultivation.

Notes

A species of questionable status that may be regarded as a variety or form of the widespread and very variable *G. montanum*. In the past this species was reported as a common plant in China and Vietnam. Occasionally it is used locally for rope handicraft and as crop plant due to its edible seeds. However, the major threat to *G. parvifolium* is habitat loss caused by deforestation. Though the global

population of the species has almost certainly declined, it probably does not need special protection besides conservation of forest areas.

Conservation status

Gnetum parvifolium as a separate species was globally assessed recently as 'Least Concern' (LC) (Baloch 2011e). In Laos we have only a single record of this species and there are no additional details on its distribution and extant subpopulations, hence conservation status 'Data Deficient' (DD) may be reasonably applied. Field and taxonomic studies are necessary for a better understanding of this species in Laos.

Pinaceae

Key to genera

1. Branches with only long shoots; leaves oblong lanceolate, solitary *Keteleeria*
– Branches with long and short shoots; leaves needle-like, in fascicles of 2–5, sheathed at base by scarious scales *Pinus*

Keteleeria Carriere

K. evelyniana Mast. (1903, p. 194)

Described from south China ("Chine, Yunnan, pres de Yuan Chiang (Jianchuan)"). Type ("A. Henry 11815") in NY.

Description

Trees to 40 m tall and 1.5 m dbh with broad conical crown. Bark grayish brown, irregularly fissured, flaking. Branchlets brownish red, turning brown. Leaves oblong lanceolate, mucronate, 4.0–6.5 cm long, 2.0–3.5 mm wide. Pollen cones cylindric, yellowish, 5–10 mm long, 3 mm wide, densely clustering on branchlet apex. Seed cones cylindric, 10–18 cm long, 4–6 cm in diameter. Seed scales rhombic-ovate, 2.5–4.0 cm long and wide, apex subacute to erose-denticulate. Seeds oblique obovoid, 5–7 mm long; wing yellowish brown, half-ovate, 8–14 mm long. Pollination April–May, seeds October–March (Fig. 10g–i).

General distribution

South China, Vietnam.

Distribution in Laos

Bolikhambxai, Champasak, Champasak, Houaphan, Khammouan, Saravan and Xiangkhoang provinces (Fig. 2, Map 13).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Bolikhambxai:** B. Svengsuksa BT 136 (L). **Champasak:** E. Poilane 16188 (L, P). **Houaphan:** E. Poilane 1959 (P). **Khammouan:** B. Svengsuksa BT 327 (L); M. F. Newman LAO 329, LAO 330, LAO 338, LAO 727, LAO 1261, LAO 1307, LAO 1391 (E); C. J. Spire

1505 (P). **Saravan:** E. Poilane 16188 (L, P). **Xiangkhoang:** C. J. Spire 494 (P); M. F. Newman LAO 1128 (E); E. Poilane 20064 (P); A. F. G. Kerr 20971 (P); A. Chevalier 37068 (P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Champasak** Prov., Paxong Distr., Lac 15 village. 15°11'15.2"N, 106°22'36.2"E, 1200 m a.s.l., 2 Mar 2013, L. Averyanov et al. LA-VN 142 (Fig. 10h–i). **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt, 17°35'13.2"N, 105°47'49.8"E, 500–800 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 240 (Fig. 10g).

Ecology

Primary and secondary coniferous, mixed and broad-leaved, evergreen montane forests at elevations 500–1200 m a.s.l. on neutral or acidic soils. In some localities the species appear as a dominant of canopy forest stratum. Natural regeneration may be abundant, but seedlings often do not survive under dark shade. Successfully planted as a timber species in southern China.

Notes

This species is found scattered or as a co-dominant tree of the first canopy stratum in warm, primary and secondary, evergreen, tropical, mixed or coniferous submontane forests often in association with *Nageia wallichiana*, *Dacrydium imbricatum*, *Dacrydium elatum*, *Podocarpus neriifolius*, *Cephalotaxus mannii*, *Pinus dalatensis*, *P. latteri* and other conifers. Deforestation and overexploitation for its high-quality timber by local people are the main threat factors.

Conservation status

Globally, this species was listed as 'Vulnerable' (VU) under criteria A2cd, B2ab(iii) (Thomas 2013a). Presently, in Laos this species should be assessed as 'Endangered' (EN), with the criteria A2cd: a reduction in population size of at least 50% over the last three generations due to persistent habitat loss and direct exploitation. Majestic primary forests with *Keteleeria evelyniana*, discovered in mountains of Hin Namno protected area in Khammouan province (Fig. 2, Map 13; Fig. 10g–i), are a true national treasure desirable for special protection and monitoring. Use of this important timber tree in plantations and forestry may be additional important actions for species protection as the plant grows relatively quickly and produces timber of good quality.

Pinus L.

Key to species

1. Leaves 2–3 in a fascicle, triangular or semi-orbicular in section 2
– Leaves 5 in a fascicle, triangular in section 3
2. Leaves 2 in a fascicle, semi-orbicular in section *P. latteri*
– Leaves 3 in a fascicle, triangular in section ... *P. kesiya*

3. Leaves longer than 12 cm, nutant; seed cones, ovoid, 8–11 cm long, 5–7 cm in diameter, clustering by 2–6, pendulous, suberect and erect *P. cernua*
 – Leaves shorter than 12 cm, erect; seed cones, cylindrical, 5.5–10(12) cm long, 2.5–4(6) cm in diameter, solitary or paired in whorl, pendulous
 *P. dalatensis* var. *anemophila*

*****P. cernua* L. K. Phan ex Aver., K. S. Nguyen & T. H. Nguyen sp. nov.**

Described from the border of northern Laos and Vietnam (“Son La and Houaphan provinces border”). **Type:** (“12 November 2013, L. Averyanov et al. CPC 6992”) in Herbarium of the Center for Plant Conservation (holotype), LE (isotype).

Previously referred to as: *P. armandii* auct non Franch.: Phan et al. (2013b, p. 42) – *P. fenzeliana* auct. non Hand.-Mazz.: Businský pro parte (2004, p. 218, 2011, p. 84, 2013, p. 247, 257).

Description

Tree 20–30(35) tall, 0.4–0.8(1) m dbh. Canopy conical, becoming with age irregularly rounded; branches suberect to pendulous; leafy branchlets gray–green, olive or yellow–brown, slightly glaucous, glabrous. Bark dull gray–brown to dark brown, roughly fissured into irregular polygonal flat or slightly concave plates, often resinous, inner bark reddish–brown, finely fibrous. Winter buds, orange–brown, often, cylindrical, 1–2 cm long, 3–5 mm in diameter; scales narrowly triangular, (3)4–5 mm long, 1–2 mm wide at the base, acuminate, with slightly recurved scarios apex. Needles in fascicles of 5, (12)15–20(22) cm long, 0.8–1.2 mm thick, bright dark green, slender, cernuous, slightly twisted, serrulate, triangular in cross section; vascular bundle 1 resin ducts 3, medial and two marginal; the sheath early deciduous. Pollen cones numerous, in spiral clusters at the base of new shoots, ovoid, later elongate, suberect, more or less stout, 0.8–1.5 cm long, 6–8 mm in diameter. Seed cones on stout peduncles 1–2 cm long, alone or commonly clustering by 2–6 in whorl, erect, later erect, suberect and pendulous, persistent for many years, brown to dark brown, ovoid, 8–11 cm long, 5–7 cm in diameter, dehiscent at maturity, often resinous. Seed scales woody, rigid, obovate-deltoid, 2.4–2.8(3.0) cm long, 1.5–2.5 cm wide, apophysis deltoid, recurved and thickened at apex in form of transversal finely grooved cushion, umbo insignificant, without mucro. Seeds dark brown, smooth, oblique obovoid, 1.0–1.2 cm long, 0.5–0.7 mm in diameter, with rudimentary scarios thin wing 1–2 mm wide disintegrating to seed maturity and occasionally remaining in form of low irregular distal ridge. Pollination February–March, seeds September–October (Fig. 11–12).

General distribution

Currently only known with certainty from Vietnam but is highly likely to occur in northern Laos near the Vietnamese border and possibly also on Hainan.

Distribution in Laos

Houaphan province (Fig. 2, Map 14).

Data for species distribution in Vietnam along Laos border

Available literature data (Nguyễn et al. 2013). **Son La:** P. V. Thảng et al. 5 (VNU, PanNature Herbarium); N. Đ. T. Lú'u et al. 24 (VNU, PanNature Herbarium); P. K. Lộc et al. P 11077-11082, 11084-11089 (LE, VNU, PanNature Herbarium). New current records from Laos-Vietnamese border (LE, Herbarium of the Center for Plant Conservation, Hanoi): NW. Vietnam, border area of **Houaphan** and **Son La** Prov., Van Ho Distr., Chieng Xuan Municipality, Co Hong village, territory of Xuan Nha natural reserve, Pha Luong Mt, 20°42'14.2"N, 104°43'53.9"E, 1000–1050 m a.s.l., 12 Nov 2013, L. Averyanov et al. CPC 6992 (Fig. 11–12). **Son La** Prov., Van Ho Distr., Chieng Xuan Municipality, Co Hong village, territory of Xuan Nha natural reserve, Pha Luong Mt, 20°41'40.47"N, 104°39'24.67"E, 1426 m a.s.l., 13 Nov 2013, N. S. Khang CPC s.n., photo (Fig. 11).

