

Zeitschrift: Candollea : journal international de botanique systématique = international journal of systematic botany
Herausgeber: Conservatoire et Jardin botaniques de la Ville de Genève
Band: 54 (1999)
Heft: 1

Artikel: Study of Pinus dalatensis Ferré and of the enigmatic "Pin du Moyen Annam"
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DOI: <https://doi.org/10.5169/seals-879383>

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Study of *Pinus dalatensis* Ferré and of the enigmatic “Pin du Moyen Annam”

ROMAN BUSINSKÝ

ABSTRACT

BUSINSKÝ, R. (1999). Study of *Pinus dalatensis* Ferré and of the enigmatic “Pin du Moyen Annam”. *Candollea* 54: 125-143. In English, English and French abstracts.

Pinus dalatensis Ferré, an imperfectly known species from the viewpoint of taxonomy and distribution, was studied in detail in the field. Ample herbarium collections were gathered and examined. Two new infraspecific taxa, *Pinus dalatensis* var. *bidouensis* Businský, and *Pinus dalatensis* subsp. *procera* Businský are recognized. Their ecology and known or presumed distribution are evaluated. *Pinus dalatensis* locally dominates the tree layer of primary forests in some high mountain massifs in C and S Vietnam. The rather confusing taxonomic history of the first finding of a *Pinus* species of the sect. *Quinquefoliae* in Indo-China is presented. The pine discovered in 1918 and later referred to as a “Pin du Moyen Annam” has appeared under five specific names. The enigmatic “Pin du Moyen Annam” is in fact identical with *Pinus dalatensis* subsp. *procera* Businský.

RÉSUMÉ

BUSINSKÝ, R. (1999). Etude du *Pinus dalatensis* Ferré et de l'énigmatique “Pin du Moyen Annam”. *Candollea* 54: 125-143. En anglais, résumés anglais et français.

Pinus dalatensis Ferré, dont la taxonomie et la distribution sont mal connues, a été étudié en détail sur le terrain. De nombreux échantillons ont été récoltés et analysés. Deux nouveaux taxons infraspécifiques, *Pinus dalatensis* var. *bidouensis* Businský et *Pinus dalatensis* subsp. *procera* Businský, sont décrits. Leur aire de répartition connue ou supposée, ainsi que leur écologie, sont présentées. *Pinus dalatensis* est un dominant de la forêt primaire dans quelques massifs de montagnes du Moyen et Sud Viet-Nam. L'histoire confuse de la découverte de la première espèce du genre *Pinus* de la section *Quinquefoliae* en Indochine est présentée. Ce Pin fut découvert en 1918 et est connu sous le nom “Pin du Moyen Annam”. Il a reçu cinq noms d'espèce différents. En réalité, cet énigmatique “Pin du Moyen Annam” est identique au *Pinus dalatensis* subsp. *procera* Businský.

KEY-WORDS: *Pinus dalatensis* – Taxonomy – Distribution – Ecology – Vietnam.

Introduction

A Vietnamese *Haploxyylon* pine [*Pinus* subgen. *Strobus* (Sweet ex Spach) Lemmon] of the section *Quinquefoliae* Duhamel, described under the name *Pinus dalatensis* Ferré in 1960, repre-

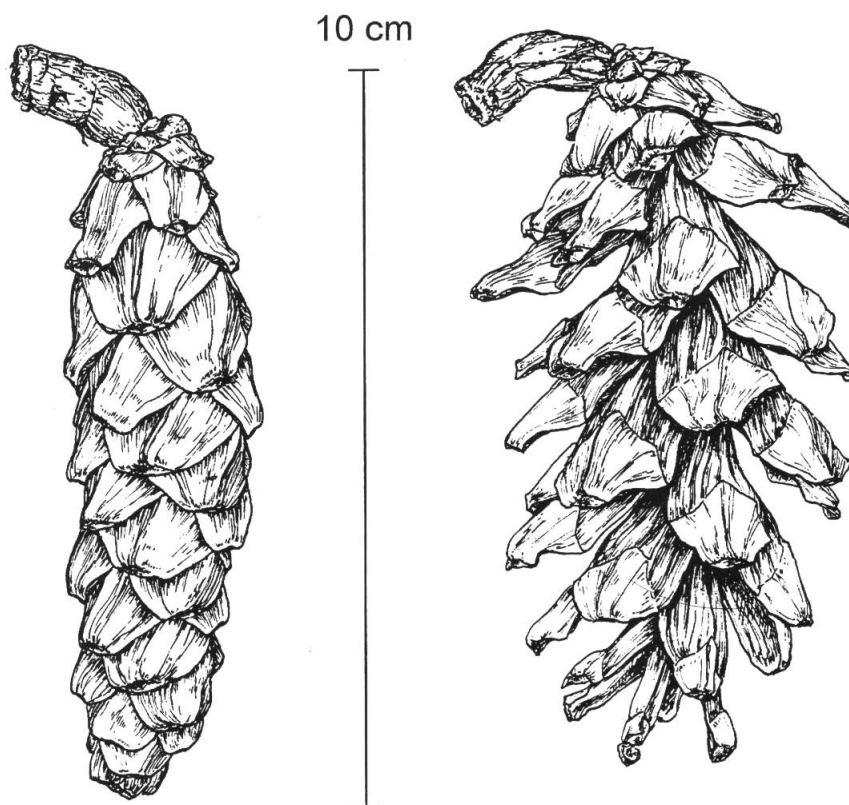


Fig. 1. – Cones of *Pinus dalatensis* Ferré var. *dalatensis* from the type locality near Trai Mat (both cones come from the specimen R. Businský 24108). Del. L. Businská.

sents one of the rarest and the least thoroughly sampled and investigated species of the Eurasian pines. The present author studied, together with his wife, Ludmila Businská, natural populations of this pine at three of six localities known at present, during three expeditions to Vietnam in 1986, 1994 and 1997. Furthermore, selected herbarium specimens and literature data were examined, elucidating the problem of *Pinus dalatensis* and another taxon of the sect. *Quinquefoliae*. The latter was discovered in the former C Annam in 1918 at a locality of a hitherto unknown identity. At that time, it was the first dated finding of a *Haploxylon* pine in Indo-China. The only, and rather unsatisfactory specimen of it was re-evaluated by Ferré in 1960, and tentatively classified as different from *P. dalatensis* under the name “Pin du Moyen Annam”. In what follows, a summary of herbarium and literature data is given, together with results of the new investigation of the above two taxa. In particular, a close intraspecific relatedness between them is documented, and descriptions of two new infraspecific taxa are presented.

Taxonomy

Pinus dalatensis Ferré in Bull. Soc. Hist. Nat. Toulouse 95: 178, fig. 3. 1960.

≡ *Pinus wallichiana* var. *dalatensis* (Ferré) Silba in Phytologia Mem. 7: 59. 1984.

Type: Vietnam: Trai-Mat, 6 km. de Dalat, décembre 1957, *H. Gaussen s.n.* (Holo-: TLF).

The species was described on the basis of rather scanty herbarium material, altogether six fragmentary specimens from two localities in a single mountain system in S Vietnam, in the vicinity of the town Dalat and on the Chu Yang Sinh massif (2442 m / 2405 m) about 50 km SE of

the town Buon Ma Thuot. The type specimen of the name *P. dalatensis* comes from an easily accessible site near the road seven km east of the centre of Dalat in the vicinity of the village Trai Mat. Even at the time of the discovery of this isolated locality, the population consisted of few trees (SCHMID, 1961) growing under rather marginal conditions – at an altitude of about 1470 m (the lowest locality of the species), and at a site changed by human activities. The population, therefore, cannot be considered as typical from the point of view of the species' variation and character development. Moreover, the locality represents the southern limit of the species' geographical range and, at the same time, the southernmost known natural occurrence of a *Haploxylon* pine in the world (11°56'N). *Pinus dalatensis* has been reported (HIỆP & VIDAL, 1996) to occur at the above two sites and at another locality in the range of Ngoc Linh (2598 m) in C Vietnam. Already in 1994, however, a new station of this species was revealed in the mountain region of Bi Doup (2287 m), about 30 km ENE of Dalat.

The type locality near Trai Mat was visited by us in 1986. We gathered a number of samples from the most vigorous tree in the population consisting of four trees only. The tree (sampled under No. 24108), having a well developed crown, perfectly matched the character states and quantitative ranges of those given in the original description of *P. dalatensis*. It is even possible that we collected our material from the very tree used as a source of the type specimen. Later on we had an opportunity to study a population of *P. dalatensis* in the mountain region of Bi Doup a few weeks after its discovery. The population, also limited to a low number of individuals (no more than 30 mature trees), is confined to a very small area but forms a part of a very natural primary mountain woodland at an altitude of almost 1900 m. It consists of well developed representative trees of varied age. In spite of the spatial concentration of the population, the trees exhibit an unexpectedly wide range of character variation. Although a few trees correspond in most characters to the original description of *P. dalatensis* (only a single very old tree, sampled under No. 39161, matched the quantitative values found in the type, with the exception of the general habit and size of the tree), the majority of individuals were found to deviate conspicuously from the typical morphology of *P. dalatensis*. I consider it as appropriate to evaluate these aberrant trees of the population from the Bi Doup region as a new infraspecific taxon at the rank of variety:

***Pinus dalatensis* var. *bidoupensis* Businský, var. nova (Fig. 2).**

Type: Vietnam: Lam Dong and Thuan Hai Prov. border NE of Dalat, Bi Doup (2287 m) mt. region, W slopes of massif 2010 m sit. 6 km SE of Bi Doup, a flat ridge approx. 1 km WNW of elev. point 1978 m; dense mixed forest together with *Pinus krempfii* & *Fokienia hodginsii*; 1895 m a.s.l.; 12°02'30"N & 108°41'55"E; tree: 230 cm trunk circumfer., 25 m h., 18 m crown diam., old; 17.2.1994, R. Businský 39160 (Holo-: G; iso-: HN, K; duplicates of cones in the herbarium of the author).

A varietate typica notis sequentibus perspicue differt: ramuli novelli ab initio glaberrimi et saepe expresse pruinosi, deinde nitide brunnei; folia in lateribus ventralibus stomatum seriebus (3-)4-6(-8) praedita; strobili (10-)12-17 cm longi, squamis (50-)60-95 compositi, squamae maximae 33-42(-45) mm longae et (19-)22-27(-29) mm latae, apophyses relative validae et firmae, plerumque nitide brunneae non pruinosae, squamae basales steriles plerumque recurvatae; semina alis inclusis (21-)25-37 mm longa.

The new variety differs from the typical *P. dalatensis* by the following characters: first-year shoots from the very beginning of growth totally glabrous and often conspicuously pruinose, later glossy pale brown; leaves with (3-)4-6(-8) stomatal lines on ventral sides; cones (10-)12-17 cm long, with (50-)60-95 scales, the largest of them 33-42(-45) mm long and (19-)22-27(-29) mm wide; apophyses relatively thick and firm, in freshly mature cones usually glossy brown, not pruinose; the basal sterile scales around the peduncle insertion usually recurved or at least deflected; seeds together with wings (21-)25-37 mm long.

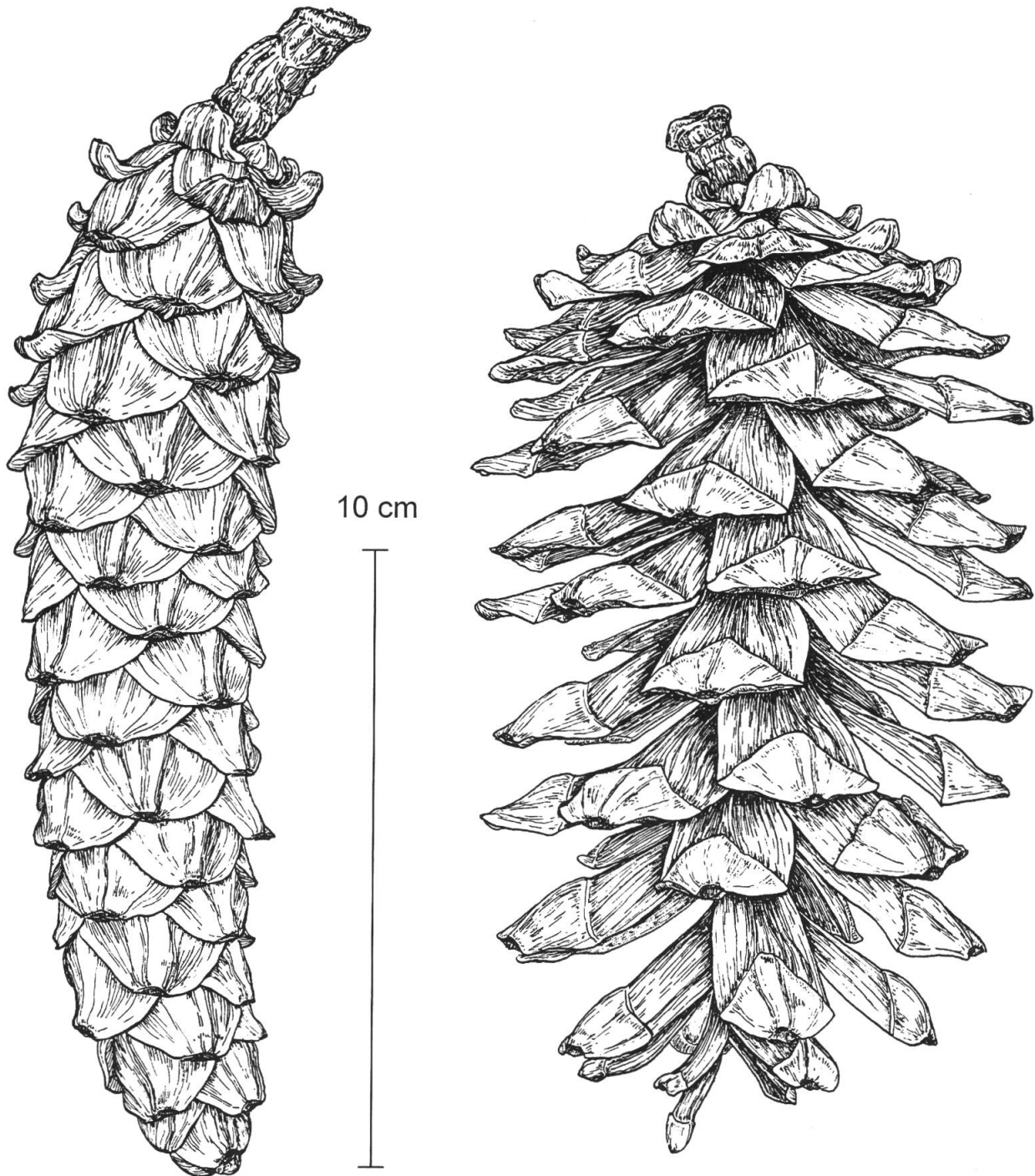


Fig. 2. – Cones of the type specimen tree of *Pinus dalatensis* var. *bidouensis* Businský Del. L. Businská.