Ecology

Primary humid coniferous and mixed forests on steep slopes, cliffs and rocky outcrops of remnant, highly eroded solid sandstone at elevations (900)1000–1500 m a.s.l. Occasional gymnosperm associates are *Fokienia hodginsii*, *Dacrycarpus imbricatus* and *Podocarpus neriifolius*. Seed fertility is moderate. Saplings are sporadically observed on open rocky slopes and cliff shelves, but in shady forest on mountain summits regeneration is very poor or absent. Data are available regarding the successful cultivation by seeds and cuttings (Phan et al. 2013b).

Notes

This new species probably has some relation to the variable complex of *P. fenzeliana* Hand.-Mazz. and *P. armandii* Franch. Among a series of infraspecific taxa described at different ranks and associated with the mentioned species, our species may be closer to the Taiwanese *P. armandii* var. *mastersiana* (Hayata) Hayata which has a very similar morphology of its seed cones. At the same time our species distinctly differs from *P. armandii* in having slender narrow needles more than twice as long as the seed cones, ovoid small persistent seed cones clustering regularly by 2–6 in whorls, smaller seed scales with deltoid apophysis recurved and thickened at apex in form of transversal finely grooved cushion without distinct mucro and in seeds with a rudimentary, scarios early disintegrating wing. These characteristic features have already been emphasized during initial studies of the first discovered subpopulation (Nguyễn et al. 2013, Phan et al. 2013b). Meanwhile, the application of the name *P. fenzeliana* remains problematic due to the loss of Fenzel's authentic materials. Specimens from Hainan selected as the neotype for *P. fenzeliana* do not agree with the species protologue (Handel-Mazzettii 1931, Businský 2004, 2011). They somewhat resemble Vietnamese plants and may be close to our species described here. At the same time Fenzel's specimens were certainly closer to *Pinus kwangtungensis* Tsiang and *P. parviflora* Siebold & Zucc.

according to Handel-Mazzettii's original description (1931).

The species is probably a local endemic of Pha Luong Mountains occurring on the Laos–Vietnamese border between Houaphan and Son La provinces (Nguyễn et al. 2013). Deep erosion of the solid orange–brown sandstones forms unique picturesque landforms with numerous rocky ridge edges, very steep cliff slopes and rocky outcrops on the tops of remnant mesas. *P. cernua* inhabits almost exclusively steep rocky slopes and cliffs (Fig. 11). This may be caused by its zoochores (most probably birds or rodents) delivering seeds into such inaccessible habitats where they can germinate and develop. Annual growth of individual trees in observed populations is very variable and depends of habitat conditions. Timber of plants found on relatively dry open rocky summits exhibits annual rings 0.5–1.5 mm wide which indirectly estimates age of oldest observed trees as 200–250 years.

The name *P. cernua* refers to the long slender weeping needles and drooping branches of old trees growing on open rocky cliffs. This species is certainly highly desirable for cultivation as an ornamental tree, particularly in rock gardens in the Asian style.

Conservation status

The distribution of *P. cernua* is limited to small, isolated, highly eroded remnant mountain massives dissected by deep canyons into numerous narrow ridges on its periphery. Trees grow at elevations above 1000 m and this restricts the taxon to a maximal area of less than 80 km². Cliff habitats of the species are small in size and are severely fragmented with a total area of occupancy of less than 10 km². The time to species regeneration is uncertain, but it is highly probable that a single generation would exceed 50 years. In this circumstance the decline of population of 25% (or more) during one generation may be reasonably expected, though the part of the species area (within Vietnam) fits within the area of Xuan Nha natural reserve. On the basis of these conditions, the species may be preliminarily assessed both in Laos and Vietnam as 'Critically Endangered' (CR) under formal IUCN red list criteria – B1ab(iii), B2ab(iii), C1, C2a(ii). Occasional uncontrolled forest fires, sporadic logging, deforestation and loss of habitats are main threats for the species today. Protection and monitoring of all known subpopulations, ex-situ propagation and introduction into cultivation as an ornamental tree may be effective measures to support species conservation.

P. dalatensis Ferré var. *anemophila* (Businský) Aver. comb. et stat. nov.

Basionym: *P. anemophila* Businský (2010, p. 5).

Missapplied name: *P. dalatensis* auct. non Ferré: Newman et al. 2007, p. 35, Thomas et al. 2007, p. 43.

Described from central Laos ("Laos, Khammouan Province, east margin of Phou Ak plateau above Mu Gia Pass, ca 200 m west from plateau edge with Vietnam frontier west above road from the Cha Lo border checkpoint to the border pass; mixed forest on rugged rocky sandstone plateau, together with *Fokienia hodginsii*, top of sandstone rock, 995

m a.s.l., 17°40.20.8"N, 105°44.54.5"E"). Type ("22.4.2010 R. Businský 68102") in PR (holotype), BM, G, MO, P (isotypes).

Description

Tree to 45 m tall and 1.5 m dbh with broad obconical crown. Bark gray–brown, irregular to longitudinally fissured. Needles 5 in fascicles, 5–8(10) cm long. Pollen cones dull yellow, ovoid, clustering at branchlet apex. Seed cone brown, cylindrical, (5.5)6–10(12) cm long, (2.5)3–4(6) cm in diam., with (20)30–50(70) normally developed scales. Seeds ovate, brown, winged. Pollination April–May, seeds October–December (Fig. 13a–c).

General distribution

Vietnam.

Distribution in Laos

Khammouan and Saravan provinces (Fig. 2, Map 15).

Data for species distribution in Laos

Available literature data (Newman et al. 2007, Thomas et al. 2007, Businský 2010). **Khammouan:** M. F. Newman LAO 1214, LAO 1311, LAO 1315, LAO 1316, LAO 1383, LAO 1384, LAO 1415, LAO 1481 (E, FRCL, L, NUL, P); Businský 68101, 68103, 68104 (PR). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Saravan** Prov., Sa Mouay Distr., to the southeast of Sa Mouay town, Ta Oy village. 16°08'47.0"N, 106°52'35.4"E, 1150 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 195 (Fig. 13a–c).

Ecology

Primary coniferous, mixed and broad-leaved, moist, evergreen, montane forests at elevations 800–1200 m a.s.l. on acidic silicate soils derived from sandstone. The species sometimes appears as co-dominant or dominant of coniferous forest. Abundant natural regeneration was observed in some studied habitats, particularly in open mossy places. No data were recorded on cultivation.

Notes

The tree is an endemic of the central part of Truong Son Range where it grows in primary coniferous and mixed forests along sandstone mountain ridges and plateaus in association with *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Fokienia hodginsii*, *Nageia wallichiana*, *Podocarpus neriifolius* and other rare conifers. Natural regeneration may be abundant, but seedlings are shade intolerant and plants may require periodic fire to provide clearings for regeneration. Deforestation and selective logging for high-quality timber are main threats to the known populations. This tree may be used as an ornamental plant in highland areas.

Plants recorded from a sandstone massif along the border of Khammouan province of Laos and Quang Binh province of Vietnam were described recently as a separate species: *P. anemophila* Businský (2010). In our investigation we found few morphological differences between these plants and *P. dalatensis* known southwards in Vietnam. In our

opinion this sandstone adapted race hardly deserves taxonomic status higher than the rank of variety.

Conservation status

Pinus dalatensis s.l. was estimated globally as 'Near Threatened' (NT) (Thomas and Phan 2013) as it is known from about 10 locations, subpopulations of which inhabit remote mountain areas in Vietnam and still retain relatively high vitality (Nguyen et al. 2004). Meanwhile, *P. dalatensis* var. *anemophila* is found only in a lone location in Vietnam in Quang Binh province where it grows along the border to Laos and represent the same subpopulation which was recorded in Khammouan province area allied to Vietnamese border (Newman et al. 2007, Thomas et al. 2007, Businský 2010). In fact, only two extant subpopulations of *P. dalatensis* var. *anemophila* are known (Fig. 2, Map 15; Fig. 13a–c). They occupy summits of sandstone ridges running along the Laos–Vietnamese border in central part of Truong Son Range and have a very limited area of occurrence and occupancy that are certainly less than 5000 and 500 km² respectively. Both discovered subpopulations exhibit high fragmentation and progressive decline of their area and quality of habitats hence status 'Endangered' (EN) may be applied globally and nationally for both countries following criteria B1ab(i, iii, v), B2ab(ii, iii, v).

Climax stands of *P. dalatensis* var. *anemophila* containing numerous mature trees were observed during our assessment on mountain tops of Xe Xap protected area in eastern part of Saravan province near the Vietnamese border (Fig. 2, Map 15; Fig. 13a–c). Some trees there were 40 m tall and 1.5 m in diameter, and many older than 500 years. Similar stands were also reported from the southern part of the Nakai Nam Theun protected area (Khammouan province) where this species grows in association with other conifers such as *Calocedrus macrolepis*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Keteleeria evelyniana*, *Fokienia hodginsii*, *Pinus latteri*, *Podocarpus neriifolius* and *Podocarpus pilgeri* (Thomas et al. 2007, Businský 2010). Monitoring of forest fires and local logging is the primary course of action for conservation of this species in both known localities.

P. kesiya Royke ex Gordon (1840, p. 8)

Described from northeast India ("A tree found on the Khasiya Hills at elevation from 2000 to 6000 feet, and on the mountains of Upper Assam in Eastern India"). Type not located.

Taxonomic synonyms: *P. langbianensis* A. Chev. (1944, p. 25) – *P. kesiya* var. *langbianensis* (A. Chev.) Gaussen (1962, p. 38) – *P. insularis* var. *khasiyana* (Griff.) Silba (1990, p. 51) – *P. insularis* var. *langbianensis* (A. Chev.) Silba (1990, p. 51).

Description

Tree to 35 m tall and 1 m dbh with spreading yellowish–brown branches forming broadly domed crown. Bark orange–brown, later dull gray–brown, irregularly flaking. Leaves 3 per fascicle, 10–22 cm long, slender, rigid, base with persistent sheath 1–2 cm long. Pollen strobiles ovoid, later fusiform light orange–yellow, clustering near branchlet

apex. Seed cones 1–2, on short stalk, glossy olive green to gray–brown, ovoid to conic, 4–6 cm long, 3.0–3.5 cm in diameter, persistent for many years; scales oblong, 2.5–3.0 cm long, with pyramidal, transversely ridged apophysis, umbo small, shortly apiculate. Seeds winged, black–brown, 5–6 mm long. Pollination April–May, seeds September–November.

General distribution

Northeast India, Myanmar, south China, Thailand, Vietnam, Cambodia, Malaysia, Philippines.

Distribution in Laos

Attapu, Houaphan, Saravan and Xiangkhoang provinces.

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Attapu:** E. Poilane 15992 (P). **Houaphan:** E. Poilane 1972, 2050 (P). **Saravan:** E. Poilane 15525, 16159 (P). **Xiangkhoang:** C. J. Spire 554 (P); P. A. Petelot 4383, 4385 (P).

Ecology

This species forms pure open stands or appears as co-dominant of mixed closed humid seasonal submontane and montane forests at elevations 700–1600 m a.s.l., usually on poor, well-drained quartzite or sandy soils. Natural regeneration is often fairly strong but seedling and saplings are shade intolerant. This species is often used in plantations for silviculture, particularly in southern China and in southern Vietnam.

Notes

In humid areas *Pinus kesiya* can occupy well-drained lands at elevations 1000–1600 m a.s.l. cleared after deforestation. This species forms secondary pine savannas, woodlands and pure stands with a nearly closed canopy. Often this species appears as a pioneer in deforested secondary vegetation, especially when fire has been a factor in the disturbance. In primary forests of Laos it grows in pure stands or mixed with *Pinus latteri* and *Keteleeria evelyniana*. Angiosperm associates includes *Schima wallichii*, *Quercus serrata* and *Q. griffithii*. *Pinus kesiya* may be successfully cultivated at elevations up to 2000 m and higher.

Conservation status

Pinus kesiya is a widespread species whose extent of occurrence and area of occupancy are well beyond the thresholds for a threatened category. It is assessed globally as 'Least Concern' (LC) as there is no range wide decline and it is increasing in some parts of its range due to anthropogenic land-use (Farjon 2013a). The same status may be applied to the species in Laos. Meanwhile, primary coniferous forest with *P. kesiya* requires special attention in relation to nature protection as this species creates habitats for many rare native plant species. Widespread logging, repeated burning and over grazing represent serious threat for the species natural stands. The species may be used in commercial plantations, for reforestation and soil erosion control that promote its conservation ex situ.

***P. latteri* Mason (1849, p. 74)**

Described from southern Myanmar (“In provincial Amherst: in convalli fluvii Thoungyeen”). Type (“Latter”) in K?

Taxonomic synonyms: *P. tonkinensis* A. Chev. (1944, p. 29) – *P. merkusii* var. *tonkinensis* (A. Chev.) Gausсен ex Bui (1962 p. 336) – *P. merkusii* var. *latteri* (Mason) Silba (1990, p. 53) – *P. merkusii* subsp. *latteri* (Mason) D. Z. Li (1997, p. 346).

Description

Tree to 30 m tall and 1 m dbh with upcurved branches forming open crown changing from conical to rounded as the tree ages. Bark rough, gray–brown, deeply fissured. Leaves 2 per fascicle, 20–27 cm long, slender, rigid. Pollen strobiles dull yellow, ovoid, clustering along rachis near branchlet apex. Seed cones 1–2, on short stalk, glossy brown, ovoid to broadly conic, 6–12 cm long, 5–8 cm in diameter; scales with a flat apophysis and a prominent transverse keel. Seeds with a long wing. Pollination April–May, seeds October–December (Fig. 13d–e).

General distribution

Southern Myanmar, southern China, Thailand, Vietnam, Cambodia.

Distribution in Laos

Attapu, Borikhamxai, Khammouan, Saravan, Savannakhet and Savannakhet provinces (Fig. 2, Map 16).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Attapu:** E. Poilane 15926 (P); E. Poilane 28632 (L). **Khammouan:** K. Nanthavong, V. Lamxay BT 186 (L); M. F. Newman LAO 235, LAO 725, LAO 805, LAO 888, LAO 1313, LAO 1386 (E). **Savannakhet:** E. Poilane 2292, 12184 (P). **Xiangkhoang:** Magnein 46 (P); E. Poilane 2342 (P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Borikhamxai** Prov., Khamkeut Distr., Dan Khum Ngan locality. 17°57'32"N, 105°01'05"E, 538 m a.s.l., 18 Jan 2009, S. Bounphanmy et al. LA-VN 23. **Saravan** Prov., Sa Mouay Distr., to the southeasteast of Sa Mouay town, Ta Oy village. 700 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 206. **Saravan** Prov., Ta Oy Distr., to the southwest of Sa Mouay town, Thong Hang village. 15°37'30.9"N, 106°12'26.5"E, 650–700 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 214 (Fig. 13d, i).

Ecology

Primary and secondary coniferous, mixed and broad-leaved, evergreen and semideciduous lowland Dipterocarp forests and woodlands at elevations 500–700 m a.s.l. on poor ferralitic soils. It is a fire-adapted species capable of occasionally invading open terrains especially in nutrient-poor soils. Poor and erratic natural regeneration was observed in the studied habitats. This species is commonly used in plantations for silviculture, particularly in southern China.

Notes

This pine is found in pure stands or mixed with Dipterocarp species in lowland, periodically inundated areas on infertile ferralitic soils. Such forests often support high diversity of native shrubby, herbaceous and epiphytic plant species. Natural regeneration is light-dependent and this species is occasionally able to colonize bare ground. Forest fires, widespread logging for high-quality timber and land conversion for agricultural purposes are the main threats for the species within its range of distribution. Resin extraction is causing mortality within many natural populations due to the destructive methods used. Conversion of forest to agricultural land has already eliminated all native populations of the species in the lowlands in Vietnam (Nguyen et al. 2004). In Laos, populations were observed during our assessment in Borikhamxai and Saravan provinces (Fig. 2, Map 16; Fig. 13d, i) where they represent a unique yet typical pattern of lowland native vegetation.

Conservation status

Although widely distributed, this species should be presently assessed in Laos as ‘Vulnerable’ (VU) under criteria A2acd, B2ab(i–v) due to widespread and overall decline and fragmentation of its natural range, wide-spread logging and rapid extinction of small local populations. The species may be used in commercial plantations, for reforestation and soil erosion control that promote its conservation ex situ. The large population discovered in Saravan province (documented as LA-VN 206 and LA-VN 214) may be protected as a seed source area. Globally assessed as ‘Near Threatened’ (NT) (Thomas 2013b).

Podocarpaceae

Key to genera

1. Leaves rather monomorphic, lanceolate to ovate, more than 5 mm wide 2
– Leaves dimorphic, scale- or needle-like, less than 5 mm wide 3
2. Leaves opposite, ovate, more than 1.5 cm wide, without distinct median vein; receptacle of the mature seeds only slightly swollen, not fleshy *Nageia*
– Leaves spirally arranged, lanceolate to broadly lanceolate, less than 1.5 cm wide, with distinct median vein; receptacle of the mature seeds swollen and fleshy *Podocarpus*
3. Juvenile leaves distichous, linear lanceolate; adult leaves distichous, linear lanceolate, falcate, 5–15 mm long or spirally arranged, scale-like, elongate, 1–2 mm long; receptacle verruculose, without distinct scale rudiments *Dacrycarpus*
– Juvenile leaves spirally arranged, needlelike; adult leaves spirally arranged, scale-like, triangular, about 1 mm long; receptacle with distinct scale rudiments *Dacrydium*

Dacrycarpus (Endl.) de Laub.