The author examined herbarium material coming from the locality in the Chu Yang Sinh massif. Older material at Paris (P) cited below consist of two herbarium specimens, both included in the protologue of *P. dalatensis* as paratypes. One of these, *Poilane* 32581, a representative sample from 1941, with totally glabrous and pruinose young shoots, belongs to the new var. *bidoupensis* (the specimen was incorrectly determined as *Pinus kwangtungensis* Chun ex Tsiang by Chinese specialists L. K. Fu & N. Li in 1995). The other specimen, *Deschamps* (unnumbered, without date), represents a fragment of a sterile branch with male strobili, and cannot be assigned to the new variety because young branchlets of the specimen are distinctly pubescent. Moreover, in early February, 1994, in the Institute of Tropical Biology, Ho Chi Minh City, we studied a few fresh gatherings of *P. dalatensis* and many photographs, reportedly from a rich locality in the top area of the Chu Yang Sinh massif. The samples consisted of fragments of branchlets and cones of lower quality but were sufficient to document a considerable variation in the local population and often higher quantitative values of features than those reported for this species up to now. Some of these samples would probably be referable to the new variety (however, as it happened, this new infraspecific taxon within *P. dalatensis* was recognized in the field a few days later).

The protologue of *Pinus dalatensis* (FERRÉ, 1960) includes three specimens from the Chu Yang Sinh massif but the original description seems to have been compiled exclusively on the basis of the not very representative material from the type locality near Trai Mat (with the exception of male strobili and pollen from the Chu Yang Sinh samples). Most of the quantitative values and their ranges given in the protologue and in a simultaneously published description in the Toulouse monograph of pines (GAUSSEN, 1960) are lower than the normal variation ranges found in the larger population in Chu Yang Sinh. Some qualitative features were omitted from the above two descriptions, primarily due to insufficient material available at that time, some others were overlooked (e.g., the glabrous and conspicuously pruinose young shoots in the specimen *Poilane* 32581). That is why FERRÉ (1960: 177) says, in an introduction to a detailed description, that “d’un échantillon à l’autre les différences sont minimales; la description suivante s’applique à tous”. In consequence, *P. dalatensis* was considered as a morphologically homogeneous species with a limited variation until 1994.

History and identification of Ferré’s “Pin du Moyen Annam”

FERRÉ (1960) published *Pinus dalatensis* simultaneously with an incomplete description of another *Haploxylon* pine under a provisional name “Pin du Moyen Annam”. The description is based on a single fragment of a first year branchlet collected in central Annam in 1918, later numbered as *Chevalier* 38353. This pine was first mentioned in the literature by M. H. Guibier in his paper “Caractères généraux de la forêt Indochinoise” (appendix in LECOMTE, 1926: 269): “On retrouve les Pins dans les environs de Hué et, sur les hautes altitudes, vers le plateau de l’At’ouat, en allant vers le Laos (...), le Pin à cinq feuilles, Pin de l’Himalaya, fait une apparition.”. The original gathering from 1918 also included a cone (CHEVALIER, 1944: 24). The cone led Guibier to the above determination, which was originally accepted by Chevalier. In 1918, when he received a sample from Guibier, he designated it as “le Pin bleu de l’Himalaya” the correct name of which is *Pinus wallichiana* A. B. Jackson. Subsequently, the cone was removed or lost, and Chevalier changed his opinion and concluded that “le Pin à cinq feuilles de l’Annam devait être rattaché à l’espèce suivante de Chine: *Pinus armandii* Franchet” (CHEVALIER, 1944: 24). Subsequently, Ferré studied the branchlet fragment in question, and suggested (FERRÉ, 1960: 177) that “Pin du Moyen Annam” is “un représentant du groupe de *Pinus parviflora* [S. & Z.] sur la péninsule indochinoise n’est pas douteuse”, and more precisely: “n’était le ramule pubescent, on serait tenté de le classer dans l’espèce *P. Fenzeliana* [Handel-Mazzetti], géographiquement la plus proche”. Ferré understood “*P. Fenzeliana*” as a taxon from Hainan island and classified it as a member of the *P. parviflora* group, “peut-être” identical with *P. kwangtungensis* Chun ex Tsiang. The Hainan taxon is classified under the latter name in the *Flora Reip. Pop. Sinicae* (CHENG & FU, 1978).

FERRÉ (1960), however, was correct to refrain from a precise identification of the specimen *Chevalier 38353* because only a branchlet fragment was available: “de toutes façons, en l’absence de cônes, une détermination précise est impossible”. CRITCHFIELD & LITTLE (1966: p. 8, map 14) included “Pin du Moyen Annam” in *P. fenzeliana* Handel-Mazzetti on the basis of an inaccurate interpretation of Ferré’s work: “a white pine of central Vietnam which de Ferré [reference] has tentatively classified as *P. fenzeliana* on the basis of a vegetative specimen”. (The name *P. fenzeliana* was incorrectly used by CRITCHFIELD & LITTLE (1966) for the taxon currently classified as *P. kwangtungensis* – cf. LI, FU & MILL, ms.). MIROV (1967: 297, 545) summarized, with minor mistakes, the principal data dealing with the “Pin du Moyen Annam”, and considered it as a “yet undescribed pine” with a recommendation that “at the first opportunity, more complete specimens of this pine should be collected and studied”.

N. T. Hiệp, a Vietnamese botanist of Hanoi, determined the specimen *Chevalier 38353* as *P. dalatensis* at the end of 1991, and listed it under this name in his manuscript of a prepared volume 28 of the new “Flore du Cambodge, du Laos et du Vietnam” covering gymnosperms (see HIỆP & VIDAL, 1996). A draft version of the text dealing with *P. dalatensis* was put at our disposal by J. E. Vidal in September 1993 (originally, the book was scheduled to appear in 1994). In September 1995, the specimen *Chevalier 38353* was revised by Chinese specialists L. K. Fu and N. Li and wrongly determined as *P. wangii* Hu & Cheng. The actual appearance of Vol. 28 was postponed to include some changes. Unfortunately, the latest interpretation of the *Haploxyton* pine from C Annam was also among accepted changes. Under the name *P. dalatensis* a record referring to *Chevalier 38353*, province of Binh Tri Thiên, was retained by mistake on p. 41.

The specimen *Chevalier 38353* (P) has been available on loan to the author since November 1996. The examination led to an unequivocal conclusion that it could not be assigned to *P. wangii* (populations of the latter species were sampled and investigated a few months earlier in SE Yunnan, not far from the extinct type locality). Likewise, it was possible to exclude the conspecific status of *Chevalier 38353* with other taxa considered by other authors, i.e., *P. wallichiana*, *P. armandii* and *P. kwangtungensis*. Among the Asian five-leaved *Haploxyton* pines, the specimen *Chevalier 38353* is morphologically most similar to the Taiwanese *P. morrisonicola* Hayata but the pubescence of the shoot is more conspicuous. My tentative conclusion after examination of the specimen was that it represented, in all likelihood, a new, hitherto undescribed species whose taxonomic position cannot be judged without the knowledge of cones and seeds. Thus, it was inevitable to re-find the taxon in nature.