D. imbricatus (Blume) de Laub. (1969, p. 317)

Based on the same type: *Podocarpus imbricatus* Blume (1827, p. 89).

Described from Java (“Java”). Type (“Blume s.n.”) in L (holotype), BO (isotype).

Description

Tree to 40 m tall and 1 m dbh, with straight clear bole of up to 20 m and a dome-shaped crown. Branches spreading, often pendulous. Bark red–brown, rugose. Leaves imbricate, linear, 1.0–1.7 cm long, 1.2–2.2 mm wide, leaves on older trees becoming scale-like, imbricate, triangular, 1–3 mm long, 0.4–0.6 mm wide. Involucral leaves spreading, acicular. Pollen strobiles axillary, cylindrical, 1 cm long, 2 mm wide. Seed strobiles solitary or grouped in 2 at the tip of twigs, but only one fertile, ripe receptacle red. Seeds glossy, reddish–brown, ovoid, 0.5–0.6 cm long. Pollination February–March, seeds September–November (Fig. 13f–g).

General distribution

Myanmar, southern China, Thailand, Vietnam, Cambodia, Malaya, Philippines, Sumatra, Java, Kalimantan, Celebes, Moluccas, Lesser Sunda Islands, New Guinea, New Hebrides, Fiji.

Distribution in Laos

Attapu, Champasak, Khammouan, Saravan and Xiangkhoang provinces (Fig. 2, Map 17).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007): **Attapu:** F. J. Harmand 1325 (P); E. Poilane 15922 (P). **Khammouan:** M. F. Newman LAO 70, LAO 1314, LAO 1388 (E); B. Svengsuksa BT 352 (L); K. Nanthavong, C. E. Ridsdale BT 547 (L); T. C. Whitmore 3724 (E). **Saravan:** E. Poilane 12207, 13261, 15520, 15542, 16092 (P). **Xiangkhoang:** E. Poilane 2147 (P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Champasak** Prov., Paxong Distr., Nongkingham village, 15°10′29.4″N, 106°14′30.0″E, 1290 m a.s.l., 2 Mar 2013, L. Averyanov et al. LA-VN 141. **Saravan** Prov., Sa Mouay Distr., to the southeast of Sa Mouay town, Ta Oy village. 16°08′47.0″N, 106°52′35.4″E, 1150–1350 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 197 (Fig. 13f). **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt, 17°35′13.2″N, 105°47′49.8″E, 700–1000 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 238 (Fig. 13g).

Ecology

Primary coniferous, mixed and broad-leaved, evergreen montane forests at elevations 700–1200 m a.s.l. preferably on silicate soils, and very rarely found on limestone. Natural regeneration is often abundant yet seedlings and saplings are light demanding. Information is available to facilitate

successful cultivation of the species in the area of natural distribution.

Notes

This species is commonly found as a scattered emergent in primary lowland and submontane forests associated with *Cephalotaxus mannii*, *Dacrydium elatum*, *Nageia wallichiana* and *Podocarpus neriifolius*. The species rarely forms oligo- or mono-dominant stands. In Laos, primary coniferous forests with *D. imbricatus* as a significant co-dominant were found by us within sandstone mountains adjacent to the Vietnamese border in Khammouan and Saravan provinces in Hin Namno and Xe Xap protected areas (Fig. 2, Map 17; Fig. 13f–g). Many trees there reach their maximal size of 40 m tall and more than 1 m in diameter. Both these localities are suitable for special protection. Deforestation, land conversion for agriculture and selective felling are the main threats to this species. The tree may be used as a relatively fast-growing ornamental tree.

Conservation status

Due to its wide distribution this species is presently listed as ‘Least Concern’ (LC) at the global level (Thomas 2013c). Based on our assessment, it should be preliminarily assessed in Laos as ‘Vulnerable’ (VU) under criteria A2acd, B2ab (i–v) due to wide deforestation, uncontrolled logging and severe population fragmentation. Fertile and dense populations discovered in Hin Namno and Xe Xap protected areas should be protected as a rare occurrence of intact primary coniferous forest and as an important seed source for further possible cultivation and protection in reforestation and plantations.

Dacrydium Sol. ex G. Forst.

D. elatum (Roxb.) Wall. ex Hook. (1843, p. 144)

Based on the same type: *Juniperus elata* Roxb. (1832, p. 838).

Described from Malacca Peninsula (“Peninsule malaise”). Lectotype (“Wallich 6045”) in BM, K, P.

Description

Tree to 30 m tall and 1 m dbh, with straight bole and dome-shaped crown. Bark brown. Young leaves needle-like, relatively soft, spreading but curved forward, 1.0–1.4 cm long. Adult foliage shoots cord-like, 1–2 mm diameter, leaves in the form of imbricate triangular scales 1.0–1.5 mm long, 0.4–0.6 mm wide, sharply keeled outside. Pollen strobiles, apical, 4–8 mm long, 1.0–1.2 mm in diameter. Seed cones apical, solitary, forming 1 seed. Seeds dark glossy brown, 4.0–4.5 mm long, 3 mm in diameter. Pollination February–March, seeds October–November (Fig. 13h, i).

General distribution

Southern China, Thailand, Vietnam, Cambodia, Malaysia, Sumatra, Kalimantan, Philippines.

Distribution in Laos

Khammouan, Phongsali, Saravan provinces and Xaisomboun Special Area (Fig. 2, Map 18).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007, Thomas et al. 2007). **Khammouan:** T. C. Whitmore 3725, 3726 (E); K. Nanthavong, C. E. Ridsdale BT 513 (L); K. Nanthavong, C. E. Ridsdale BT 521 (L); M. F. Newman LAO 1310, LAO 1387, LAO 1390 (E, FRCL, L, NUL, P). **Xaisomboun Special Area:** M. F. Newman LAO 1103, LAO 1104 (E, FRCL, L, NUL, P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Phongsali** Prov., Muong May Distr. 21°12'32"N, 102°53'44"E, 1250–1400 m a.s.l., 22 April 2011, L. Averyanov, P. V. The, CPC 2435. **Saravan** Prov., Sa Mouay Distr., to the southeast of Sa Mouay town, Ta Oy village. 16°08'47.0"N, 106°52'35.4"E, 4 Mar 2013, L. Averyanov et al. LA-VN 180 (Fig. 13h, i).

Ecology

Primary coniferous, mixed and broad-leaved, evergreen montane forests at elevations 1200–1400 m a.s.l. preferably on poor silicate soils, very rarely found on limestone. Natural regeneration is often common and widespread. Seedlings and saplings are light demanding. Information is available on its successful cultivation within Laos.

Notes

This species is often found scattered in primary humid submontane or montane forests and rarely forms large populations or dense stands. In Vietnam, it is known from numerous localities, where it is often associated with such conifers as *Dacrycarpus imbricatus*, *Fokienia hodginsii*, *Pinus dalatensis*, *P. krempfii* and *Podocarpus neriifolius*. In Laos this humid-loving species is much rarer due to a drier continental climate. It was discovered by us in two localities (Fig. 2, Map 18; Fig. 13h, i). In Xe Xap protected area (Saravan province) the species was observed as a common and significant co-dominant of humid primary coniferous forests associated with *Dacrycarpus imbricatus*, *Pinus dalatensis* var. *anemophila* and *Podocarpus neriifolius*. In all areas of distribution, as well as in Laos, the species is threatened by forest fragmentation, selective logging and conversion of habitat to agricultural use.

Conservation status

Globally this species is listed as 'Least Concern' (LC) (Thomas 2013d). However, at the same time it was reasonably accepted as nationally 'Vulnerable' A2cd in Vietnam and some other countries on the basis of the extensive deforestation over the last 50 years (Nguyen et al. 2004). In Laos this species may be preliminarily assessed as 'VU' or 'EN' under criteria A2acd, B2ab(i–v) due to its obvious rarity and the severe fragmentation of its known populations. Full effective protection of coniferous forests with *D. elatum* as dominant within Xe Xap protected area will be very important for species protection. This species may be used as an ornamental plant and as a tree suitable for silviculture in highland areas.

Nageia Gaertn.

Key to species

1. Leaves with stomatal lines on both surfaces; receptacle distinctly swollen *N. wallichiana*
– Leaves with stomatal lines only on abaxial surface; receptacle hardly swollen *N. fleuryi*

N. fleuryi (Hickel) de Laub. (1987, p. 210)

Based on the same type: *Podocarpus fleuryi* Hickel (1930, p. 75).

Described from N. Vietnam ("Tonkin: Province de Phu-Tho, ... Trung Giap"). Lectotype ("Fleury 38017 25/51918") in P (Nguyen and Vidal 1996).

Description

Dioecious tree 15–25 m tall and 0.7 m dbh with broad conical crown. Leaves glossy dark green, coriaceous, shortly petiolate, elliptic, shortly acuminate, 8–18 cm long, 3–5 cm wide, with stomatal lines on abaxial surface. Pollen strobiles 3–5, axillary, sessile, cylindrical, 1.5–3.0 cm long. Microsporophylls triangular. Seed-bearing structures axillary, peduncle 2.0–2.8 cm long; only 1 ovule maturing. Receptacle absent. Seed globular, olive green, 1.5–1.8 cm in diameter. Pollination March–April, seeds October–November.