In addition to the above controversies and problems with the identification of the *Haploxyton* pine from C Annam, there is another difficulty: the exact location of the original gathering from 1918. The oldest herbarium label on the sheet with *Chevalier 38353* bears merely a brief hand-written, easily legible text: “Annam: Thua Luu: Forêt de Duông”. The above account of the history of the sample shows that the text was written afterwards, probably by Chevalier, and may represent an erroneous interpretation of the original locality data. Anyway, Chevalier, in his study of the Indo-Chinese conifers (CHEVALIER, 1944: 25) written long after his examination of the sample, did not cite the specimen, in spite of the fact that specimens of other conifers were cited by him. He mentioned the specimen in question in an indirect way: “M. H. Guibier, chef du Service forestier de l’Annam, me fit parvenir un petit rameau ainsi qu’un cône d’un Pin à cinq feuilles qu’un de ses collaborateurs avait observé dans la forêt couvrant un massif montagneux du Centre Annam” in an introduction to the chapter “Série des Pins à cinq feuilles (*Pinus excelsa* Wall.)”. The gathering was identified as *P. armandii* in the same chapter, with the following note about the distribution in Indo-China: “Moyen Annam: Massif du Pou Atouat, entre Hué et les Bolovens (de Faifo à Attopeu), vers 1500 m. d’alt. et par 15°30 de lat. N (Service forestier d’Annam, en 1918)”.

FERRÉ (1960: 176) quoted Chevalier’s label of the specimen of “Pin du Moyen Annam”, and read the locality as “Thua Luu”. (In fact, the reading of capital letters in the name Thua Luu is not quite certain, and we must rely on Ferré’s knowledge of the Chevalier’s handwriting). CRITCHFIELD & LITTLE (1966: map 14) mapped an isolated occurrence referring to “Pin du Moyen Annam” to the vicinity of the border between Vietnam and Laos, approximately at 16°

N. Most recently, HIỆP & VIDAL (1996: 40) interpreted the locality of the sample *Chevalier* 38353 as: “Binh Tri Thiên : Thua Luu, forêt de Duông”, and both authors (*pers. comm.* 1993 & 1994) located it in the mountains above the former railway station Thua Luu (16°16'N & 108°00'E; Binh Tri Thiên Province), near the coast between Hué and Da Nang.

The present author made every effort to identify the locality of the original gathering of “Pin du Moyen Annam” from 1918. Historical maps of the relevant areas, obtained from Institut Géographique National, Paris, were studied in detail. The name “Duông” is a local name of a wood, and represents a general Vietnamese term for a way, path, road or route. The name “Thua Luu” or “Thua Lun” was not located in the area of the Pou Atouat massif, nor in the region towards the coast, except for the above railway station. The latitude given by CHEVALIER (1944: 25) “par 15°30 de lat. N” seems to be a mistake in the light of the above facts; it corresponds to the central part of Quang Nam-Da Nang Province, not to the Pou Atouat massif. The massif can most often be found on older maps in the area around 16°N and 107°20'-30'E (it is reported by different authors to culminate in different elevation points between 2000 and 2500 m). The former position of the Thua Luu railway station was at the northern foot of the range with the highest mountain called Khe La Vong (1528 m), its summit being about nine km from the station. The range represents the easternmost extremity of the mountain system reaching about 2000 m along the Vietnamese-Laotian border in the mountain region formerly called Pou Atouat. The border between the provinces Binh Tri Thiên (its southern part Thua Thiên Hué) and the neighbouring province Quang Nam-Da Nang proceeds along the 16th parallel from the Laos border, then turns to the northeast and follows the main ridge of the Khe La Vong massif.

In January 1997, we undertook an expedition to the Khe La Vong Mts., the region of the most probable localization of the original gathering of “Pin du Moyen Annam”, based on the results of our search and on the expert opinion of N. T. Hiệp. As a result of our nine-day effort to find the enigmatic pine in that relatively small but not easily explorable mountain range we found that no pines existed there even at the beginning of this century. The range is densely covered with primary forest stands, almost intact from an altitude of 600-800 m (above 1000 m there are only sparse paths of local hunters; rare and selective felling of broad-leaved trees was observed in middle altitudes of the range). The proper Khe La Vong is a steep rocky massif with five summits (the highest at 16°11'37"N & 107°58'10"E; GPS) which, together with the main and side ridges, represent habitats suitable for pines. However, no pine was found there; the only conifers encountered were two members of the *Podocarpaceae* around the main ridge, *Dacrydium elatum* (Roxb.) Wall. ex Hook. and *Podocarpus neriifolius* D. Don. The same situation was observed on other highest summits and ridges lower by about 100 m and more. (A neighbouring massif, Bach Ma, 1448 m, about 10 km to the west in the same range, has been thoroughly explored because it is located just near an old French summer resort, easily accessible on a road.)

Further attempts to locate the original site of “Pin du Moyen Annam” may be based on additional specimens labelled by Chevalier (in P) from the same locality “Thua Luu, (Duông)” with numbers close to that of the pine in question. They evidently were collected during the same revealing expedition in 1918. It should be noted that the above two species of *Podocarpaceae*, *D. elatum* (*Chevalier* 38358, 38360, 38361) and *P. neriifolius* (*Chevalier* 38359) are among them (cf. HIỆP & VIDAL, 1996). Nevertheless, for the time being, we have to conclude that the identification of the original site of “Pin du Moyen Annam” with the range above the Thua Luu station is not correct.

The current state of knowledge (see also below) allows to suggest that the most probable position of the locality in question may be in the highest massif situated between the town Hué and the border mountain region Pou Atouat, called Dong Ngai (1774 m; 16°21'N & 107°14'E), relatively easily accessible from Hué as early as at the beginning of this century (40 km distant in a straight line). Moreover, the massif most accurately corresponds to the oldest report by Guibier (in LECOMTE, 1926: 269). The mountain group Pou Atouat proper, culminating in a mountain with the elevation point 2066 m on the Laotian side (16°07'N & 107°12'E), more than 50 km SW of Hué, was hardly reachable in the 1910's. Nevertheless, if the pine in question grows

on the Dong Ngai massif, its occurrence is very likely also in this extensive mountain group with massifs higher than 1500 m (and suitable habitats for this pine) extending in a territory 15 km long and 10 km wide, mainly in Laos.

Further material of a *Haploxylon* pine of the section *Quinquefoliae* in the central part of Vietnam, the first after 1918, was collected as late as February 1977 by Vietnamese botanists V. V. Can and N. N. Chinh. It was found in a mountain region called Ngoc Linh (2598 m) situated about 80 km N of the town Kon Tum, representing the highest mountain range in Indo-China south of 18° N. Another sample from the same site was gathered in March 1978; and the samples were identified later as *Pinus dalatensis*. The finding was first published in Vietnam (LOC, 1984), and later in the new "Flore du Cambodge, du Laos et du Vietnam" (HIÊP & VIDAL, 1996). The locality is described as "Gia Lai – Kon Tum, Dac Gley (Dak Lay), (Massif du) Ngoc Linh". The first collection from 1977 was not seen by us (it is preserved at the Forest Institute in Hanoi), the later collection from 1978, deposited in another Hanoi herbarium (HN), is composed of a few branchlet samples, without any fully developed cone. Especially one of the specimens (*Phuong 381*) strikingly resembles the specimen *Chevalier 38353* from 1918. The distance between the two localities (in accordance with the above assumptions) is about 150 km (while that from the site in the Ngoc Linh region to the nearest station of *P. dalatensis* in the Chu Yang Sinh massif is almost 300 km).

The mountain region of Ngoc Linh was visited by us in January 1997. We started from the village agglomeration called Dak Glei (Dac Gley) or Dak Pek situated along the only road reaching the northernmost corner of the Gia Lai – Kon Tum Province. The uninhabited mountain region is reasonably easily accessible from the Dak Glei region only. About 10 km ESE of Dak Glei (i.e., about 15 km W of the main summit of Ngoc Linh), there is a massif Ngok Niay (2259 m; 15°02'27"N & 107°50'02"E, GPS) where, on its side ridges, at altitudes from 1700 m to the summit, the occurrence of numerous groups of trees and isolated individuals of a pine very close to *Pinus dalatensis* was ascertained. During eight days of a detailed exploration of the Ngok Niay population, we collected specimens from more than 30 trees in seven microlocalities within the entire altitudinal range of the local distribution. Samples designed for biometric analyses, higher numbers of branchlets and cones, were collected after climbing up to the crowns of ten selected trees (marked with asterisk in the list of specimens). The selected trees varied in age, from young individuals a few dozen years old (at the beginning of fruiting age and with a trunk girth from 30 cm) to very old trees of probable age exceeding 1000 years (with a trunk girth up to 740 cm, and width of the crown up to about 30 m). Additional specimens, preferably cones, were gathered from the ground surface in order to complete the picture of the overall variation in the population. Altogether, more than 180 cones and more than 80 branchlet samples were collected. A detailed study of all the specimens available, and their direct comparison with the specimen *Chevalier 38353* revealed that, beyond any doubt, the "Pin du Moyen Annam" and the pine from the Ngok Niay massif are identical taxonomically. Conspicuous similarity of *Chevalier 38353* with some of our specimens allows to infer that the branchlet on the herbarium sheet *Chevalier 38353* comes from a young tree. The cone collected at that time (and lost later) was perhaps found under the trees and, presumably, came from an older tree. Thus, it might very easily have been misidentified as a cone of *P. wallichiana* because cones of some trees from Ngok Niay are very similar to cones of the mentioned Himalayan pine.

After a detailed exploration of the Ngok Niay population and a study of the specimens from there, and after their thorough comparison with specimens of the typical *Pinus dalatensis* from the Trai Mat site and with the material from the mountain region Bi Doup and the Chu Yang Sinh massif, I arrived at the conclusion that the population at Ngok Niay in the Ngoc Linh region and the specimen *Chevalier 38353* from 1918 belong to *P. dalatensis* but represent a distinct new infraspecific taxon which is classified at the rank of subspecies.

Pinus dalatensis subsp. *procera* Businský, **subsp. nova** (Fig. 3).

Type: Vietnam: Gia Lai – Kon Tum Prov. (N corner), Ngoc Linh (2598 m) mt. region, Dak Glei (Dak Pek), Mt. Ngok Niay (2259 m) – NW ridge; in mixed forest on a ridge of N-S bearings; 1920 m a.s.l.; 15°02'44"N & 107°49'31"E (GPS); tree: 340 cm trunk circumfer., 24 m h., 25 m crown diam., old; 27.1.1997, R. Businský 44114 (Holo-: G, iso-: HN, K, MO, P & PR; duplicates of cones in the herbarium of the author).

A subspecies typica notis sequentibus perspicue differt: ramuli novelli plerumque dense longe pubescentes et pruinosi; folia (40-)55-110(-140) mm longa et (0.7-)0.8-1.1(-1.25) mm lata, in lateribus ventralibus stomatum seriebus (3-)4-6(-8) praedita; *strobili* plerumque cylindrici, cum proportione longitudinis ad latitudinem 3.5-6, saepe parum arcuate curvati, (9-)13-20(-23) cm longi, aperti 6-9 cm lati, squamis (55-)70-120 compositi, squamae maximae (30-)34-44(-48) mm longae et (18-)19-26(-31) mm latae, cum proportione mediocri longitudinis ad latitudinem 1.79, squamae basales steriles plerumque appressae aut deflexae; *semina* alis inclusis (22-)25-35(-39) mm longa.

Trees attaining a height of 30 or 40 m, with conspicuously spreading and relatively sparsely branched crown up to about 30 m wide when old, with trunk to about 2.5 m in diameter. First-year **shoots** mostly densely long pubescent (in some individuals with a short or uneven pubescence denser below the short-shoots insertion), initially often conspicuously pruinose. **Leaves** (40-)55-110(-140) mm long (83 mm on average) and (0.7-)0.8-1.1(-1.25) mm wide (0.91 mm on average), sparsely (often irregularly) acutely serrate on edges except for the entire basal part or up to 1/5 (rarely up to 1/3) of the leaf length, with (3-)4-6(-8) stomatal lines on ventral sides; resin-ducts mostly two marginal at the dorsal side and usually an additional duct at the ventral edge – either a marginal one situated laterally or a median one situated symmetrically; hypodermis formed by one layer of cells (occasionally with cells of the second layer in scattered patches at the dorsal side). **Cones** on (10-)15-25(-35) mm long peduncles, usually cylindrical with a length/width ratio 3.5-6 when closed, often moderately crescent-shaped, (9-)13-20(-23) cm long, 6-9 cm wide when opened, with (55-)70-120 scales, the largest of them (30-)34-44(-48) mm long and (18-)19-26(-31) mm wide with an average length/width ratio 1.79 (range of average values in 22 individuals is 1.41-2.06); apophyses of newly mature cones usually dull brown and pruinose; basal sterile scales around the peduncle insertion usually appressed or deflected (only rarely recurved). **Seeds** together with wings (22-)25-35(-39) mm long, nutlets 7.5-10 × 3.5-5 mm, wings (13-)15-26(-29) mm long and 5.5-11 mm wide (in the widest part).

Geographic distribution and ecology

Pinus dalatensis Ferré var. *dalatensis* was found by us at the type locality (11°56'00"N and 108° 30'05"E) below the village of Trai Mat (7 km E of the centre of Dalat) in November 1986. The population consisted of four medium-aged trees only. At least three of them (somewhat older than the tree sampled under R. Businský 24108) had sparse, imperfectly developed crowns, and thin trunks about 0.5 m in diameter. They had a general character of untimely aged trees under the influence of deteriorated ecological conditions. *P. dalatensis* grow here at an altitude of about 1470 m, along the steep bottom of the upper part of a valley sloping towards the south, and along both sides of a brook forming cascades on the rocky bottom there. It probably is the only known occurrence of *P. dalatensis* in a valley situation. At all the other known sites, the trees of *P. dalatensis* prefer mountain ridges, ribs and elevations, occasionally also adjacent slopes. The atypical valley station below Trai Mat apparently provides conditions for *P. dalatensis* to survive under rather marginal circumstances: a low altitude at the southern escarpments of the Dalat Highlands, in a drier microclimate among hills mostly covered with sparse *Pinus kesiya* Royle ex Gordon woodlands. At the other localities, *P. dalatensis* occupies exposed habitats in the midst of dense, chiefly broad-leaved forests at elevated positions of about 2000 m, with a gene-