General distribution

Southern China, Taiwan, Vietnam, Cambodia.

Distribution in Laos

Bolikhambxai.

Data for species distribution in Laos

Available literature data (Newman et al. 2007, Thomas et al. 2007). **Bolikhambxai:** M. F. Newman LAO 1534, LAO 1535 (E, FRCL, L, NUL, P).

Ecology

Primary coniferous, mixed and broad-leaved evergreen, shady, humid, submontane forests on any kind of soils at elevation 800–1500 m a.s.l., often on rocky limestone. Throughout its range, it occurs as rare, scattered trees. Occasional natural regeneration sometimes is observed, but saplings 1 m high and taller are rare. Seedlings and saplings are fairly shade tolerant. Data exists on successful species cultivation in Vietnam for reforestation (Nguyen et al. 2004).

Notes

The species has a wide but disjunctive distribution with a series of small isolated subpopulations. In northern Vietnam it occurs commonly on tops of mountains and ridges as an occasional element of humid mixed and coniferous forest with such associates as *Fokienia hodginsii*, *Pinus wangii*, *Podocarpus pilgeri*, *Pseudotsuga sinensis* and *Taxus sinensis*. The timber of *N. fleuryi* is valued and is being selectively logged in significant parts of its range. Deforestation and agricultural land transformation are other serious factors of rapid species extinction across all areas of its native range.

Conservation status

The extent of *N. fleurii* occurrence falls outside the threshold for 'Vulnerable' (VU) status. A past decline of up to 29% is likely to have occurred within the last three decades especially in the southern parts of its range. Although generation lengths are uncertain, it is highly probable that a single generation length would exceed 30 years. On this basis it was assessed globally as 'Near Threatened' (NT) (Thomas 2013e). Meanwhile the species was assessed nationally in China and Vietnam (Liguó et al. 1999b, Nguyen et al. 2004) as 'Vulnerable' under criteria – A2ac, B1ab(iii,v), B2ab(iii,v), C1, C2a(i). In Laos this species is only known from a single location and there are no data on population size or decline. In the absence of such information 'Data deficient' (DD) would be the most appropriate national assessment. Field investigations for finding new localities and the protection of the forest in areas of known population are important for developing reasonable actions for species protection.

Nageia fleurii is not easily distinguished from the much more widely distributed close species *N. wallichiana*, hence more field and taxonomic studies are necessary for better understanding of its status in Laos.

N. wallichiana (C. Presl) Kuntze (1891, p. 800)

Described from northeast India ("Inde, Mt Sylhet"). Type ("Wallich 6050") in K (holotype), P (isotype).

Description

Dioecious tree to 30 m tall and 1 m dbh with conical crown. Leaves leathery, petiolate, elliptic, 6–14 cm long, 2–5 cm wide. Pollen strobiles in groups, pedunculate, 1–2 cm long, 3–4 mm wide. Seed strobiles solitary on peduncle to 2 cm long, with caducous scales. Receptacle with 4–7 sterile, deflexed bracts, 7–18 mm long. Seeds globular olive brown, 1.5–2.0 cm diameter. Pollination February–March, seeds November–December. (Fig. 14a).

General distribution

India, Myanmar, southern China, Thailand, Vietnam, Cambodia, Malaya, Sumatra, Java, Kalimantan, Lesser Sunda Islands, Philippines, Celebes, Moluccas, New Guinea.

Distribution in Laos

Attapeu, Khammouan and Xiangkhoang provinces (Fig. 3, Map 19).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Khammouan:** K. Nanthavong, C. E. Ridsdale BT 574 (L). **Xiangkhoang:** A. F. G. Kerr 21215 (P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Attapeu** Prov., Saysettha Distr., Dong Am Pham National protected area, Paosamphanmixay village. 14°48'24.8"N, 107°24'23.2"E, 700–920 m a.s.l., 28 Feb 2013, L. Averyanov et al. LA-VN 107 (Fig. 14i).

Ecology

Primary coniferous, mixed and broad-leaved, evergreen, humid lowland and montane forests at elevations 500–1000 m a.s.l.

preferably on silicate soils, rarely on limestone. Throughout its range, it occurs as rare, scattered trees. Not frequent, but regular natural regeneration is often observed. Seedlings and saplings are shade tolerant and the tree is easily cultivated.

Notes

This species is found in primary broad-leaved and mixed lowland, submontane and montane forests mostly on soils derived from silicate rocks. Its occasional coniferous associates are *Cephalotaxus mannii*, *Dacrycarpus imbricatus* and *Podocarpus neriifolius*. Throughout its range, it occurs as scattered trees or in small groups, commonly on fertile soils in relatively humid habitats. A single locality of this species was found during our assessment in Dong Am Pham protected area, in the eastern part of Attapeu province (Fig. 3, Map 19; Fig. 14, a) as very rare element of primary broad-leaved evergreen lowland dry forest at elevation about 900 m a.s.l. The species is occasionally cultivated as a relatively fast growing ornamental tree.

Conservation status

The wide distribution of *N. wallichiana* means that it is not listed as threatened globally (Farjon 2013b). However, in Vietnam it was recently evaluated as 'Vulnerable' (VU) based on additional fieldwork since its previous assessment (Nguyen et al. 2004). Deforestation, land conversion for agriculture and selective logging for high-quality timber are the main factors affecting this species. The preliminary proposed status of this species in Laos should be 'VU' under criteria B1ab(i–v), B2ab(i–v) due to its rarity and fragmentation of known populations. Field investigation targeting the finding of new localities and the protection of the forest in known localities will be important and effective actions for species protection.

Podocarpus L'Her. ex Pers.

Key to species

1. Leaf blade narrowly lanceolate to lanceolate 6–12 cm long, 8–12 mm wide, tapered to the acute or acuminate apex *P. neriifolius*
– Leaf blade broadly lanceolate to narrowly elliptic, 2–4 cm long, 5–10 mm wide, suddenly narrowed into an obtuse, shortly mucronate apex *P. pilferi*

P. neriifolius D. Don (1824, p. 21)

Taxonomic synonym: *P. annamiensis* N. E. Gray (1958, p. 451).

Described from Nepal ("Nepal"). Type ("Wallich 6052A") in K (holotype), P (isotype).

Description

Tree to 25 m tall and 0.7 m dbh with cylindrical pyramidal crown. Bark grayish brown, fibrous, peeling off in longitudinal flakes. Leaves shortly petiolate, lanceolate, acuminate, leathery, 6–12 cm long, 8–12 mm wide. Pollen strobiles subterminal, 1–5, sessile, cylindrical, 2.5–5.0 cm long. Seed-bearing structures axillary, solitary; peduncle 1–2 cm long.

Receptacle orange–red, obconical, 8–10 mm long, 5–8 mm in diameter. Seed ovoid, 0.8–1.6 cm long. Pollination May, seeds August–November (Fig. 14b–c).

General distribution

Northeast India, Bhutan, Nepal, Myanmar, south China, Thailand, Vietnam, Laos, Cambodia, Malaysia, Indonesia, Philippines, Papua New Guinea, Pacific Islands.

Distribution in Laos

Khammouan, Saravan, Vientiane and Xiangkhoang provinces (Fig. 3, Map 20).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007). **Khammouan:** M. F. Newman LAO 1262, LAO 1286, LAO 1419 (E). **Xiangkhoang:** J. E. Vidal 1594 (P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Saravan** Prov., Sa Mouay Distr., to the southeast of Sa Mouay town, Ta Oy village. 16°08'47.0"N, 106°52'35.4"E, 1200–1350 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 152 (Fig. 14c). **Saravan** Prov., Ta Oy Distr., to the southwest of Sa Mouay town, Thong Hang village. 15°37'30.9"N, 106°12'26.5"E, 650–700 m a.s.l., 4 Mar 2013, L. Averyanov et al. LA-VN 212. **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt, 17°35'13.2"N, 105°47'49.8"E, 500–1000 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 239 (Fig. 14b). **Vientiane** Prov., Kasi Distr., Tam Tai village, about 10 km to the northwest of Kasi town. 19°12'57"N, 102°14'59"E, 500–650 m a.s.l., 24 Mar 2013, L. Averyanov et al. LA-VN 753.

Ecology

Primary coniferous, mixed and broad-leaved, evergreen lowland and montane humid forests at elevations 500–1400 m a.s.l. both on silicate and limestone soils. Throughout its range, it occurs as scattered trees. Not very frequent, but regular natural regeneration is observed. Seedlings and saplings are shade tolerant. For this species information is available for successful cultivation.