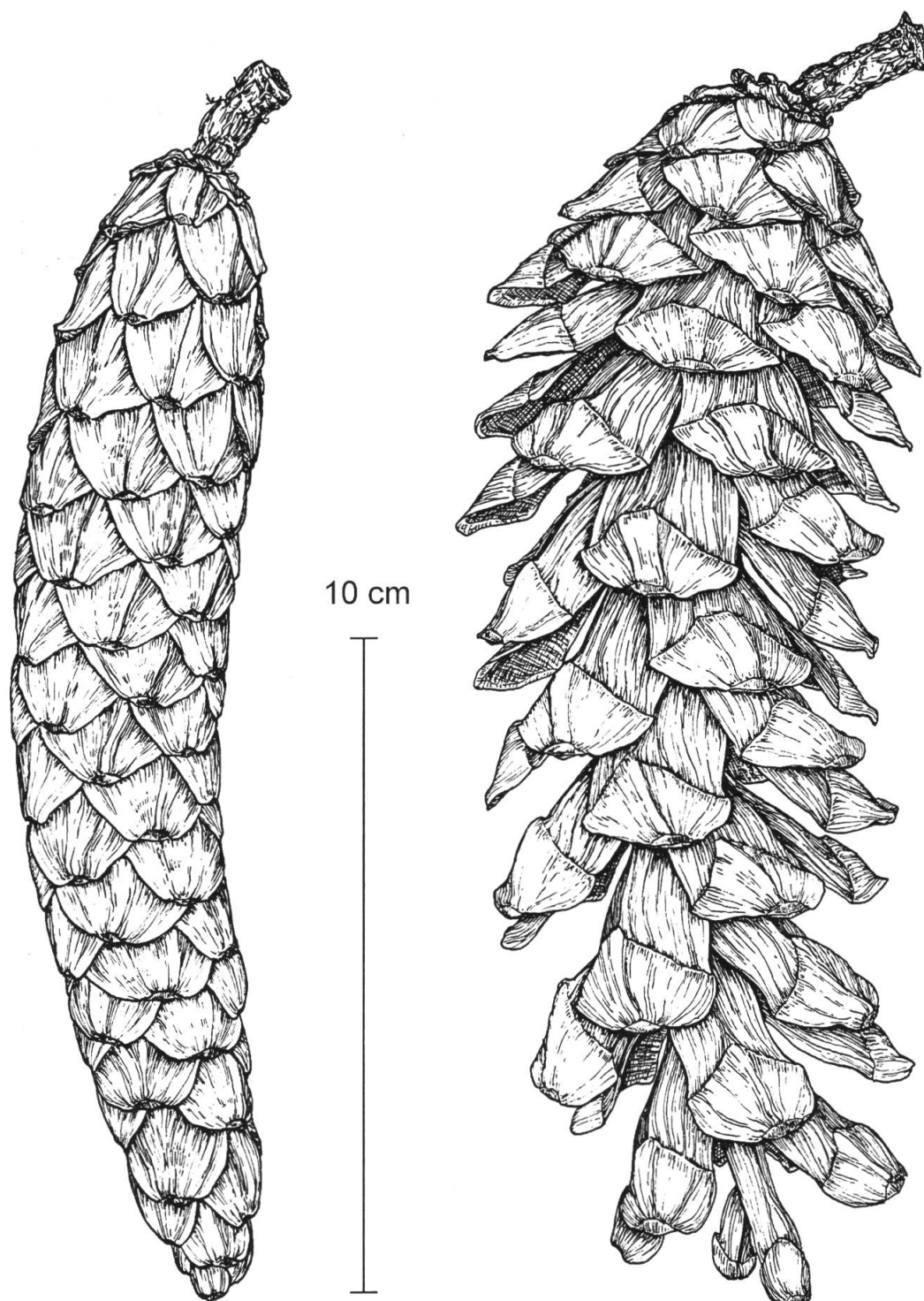


Fig. 3. – Typical cones of *Pinus dalatensis* subsp. *procera* Businský from the massif Ngok Niay (the closed cone comes from the specimen *R. Businský* 44115, the opened one comes from the type specimen tree). Del. L. Businská.

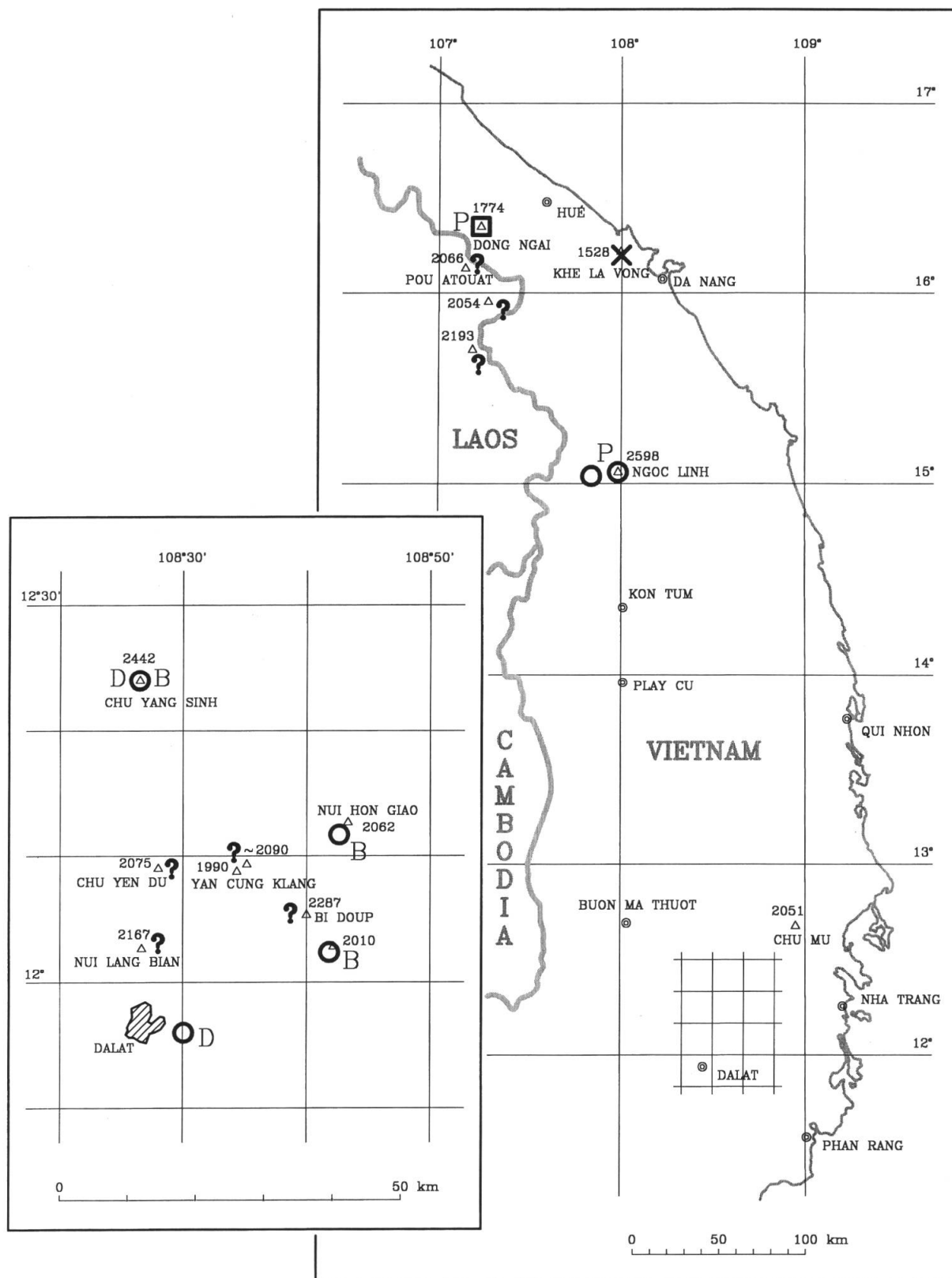


Fig. 4. – Known and presumed distribution of *Pinus dalatensis* Ferré: O: confirmed occurrence; □: the most probable position of the oldest gathering of the species (*Chevalier* 38353); X: erroneously interpreted occurrence (based on *Chevalier* 38353); ? – possible occurrence; D: var. *dalatensis*; B: var. *bidoupensis* Businský; P: subsp. *procera* Businský.

rally more humid microclimate. At the Trai Mat locality, *P. dalatensis* grows together with another member of the *Pinaceae*, *Keteleeria evelyniana* Mast. [*K. rouletii* (A. Chev.) Flous in the narrower sense]; the slopes around the site harbour stands of *P. kesiya*. The vicinity of the locality, however, was partly cleared, as observed in 1986, and higher, at the top of the valley, towards the village, almost deforested and locally used for farming. All these facts indicate that the local population of *P. dalatensis* approaches its extinction.

Pinus dalatensis var. *bidoupensis* Businský is a distinctive morphotype that represents a part of the populations of the type subspecies. Details of the distribution of this variety, however, remain imperfectly known, which is a consequence of the fact that not even the distribution of the type subspecies (and the whole species) is known satisfactorily. The var. *bidoupensis* was detected at three sites about 20-35 km from one another, i.e., in the most extensive population of the type subspecies in the Chu Yang Sinh massif (12°24'N & 108°26'E), on SW slope of Nui Hon Giao (between 1500-1600 m) and in a small population in the mountain region of Bi Doup where it is described from. The proportion and distribution of this variety in the populations at the former two sites remain unknown.

The type locality of var. *bidoupensis* represents the only known occurrence of the species in the mountain region of Bi Doup. It is found on the western slope of the broken unnamed massif culminating in an elevation point 2010 m (12°02'50"N & 108°42'10"E), about 6 km SE of the summit of Mt. Bi Doup (2287 m). This massif represents an eastern marginal part of an extensive hilly highland (situated to the NE of Dalat) whose steep slopes fall to the coast. On many maps, this massif is identifiable by means of an elevation point 1978 m that is found on a marginal ridge (parallel to that with the elev. point 2010 m) whose western slopes harbour the studied population of *P. dalatensis*. This pine was observed there only between the altitudes 1850 and 1900 m on two flat lateral ridges divided by a valley of a small brook. On the shorter (southern) ridge we found merely two old trees of *P. dalatensis*, the smaller of them (*R. Businský* 39152) corresponds to var. *bidoupensis*, the larger one (*R. Businský* 39151) is distinct in having densely pubescent branchlets and thus it is closer to the type variety. Near the mentioned trees, there is a forest path and a clearing after a recent felling of old trees. This activity supported the natural regeneration of *P. dalatensis*, which was confirmed by the occurrence of two-year seedlings in open places. On the other (northern) ridge a group of almost 30 trees was found; most of them correspond morphologically to the var. *bidoupensis* described from this population. The trees are of varied age and size, from younger trees with a trunk girth of 60-100 cm (at the height of 1.3 m) and with a sparse, undeveloped crown, to very old trees reaching a trunk girth of 470 cm, and a very broad umbrella-like crown up to nearly 30 m in diameter; the height of all trees reaches 20-30 m and corresponds to the level of the canopy of the surrounding primary forest. The local primary mixed forest is very dense, with a high proportion of robust old trees. In both microlocalities, *P. dalatensis* grows among broad-leaved trees and the conifers *P. krempfii* Lecomte and *Fokienia hodginsii* (Dunn) Henry & Thomas. The latter two conifers in this region locally dominate the communities between 1750 m and 1950 m, with a variable proportion of broad-leaved woody plants. A third conifer species, *Dacrycarpus imbricatus* (Blume) Laubenfels, is found more scattered. *P. kesiya* forms extensive pure but not dense stands westwards and south-westwards of the massif, and reaches an elevation about 500 m west of the main locality of *P. dalatensis*. On both lateral ridges the substrate consists of a deeper clayey soil without protruding rocks and with a relatively thick humus layer.

Primary forest stands on the whole massif and in its neighbourhood are intact, with the exception mentioned above, i.e., a small clearing on the southern ridge microlocality of *P. dalatensis*, and a desolate track leading to the clearing. This track was broken through a mountain primeval forest, mostly along lateral ridges, more than 6 km long, from the opposite western side of the valley of upper Da Mong rivulet, dividing the 2010 m massif from Mt. Bi Doup. The only purpose of the track was the transport of large trunks (preferably *Fokienia hodginsii*). The trees were felled only in the close vicinity of the track, particularly near the upper end of it near the two old trees of *P. dalatensis* at the southern microlocality. Both *P. dalatensis* and *P. krempfii* prefer habitats on the local flat ridges; consequently, both species evidently were felled at least

during breaking of the track through the forest (although the main economic tree was *Fokienia*). It is probable that several adult trees of *P. dalatensis* were felled on both microlocalities because the track leads through the main group of trees of *P. dalatensis* on the northern microlocality as well. The track was built and trees felled probably in 1990, before the occurrence of the local population of *P. dalatensis* was discovered by Vietnamese botanists. Fortunately, the exploitation of the forest was stopped, and the extensive mountain region surrounding Mt. Bi Doup is closed for economic activities, and proposed as a protected area. Moreover, the region is totally uninhabited and very seldom visited by local people. The local dense broad-leaved primeval forests with admixed rare species of conifers are almost impenetrable, difficult to access and mostly absolutely unexplored, in contrast to the surrounding woodlands dominated by *P. kesiya*. It is almost certain that *P. dalatensis* (probably var. *bidoupensis*) occurs at other sites in this region, probably elsewhere on the diverse slopes of the 2010 m massif and also on other, more distant massifs. The occurrence should preferably be expected on the large massif of Bi Doup proper (2287 m; 12°05'20"N & 108°40'E) where suitable habitats above 1800 m can be found in an area 9 km long and almost 4 km wide in the widest part. Further to the northwest, *P. dalatensis* may be expected on the double-summit massif of Yan Cung Klang (1990 m & ~2090 m; the higher elevation point at 12°09'20"N & 108°35'10"E), and perhaps on the massif of Chu Yen Du (2075 m; 12°09'N & 108°28'E). These two massifs are situated in the direction of massif Chu Yang Sinh with the largest known population of the type subspecies of *P. dalatensis*. Likewise, the occurrence of *P. dalatensis* may be expected on the massif Nui Lang Bian (2167 m; 12°02'40"N & 108°26'40"E) situated only 10 km north of Dalat.

Pinus dalatensis subsp. *procera* Businský has been found at two isolated sites in the southern part of the mountain system of the Annam Highlands extending along the border between C Vietnam and S Laos. The northern one of the two sites has not been located with any certainty but it is very likely that it may be in the Dong Ngai massif (40 km WSW of Hué; see the discussion above). The other, southern site in the Ngok Niay massif (see above for details) was visited and located by the present author. Both sites are found in marginal massifs in the vicinity of higher mountain groups reaching altitudes over 2000 m (or 2600 m in the latter case). Both, the border mountain group of Pou Atouat near the presumed northern site, and the Ngoc Linh Mts. in the south have not been thoroughly explored, particularly in their central parts, they are very difficult to access. Not even the local people visit the two regions. It is therefore probable that this pine grows in the centres of the two mountain groups [the taxon was discovered recently in the proper Ngoc Linh massif between 1800-2500 m (PHAN KE LOC, pers. comm. 1999)], or on some other marginal massifs. *Haploxylon* pines have not been reported to occur in Laos but the Laotian part of the Pou Atouat is a good candidate for further sites of *P. dalatensis* subsp. *procera*. The same assumption may be extended to the higher massifs of mountain regions along the Vietnamese-Laotian border between the above two sites. In particular, it concerns the mountain group with the main elevation point 2193 m (15°42'N & 107°11'E) on the territory of Laos about 45 km S of the highest point of the Pou Atouat, and the high mountains, reaching 1800 to 2050 m, situated between them.