Notes

This tree is often found scattered in primary and secondary submontane forests mainly on deep fertile silicate and limestone derived soils often in association with other rare conifers. It rarely forms large groups or dense stands. In Vietnam, as well as in Laos it is the most common and widely distributed conifer species, found in nearly all forested hills and mountains. It was found during our assessment in four new localities (Fig. 3, Map 20; Fig. 14b–c) as a more or less common plant. At the same time large mature trees are very rare throughout its range. Due to its wide distribution, this species is not regarded as threatened in Laos although it is becoming increasingly rare in many parts of its range, mainly due to changes in its habitat and selective felling.

Conservation status

Its wide distribution throughout still large forested areas of Laos means that it should not be considered as a threatened

species in the country. Meanwhile, in all of these areas it is rare or infrequent and certainly is in need of special attention for protection. This species has potential for plantation forestry, and thus silviculture trials may be successively established in mountain areas. It is presently assessed globally as 'Least Concern' (LC) (Farjon 2013c).

P. pilgeri Foxw. (1907, p. 259)

Described from Philippines ("Philippines, Mindoro, Mt Halcon"). Type ("Merrill 5754") in NY.

Taxonomic synonyms: *P. wangii* C. C. Chang (1941, p. 26) – *P. tixieri* Gaussen ex Silba (2008, p. 34).

Description

Tree to 10 m tall and 0.5 m dbh with broad obconical crown. Bark pale brown, fibrous, shallowly fissured. Leaves shortly petiolate, coriaceous, glossy green, young ones pinkish, glaucous, crowded at apex of branchlets, broadly lanceolate to elliptic, mucronate, 2–4 cm long, 5–10 mm wide. Pollen strobiles, subsessile, solitary, axillary, cylindrical, 1.5–3.0 cm long, 3–4 mm in diameter. Seed-bearing structures solitary, axillary, peduncle 4–10 mm long, receptacle red, obconical, 5–12 mm long, 3–6 mm in diameter. Seeds glaucous, ovoid, 8 mm long. Pollination in March–May, seeds October–November (Fig. 14d–f).

General distribution

Northeast India, southern China, Thailand, Vietnam, Cambodia, Indonesia, Philippines, New Guinea.

Distribution in Laos

Khammouan province (Fig. 3, Map 21).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007, Thomas et al. 2007). **Khammouan:** M. F. Newman LAO 1436, LAO 1470 (E, FRCL, L, NUL, P). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt, 17°35'13.2"N, 105°47'49.8"E, 1300–1425 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 257 (Fig. 14d–f), LA-VN 274.

Ecology

Primary coniferous, mixed and broad-leaved, evergreen montane humid forests at elevations 1300–1450 m a.s.l. on tops of mountains composed by silicate and limestone rocks. Often these trees appear as co- or mono-dominant of gnarled, short, wind-formed scrubby forest on tops of ridges. Natural regeneration is occasionally frequent. There are no data available concerning cultivation.

Notes

This species is found as a shrub or as a small to medium size tree in the primary submontane and montane coniferous, wind-pruned, short forests on the top of ridges, preferably on rocky limestone and sandstone, sometimes forming dense thickets. Common associates observed in Laos are:

Amentotaxus argotaenia, *Calocedrus macrolepis*, *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Fokienia hodginsii*, *Keteleeria evelyniana*, *Pinus dalatensis* var. *anemophila* and *Podocarpus neriifolius*. In our assessment this plant was found as a common dominant species forming short height, wind-pruned thickets on flat summits of sandstone ridges adjacent to the Vietnamese border in Hin Namno protected area, Khammouan province (Fig. 3, Map 21; Fig. 14d–f). Forest fire may be a serious threat to the species. The trees may be used as ornamentals, particularly of bonsai style.

Conservation status

The wide distribution of this species supports the idea that it not be listed as highly threatened. It is globally assessed as ‘Least Concern’ (LC) (Thomas 2013f). It is rarely exploited for its timber and its habitat is not suitable for agriculture. However, the very small size of discovered populations and its very restricted habitat means that it is best considered as ‘Vulnerable’ (VU) in Laos under criteria A2c, B1ab(i–v), B2ab(i–v) because of habitat disturbance through the selective logging of the associated species and forest fires. Full protection of a single population discovered in the mountains of Hin Namno protected area in Khammouan province is desirable as a unique example of a diverse wind-pruned primary coniferous forest and as an important seed base for ornamental horticulture.

Taxaceae

Key to genera

- Leaves 1.5–3.5 cm long, 2–4 mm wide, stomatal bands less than 1 mm wide; male cones solitary or few together; seed-bearing structures shortly pedunculate or subsessile; aril cupular, enclosing only proximal part of seed *Taxus*
– Leaves 3.5–10.0 cm long, 8–15 mm wide, stomatal bands broader than 1 mm; male cones many, in spike-like catkins; seed-bearing structures long pedunculate; aril completely enclosing seed *Amentotaxus*

Amentotaxus Pilg.

Key to species

- Stomatal bands on abaxial leaf surface 1–2 mm wide, 0.6–1.5 as wide as the green marginal band *A. argotaenia*
– Stomatal bands on abaxial leaf surface 3–4 mm wide, twice as broad as the green marginal band *A. yunnanensis*

A. argotaenia (Hance) Pilg. (1916, p. 41)

Based on the same type: *Podocarpus argotaenia* Hance (1883, p. 357).

Described from south China (“Chine, Guangdong, Mt Lofoushan”). Type (“Faber s.n. Sept. 1882”) in BM.

Description

Tree to 20 m tall and 0.5 m dbh with broad, irregular crown. Leafy branchlets ascending or suberect, broadly rectangular, axis green in 1st year. Leaves shortly petiolate, dark green adaxially, lanceolate, falcate, acuminate, 5–10 cm long, 0.8–1.2 cm wide, leathery, stomatal bands white, 1–2 mm wide, narrower than marginal bands. Pollen cones terminal, clustering 2–5 together, 2–5 cm long with 8–14 subsessile ovoid strobiles 3 mm in diameter; microsporophylls 6–8, peltate, each with 2–4 pollen sacs. Seed-bearing structures axillary, pedunculate, solitary, ovoid. Aril juicy, brightly red, glaucous. Seeds ellipsoid, 1.2–1.6 cm long, 5–7 mm in diameter. Pollination March–April, seeds February–March (Fig. 14g–i, 15a–c).

General distribution

South China, Vietnam.

Distribution in Laos

Houaphan, Khammouan and Vientiane provinces (Fig. 3, Map 22).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007, Thomas et al. 2007). **Houaphan:** V. Lamxay HP 2 (E, NUL). New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Khammouan** Prov., Bounlapha Distr., Thong Sam village, Hin Namno protected area, Pu Pha Song Mt, 17°35′13.2″N, 105°47′49.8″E, 1200–1300 m a.s.l., 9 Mar 2013, L. Averyanov et al. LA-VN 275. **Vientiane** Prov., Kasi Distr., Thong Mout village, 19°26′51.5″N, 102°07′45.8″E, 1550–1650 m a.s.l., 20 Mar 2013, N. T. Hiep et al. LA-VN 614 (Fig. 15b), specimen with male strobiles. 20 Mar 2013, N. T. Hiep et al. LA-VN 615 (Fig. 14g–i, 15a), specimen with ripe female fructifications. 20 Mar 2013, N. T. Hiep et al. LA-VN 616 (Fig. 15c).

Ecology

Primary coniferous, mixed and broad-leaved, evergreen montane humid forests at elevations 1000–1700 m a.s.l. on silicate and limestone soils. Throughout its range, it usually occurs as scattered trees, and very rarely appears as co- and dominant of the forest. Occasionally abundant natural regeneration is observed. Seedlings and saplings are shade tolerant. There is some information available about cultivation of this species.

Notes

A rare species found scattered in primary submontane forests, usually on top of ridges composed of various kinds of rocks like limestone, sandstone, shale and granite. The tree rarely forms large populations or dense stands. It was found during our assessment in two new localities (Fig. 3, Map 22, Fig. 14g–i, 15a–c) as a locally common, co-dominant of coniferous forest on sandstone and rocky limestone accompanied by such rare coniferous associates as *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Keteleeria evelyniana*, *Podocarpus neriifolius*, *Podocarpus pilgeri* and *Taxus wallichiana*. It is remarkable, that in both discovered

locations abundant natural regeneration was observed (Fig. 14i). This species is very sensitive to degradation of its habitats and is negatively affected by the resulting decrease of air humidity. Deforestation, forest fragmentation and forest degradation are the main threats. Infrequent formation of seeds is an additional negative factor affecting normal natural plant regeneration. The tree may be used as an ornamental plant, with beautiful leaf patterning, and would grow well trained in the bonsai style.

Conservation status

Globally the species is presently assessed as 'Near Threatened' (NT) (Hilton-Taylor et al. 2013). In China and Vietnam it has been evaluated as 'Vulnerable' (VU) under criteria A2c (due to the extent of deforestation within its range), B1a (an estimated extent of occurrence under 5000 km² and populations severely fragmented from deforestation in areas between populations) and B1b(i–v) based on the likely ongoing effects of deforestation and habitat degradation (Nguyen et al. 2004). Due to high fragmentation, and the very small size and rarity of existing populations in Laos, it may be estimated in the country as 'Vulnerable' (VU) or 'Endangered' (EN) under the same criteria. Further field studies searching for additional locations are needed. Recently discovered populations are small and in need of strict protection. Propagation by seeds should be encouraged in order to provide planting materials for potential ex situ conservation and possible utilization programs.

A. yunnanensis H. L. Li (1952, p. 197)

Based on the same type: *A. argotaenia* (Hnce) Pilger var. *yunnanensis* (H. L. Li) P. C. Keng (1957, p. 2).

Described from south China ("Chine, Yunnan, Makwan, 1600 m"). Type ("H. T. Tsai 51887") in US (holotype), P (isotype).

Description

Tree to 30 m tall and 0.8 m dbh with broad, irregular ovoid crown. Leafy branchlets ascending, broadly oblong ovate, axis green in 1st year. Leaves subsessile, dark green abaxially, broadly lanceolate, straight or slightly falcate, obtuse to tapered, 3.5–10.0 cm long, 0.8–1.5 cm wide, leathery, stomatal bands brown or pale yellowish–white when dry, 3–4 mm wide, marginal bands 1.5–2.0 mm wide. Pollen cones clustering 4–6 together, 10–15 cm long. Seed-bearing structures axillary, pedunculate, ovoid. Aril juicy, reddish–purple, glaucous, 2.2–3.0 cm long, 1.4–1.5 cm in diameter. Seed ellipsoid, shortly beaked at apex. Pollination April, seeds October.

General distribution

South China, Vietnam.

Distribution in Laos

Houaphan.

Data for species distribution in Laos

Available literature data (Newman et al. 2007, Thomas et al. 2007). **Houaphan:** M. F. Newman LAO 1111, LAO 1116, LAO 1118 (E, FRCL, L, NUL, P).

Ecology

Primary coniferous, mixed and broad-leaved, evergreen montane humid forests at elevations (800)1000–1600 m a.s.l. preferably on soils of limestone karst formations, rarely on silicate derived soils. Throughout its range, it usually occurs as a scattered trees, and rarely appears as co-dominant of the forest. Occasionally fairly good natural regeneration is observed. Seedlings and saplings are shade tolerant and successfully growing up under a forest canopy. There is some information available about cultivation of this species as an ornamental tree in China and Vietnam (Fu et al. 1999, Nguyen et al. 2004).

Notes

A rare species which is found scattered in primary submontane forests, usually on and near the top of ridges composed of rocky limestone, granite or gneiss. The tree rarely forms large populations. Occasional coniferous associates in Vietnam are *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Fokienia hodginsii*, *Nageia wallichiana*, *Podocarpus neriifolius*, *Pseudotsuga sinensis*, *Taxus chinensis*, *Tsuga chinensis* and *Xanthocyparis vietnamensis* (Nguyen et al. 2004, Thomas et al. 2013b). The species is threatened mainly by deforestation, leading to forest fragmentation with declining subpopulation size. The timber is used locally in house building, furniture making and for agricultural implements. Infrequent formation of seeds is an additional negative factor affecting normal natural plant regeneration. The tree has attractive foliage and sometimes is cultivated as a beautiful ornamental tree trained in the bonsai style.

Conservation status

Globally the species is presently assessed as 'Vulnerable' (VU) A2acd (Thomas et al. 2013b). In China and Vietnam it has been evaluated nationally as 'Endangered' (EN) and 'Vulnerable' (VU) respectively mainly under criteria B1ab(i–v) based on the likely ongoing effects of deforestation and habitat degradation (Nguyen et al. 2004, Thomas et al. 2013b). Due to the meager data available on populations existing in Laos, the species' status should be estimated nationally as 'Data Deficient' (DD) due to deficit of current data. Further field studies searching for additional locations are needed. Propagation by seeds should be encouraged in order to provide planting materials for potential ex situ conservation.

Taxus L.

****T. wallichiana* Zucc. (1843, p. 803)**

Described from Nepal ("Nepal"). Type ("Wallich 6054 A") in BM (holotype), P (isotype).

Taxonomic synonyms: *Cephalotaxus sumatrana* Miq. (1858, p. 1076) – *Taxus yunnanensis* W. C. Cheng & L. K. Fu (1975, p. 86) – *T. sumatrana* (Miq.) de Laub. (1978, p. 151).

Description

Tree 30 m tall and 1.3 m dbh with broad irregular crown. Bark grayish brown to dull reddish, peeling off in strips or

cracking and falling off as thin scales. Leaves spreading in two ranks, shortly petiolate, lanceolate, usually falcate, mucronate, dark glossy green, paler abaxially, 1.5–3.5 cm long, 2–4 mm wide, stomatal bands pale yellowish, 0.6–0.9 mm wide, marginal bands 0.1–0.4 mm wide. Pollen strobiles axillary, scattered along branchlet axis, sessile, yellowish, ovoid, 3–5 mm long; microsporophylls 8–14, each with 5–6 pollen sacs. Seed-bearing structures axillary, ovoid. Aril fleshy, red. Seed ovoid, mucronate, brownish, 5–8 mm long, 3.5–5.0 mm wide. Pollination December–February, seeds September–November (Fig. 15d–e).

General distribution

Northern India, Bhutan, Nepal, Myanmar, south China, Thailand, Vietnam, Malesia, Philippines, Sumatra, Sulawesi.

Distribution in Laos

Vientiane province (Fig. 3, Map 23).

Data for species distribution in Laos

No previous data, new species for the flora. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Vientiane** Prov., Kasi Distr., Thong Mout village. 19°26'51.5"N, 102°07'45.8"E, 1550–1650 m a.s.l., 20 Mar 2013, N. T. Hiep et al. LA-VN 630 (Fig. 15d–e).

Ecology

Primary coniferous, mixed and broad-leaved, evergreen montane humid forests at elevations 1500–1700 m a.s.l. on limestone soils. Throughout its range, this species usually occurs as scattered trees. Natural regeneration is weak, yet seedlings and saplings are shade tolerant. Specific information regarding successful cultivation exists.

Notes

This rare tree is commonly found scattered or in small isolated groups in primary submontane forests preferably on soils formed from silicate rocks. In our assessment it was found as a common species with normal natural regeneration on limestone soil. This is rather unusual for this species in other parts of its range. A single population was discovered in Vientiane province (Kasi district) on rocky limestone at elevation 1600–1650 m a.s.l. (Fig. 3, Map 23; Fig. 15d–e), representing the first record of this rare species in Laos. Regular associates observed in its habitat were conifers such as *Amentotaxus argotaenia*, *Cephalotaxus mannii* and *Podocarpus neriifolius*. It is noticeable that this species is fairly rare within its entire range of distribution. It is included in Appendix II of CITES and is a nationally protected plant in a number of countries including Vietnam (Nguyen et al. 2004). Deforestation, forest fire and overexploitation as medicinal plant are main factors of the species threat throughout its native range.

Conservation status

Despite its widespread distribution, this species was recently listed as globally 'Endangered' (EN) under criteria A2acd (Thomas and Farjon 2011). Additionally, in countries where

it is native, it has been assessed as rare, vulnerable, endangered and even critically endangered. The last assessment in Vietnam recognized the species status for the country as 'EN' (Nguyen et al. 2004). A single population discovered in Laos faces a high level of threat, especially from ongoing deforestation and fire in the surrounding scrub and secondary degraded forests. This single population should be proposed as a nature reserve site for conifers as it includes *Amentotaxus argotaenia* and *Cephalotaxus mannii*. It is also a good site for ecological and seed studies of the species. Seed and vegetative propagation and cultivation in a plantation may be effective additional actions for species protection. National IUCN status for the species in Laos may be 'EN' or 'CR' due to the very small size of the only known population – A2acd, B1ab(i–v), B2ab(i–v), C1, C2(ai).

Taxodiaceae

Key to genera

1. Trees without pneumatophores, growing on well drained steep mountain slopes; stem to 50 m tall and 2.5 m dbh newer swollen at the base; leaves narrowly lanceolate, serrulate; mature seed cones 2–3 cm long; cone scales 3-seeded *Cunninghamia*
– Trees with pneumatophores, growing on stream valley swamps; stem to 20 m tall and 1 m dbh, swollen at the base; leaves scale-like or subulate, with entire margin; mature seed cones 1.0–1.5 cm long; cone scales 2-seeded *Glyptostrobus*

Cunninghamia R. Br.

C. konishii Hayata (1908, p. 194)

Described from Taiwan ("Taiwan, Nanto"). Type ("Konishi s.n.") in TI.

Taxonomic synonym: *C. konishii* subsp. *houaphanensis* A. D. Silba & J. A. de Silva (2013, p. 12).

Description

Tree to 50 m tall and 2.5 m dbh with pyramidal crown. Bark fissured, gray to red–brown. Branches spreading, apically pendulous. Leaves stiff, lanceolate, slightly falcate, apiculate, spreading in 2 ranks, glossy dark green, 1.5–3.5 cm long, with stomatal bands on both surfaces. Pollen cones terminal, (10)15–25 together, broadly ovoid. Seed cones terminal, solitary or 2–4 together, glossy green, later olive brown, ovoid to subglobose, 2.0–3.5 cm long; bracts coriaceous, broadly triangular-ovate, base clawed, pointed at apex. Seeds dark brown, narrowly ovate, 5–6 mm long, narrowly winged laterally. Timber dull brown, very fragrant. Pollination January–May, seeds August–November.

General distribution

Southeast China (Fujian), Taiwan, north Vietnam.

Distribution in Laos

Houaphan and Xiangkhoang provinces (Fig. 3, Map 24).

Data for species distribution in Laos

Available literature data (Nguyen and Vidal 1996, Newman et al. 2007): **Houaphan**: M. F. Newman LAO 1107, 1108 (E); E. Poilane 1875 (P). New current records from Laos–Vietnamese border (LE, Herbarium of the Center for Plant Conservation, Hanoi): northwest Vietnam, border area of **Houaphan** and **Thanh Hoa** Prov.: Thanh Hoa Prov., Thuong Xuan Distr., Bat Mot Municipality, Vin village, Xuan Lien Natural Reserve. 19°58′18.2″N, 104°59′24.0″E, 1000–1200 m a.s.l., 2 Nov 2013, L. Averyanov et al. CPC 6601. Northwest Vietnam, border area of **Xiangkhoang** and **Nghe An** Prov.: Nghe An Prov., Ky Son Distr., Na Ngoi Municipality, Phu Xai Lai Leng Mt 19°13′37.5″N, 104°06′11.8″E, 1900 m a.s.l., 20 Oct 2013, L. Averyanov et al. CPC 6017; 19°13′52.9″N, 104°05′30.5″E, 2100–2200 m a.s.l., 25 Oct 2013, L. Averyanov et al. CPC 6126; 19°11′58.2″N, 104°11′38.6″E, 2000–2300 m a.s.l., 1800–2200 m a.s.l., 24 Oct 2013, L. Averyanov et al. CPC 6154.

Ecology

Primary broad-leaved and coniferous, evergreen, humid montane forests at elevations 900–2200 m a.s.l. on shale or granite derived soils, regularly on very steep slopes. Usually associated with conifer species such as *Fokienia hodginsii*, *Amentotaxus argotaenia* and *Podocarpus neriifolius*.

Good natural species regeneration is observed along the Laos–Vietnamese border between Houaphan (Laos) and Thanh Hoa and Nghe An provinces (Vietnam) where seedlings were observed abundantly colonizing exposed clayey weathered soils on shady road cuts, anthropogenic soil slips and rock slides. Occasional cultivation of some trees was observed in local villages both in Vietnam and Laos, but these plantings have no regular character.

Notes

In the past this species undoubtedly occupied large areas that have been dramatically reduced to three small and restricted areas in Fujian, Taiwan and on the border of Laos and northern Vietnam. Primary mono-dominant climax stands of this tree still survive on Phu Xai Lai Leng mountains on the Laos–Vietnam border at elevations between 1800–2200 m a.s.l. This area undoubtedly supports the largest population of this species anywhere in the world. Regrettably it is presently highly threatened by the construction of the border road and timber harvesting. Extensive logging for high-quality timber is the primary threat to the species in Laos. This species has good promise for planting and reforestation as a fast growing tree with valuable fragrant timber.

Conservation status

Globally, this species was recently assessed (Thomas and Yang 2013a) as ‘Endangered’ (EN) A2cd; B2ab(ii,iii,v), that fits well with the national assessment for Lao PDR. Effective regulations of timber exploitation and limitation of trees felling in all known habitats, as well as the organization of local protected areas are necessary for species conservation. Protected mature stands of this species in Laos can serve as a globally important seed source for future species propagation and forest plantation.

Glyptostrobus Endl.

**G. pensilis* (Staunton ex D. Don) K. Koch (1871, p. 191)

Based on the same type: *Thuja pensilis* Staunton ex D. Don (1824, p. 125, 129).

Described from southeast China (“Province of Guangdong”). Type (“G .L. Staunton s.n.”) in BM.

Description

Tree to 20 m tall, trunk distinctly enlarged to the ground, to 1 m dbh. Crown irregularly conical. Pneumatophores grow from lateral roots, and spread to 5–6 m. Bark thick, greyish–brown, longitudinally fissured. Shoots of two kinds, long and short. Leaves on the long shoots overlapping and scale-like; leaves on the short shoots needle-like, enlarged at the base, quadrangular in cross section, 8–12 mm long, on one-year shoots 2-ranked. Pollen strobiles terminal on short shoots. Seed cones terminal on lateral shoots, ovate, 12–18 mm long, stalked. Seeds ovate, 5–6 mm long, terminated by small wing 3 mm long. Pollination January–March, seeds September–November, cones persisting until following spring (Fig. 15f–i).

General distribution

South China (extinct), south Vietnam (almost extinct).

Distribution in Laos

Borikhamxai and Khammouan provinces (Fig. 3, Map 25).

Data for species distribution in Laos

Available literature data (Averyanov et al. 2009): **Borikhamxai**. New current records (LE, NUOL, NHOL, Herbarium of the Center for Plant Conservation, Hanoi): **Borikhamxai** Prov., Khamkeut Distr., Phone Sa At Village. 18°01′48″N, 105°02′30″E, 615 m a.s.l., 17 Jan 2009, S. Bounphanmy et al. LA-VN 1 (Fig. 15g–i). **Borikhamxai** Prov., Khamkeut Distr., Phone Sa At village. 18°02′09″N, 105°02′31″E, 618 m a.s.l., 18 Jan 2009, S. Bounphanmy et al. LA-VN 40 (Fig. 15f).

Ecology

Primary mixed and coniferous forest on basalts, along stream or river valleys at elevation 600–700 m a.s.l. in permanently inundated swampy forest, usually in pure stands. No natural regeneration was observed. There are no data available on successful cultivation of this species in Indochina.

Notes

This species is a relictual tree that has been recently extirpated within the largest part of its known native range. In the recent past this conifer formed mono-dominant and mixed primary coniferous swamp forests in many localities of southern China and southern Vietnam (Nguyen et al. 2004). No other conifers are indigenous to such habitats. Usual angiosperm evergreen and deciduous woody associates in Vietnam include *Dillenia ovata*, *D. pentagyna*, *Litsea longipes*, *Michelia mollis*, *Pterocymbium tinctorium*, *Rhaphiolepis indica*, *Sterculia pierrei*, *Syzygium chanlos*,

S. syzygoides, *S. tinctorium*, *S. tramnion* and species of *Elaeocarpus* and *Ficus* (Averyanov et al. 2009). Deforestation, logging for valuable timber, forest fire, conversion of lands for agriculture and changing of ground-water level in native habitats are main factors leading to rapid species extinction from these areas. Most records from southeast China refer now to cultivated trees because no more native populations remain (Liguo et al. 1999a). In Vietnam the species is confined to few very small natural populations surrounded by coffee plantations. These populations are severely declining and face fatal threats from fires and habitat changes due to decreasing ground-water level that give them little chance to survive (Averyanov et al. 2009). Several small stands of *Glyptostrobus* were observed during our assessment in Borikhamxai province (Fig. 3, Map 25, Fig. 15e–i) in similar conditions as were found in Vietnamese populations. There are also additional records about its occurrence in Khammouan province (Vichith Lamxay, pers. comm.) verified by herbarium collections deposited at L, E and NUOL. Land conversion for agricultural purposes, felling for timber and modification of landscape hydrology are the main factors explaining the rapid loss of the species in all habitats discovered in Laos. No regeneration and no seed germination were ever observed in Laotian and Vietnamese populations.

Conservation status

Presently its global species status, as well as natural status in Vietnam is assessed as ‘Critically Endangered’ (CR) under categories A2c, B1ab(i-v), B2ab(i-v), C1, C2a(i) (Nguyen et al. 2004, Thomas et al. 2011). A very similar situation is seen in Laos. The very few observed populations should be regarded as severely fragmented and experiencing a continuing decline in the area, both in extent and quality of habitat. According to preliminary studies, the overall Laotian population of the species contains less than 250 mature individuals and should certainly be assessed as ‘CR’. Some remaining swamps with *G. pensilis* are surrounded by logging areas and plantations that are changing the swamp hydrology inevitably leading to the loss of this species at these sites. Effective species conservation needs the establishment of special protected areas comprising all discovered populations with strong control and monitoring of habitat quality. It should be emphasized that the *Glyptostrobus* coniferous swamp community represents unique relictual tertiary assemblages that no longer occur anywhere else. This habitat and this species are national heritage treasures having global biodiversity significance. Any form of ex situ conservation may be very important. Meanwhile, seed collections have been made in Vietnam repeatedly but no germination has been recorded. Attempts to vegetatively propagate Vietnamese plants have also been unsuccessful (Nguyen et al. 2004). Indochinese plants strikingly differ from plants planted widely in southern China over a long period of time. Additional studies of the reproductive biology and possible ways of propagation are necessary for successive conservation of this species in Laos.

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