The present author examined the distribution of the stands of *P. dalatensis* subsp. *procera* in the Ngok Niay massif. This pine forms relatively dense group of old trees with typically conspicuously broad crowns overtopping the level of the broad-leaved primeval forests. These groups are centred on ridges and hilly elevations. On these sites the taxon dominates the tree layer of primary mountain forest. When the visibility is good, the pine groves can be discerned from a considerable distance. The occurrence of groups of old trees of *P. dalatensis* subsp. *procera* was observed in all directions from the highest summit of the Ngok Niay massif. The very top of the mountain with the elevation point 2259 m is covered with dense evergreen low trees or shrubs and low bamboo; however, old trees of *P. dalatensis* subsp. *procera* occur at about 2200 m on a summit ridge N (and further NE) of the main top. An altitudinal maximum of the local occurrence was recorded here: last old trees grow at 2240 m and a single young tree 6 m tall was found very close to the summit at an altitude of about 2250 m. The main northern ridge of the

mountain gradually turns to the east about 1 km from the main top, and, in the southern direction, forms a hilly promontory covered with a large group of our pine comprised of several dozens of old trees. Likewise, on the main ridge the pine can be observed further to the east, towards extensive massifs reaching an altitude above 2200-2300 m (and forming a link ridge between Ngok Niay and the main massif of Ngoc Linh). The occurrence of our pine on the extensive massifs is very likely but the area was too distant (4-7 km) to confirm it. A most detailed exploration of the trees of *P. dalatensis* subsp. *procera* was performed on a steep descending lateral NW ridge of Ngok Niay where old trees grow in groups or solitary on several sites between 1850 and above 2100 m. On elevated places with the protruding rocky substrate, the pine trees usually do not exceed a height of 20-25 m while in depressions of the ridge at about 2000 m, trees 30-40 m high with straight smooth trunks 20 m or more tall with a girth (at 1.3 m) of 300-400 cm can be found. Lower on the western slopes of the same ridge, there is an elevation on a side western rib at an altitude of 1700 m with an isolated group of robust trees of *P. dalatensis* subsp. *procera*. These trees represent the lowest known occurrence of this taxon in the region of Ngok Niay. The occurrence of old trees of *P. dalatensis* subsp. *procera* was revealed also on elevations of the S / SW ridge of Ngok Niay from nearly 2200 m down. The tree vegetation on a horizontal part of the ridge at about 2160 m was destroyed by a spontaneous fire a few decades ago, which was documented by a thin layer of coals in the lower humus. There were no adult trees of our pine before the fire or, alternatively, remnants of fallen trunks did not remain at that place. Anyway, at present four young little trees (5-10 m tall) at the stage of intensive primary growth are found amongst low bamboo stands. Their successful development was obviously enabled by the fire destruction of the tree vegetation with high coverage, and by subsequent appearance of an open site. Thus, only two places with the occurrence of young trees of *P. dalatensis* subsp. *procera* were detected: the site after fire with four trees and another station in the northern vicinity of the main summit with a single little tree (see also above); the low shrub vegetation at the latter locality is a result of the influence of the extreme summit conditions or, possibly, of another fire. Neither here nor elsewhere in the Ngok Niay massif any seedlings or juvenile individuals up to a few centimetres or decimetres were found.

In the Ngok Niay massif, *P. dalatensis* subsp. *procera* grows surrounded with broad-leaved, mostly evergreen forests, predominantly constituted by representatives of the *Fagaceae*. From among conifers, three additional species were observed. Primarily, it is *P. kesiya* Royle ex Gordon that forms extensive, sometimes pure stands towards the northwest to southwest of Ngok Niay at altitudes particularly between 900-1500 m. Exceptionally, isolated trees of this *Diploxylon* pine can be found scattered on exposed habitats in the broad-leaved primeval forest at higher altitudes. For instance, a single tree of *P. kesiya* was found on a steep NE declivity below the NW ridge of Ngok Niay at 2040 m, in the vicinity of trees of *P. dalatensis* subsp. *procera*. Furthermore, *Keteleeria evelyniana* Mast. [*K. roulletii* (A. Chev.) Flous in narrower sense], a species not yet reported from the region (cf. LOC, 1984; HIËP & VIDAL, 1996), was found to occur there at several places from 700 m a. s. l. (not far above the bottom of the main valley below Dak Gleï village) up to 1900 m. This latter species was also observed near the trees of *P. dalatensis* subsp. *procera* in a few sites, i.e., on the NW ridge of Ngok Niay and on its western side rib. The last conifer to be mentioned is *Dacrycarpus imbricatus* (Blume) Laubenfels, found at a single site at about 1500 m. The vegetation under the groups of old trees of *P. dalatensis* subsp. *procera* consists of little or juvenile broad-leaved trees and usually is dominated by bamboo stands comprised of a few species (of various growth, from two to more than 10 m high) distributed according to the altitude of the localities. The Ngok Niay massif and its side ridges generally are not rocky but locally on the prominent ribs and steep elevations the dilapidated rocky substrate protrudes above the soil surface. The vicinity of these exposed places, often with a lower tree layer, are preferred by our pine. All the sites with our pine, however, are characterized by a very thick humus with a well aerated surface layer.

Primary woodlands in the region of the Ngok Niay massif above 1500 m and in high mountains further to the east are quite intact but the large *P. kesiya* foothill forests below that altitude (with the exception of valleys) are intensively exploited for timber industry. It is probable that the tree felling will proceed in slopes at higher altitudes, in stands of robust broad-leaved trees

with valuable timber. Although the groups of trees of *P. dalatensis* subsp. *procera* are difficult to access and, hopefully, will not be felled, the deforestation of the foothill belt may cause changes in the stability of the local ecosystem. It is likely that a pine of the *P. dalatensis* type is an ecologically conservative species easily threatened by changes in the ecosystem of primary mountain forests. Moreover, large areas to the south and southwest of the Ngoc Linh mountain region have been totally deforested, which must have an influence on the changes of local climate, as compared with the situation in the past when robust mountain trees hundreds of years old were able to grow up.

P. dalatensis evidently represents an ancient species of the climax vegetation, well adapted to the environment of primary mountain forests. Its growth strategy depends on initial rapid growth and on later formation of large crowns overtopping the level of the surrounding forest stand. The reproduction of this pine is supported, or rather enabled, by an occasional appearance of open sites in the primary forest, as a result of fire, wind-damage or falling of an individual old tree. The frequency of the above phenomena under the conditions of the common occurrence of our pine may be, on average, once a century. The trees of *P. dalatensis*, however, reach a very high age of presumably more than 1000 years. Therefore, the probability of regeneration after episodic local events of disturbance suffices to maintain adequate population dynamics, and the long-term survival of the species under these ecosystem conditions.

Character comparison

The discrimination among the infraspecific taxa of *Pinus dalatensis* or a determination of representative samples of the three taxa is facilitated by the following set of morphological features easy to record:

<i>Pinus dalatensis</i> subsp. <i>dalatensis</i>		<i>P. dalatensis</i> subsp. <i>procera</i>
var. <i>dalatensis</i>	var. <i>bidoupensis</i>	
first-year shoots sparsely, unevenly or densely pubescent	first-year shoots totally glabrous, initially pruinose	first-year shoots (mostly densely) pubescent, initially pruinose
leaves (30-)50-85(-100) mm long	leaves (30-)50-95(-115) mm long	leaves (40-)55-110(-140) mm long
leaves (0.5-)0.6-0.8(-0.9) mm wide	leaves (0.5-)0.7-0.85(-0.95) mm wide	leaves (0.7-)0.8-1.1(-1.25) mm wide
cones (5.5-)7-14(-16) cm long	cones (10-)12-17 cm long,	cones (9-)13-20(-23) cm long,
length/width ratio 2.5-4 (closed)	length/width ratio 2.5-4.5 (closed)	length/width ratio 3.5-6 (closed)

In the above table, all diagnostic features are evaluated on the basis of the complete material cited below (i.e., both the material collected by the author and the additional herbarium material).

In view of the relatively extensive variation within populations and subpopulations in most of the known localities, it is appropriate to use samples from several individuals (per locality) for reliable identification. For instance, the character of indumentum of first-year shoots may be misleading in some individuals because sporadic individuals with pubescent first-year shoots can be found in populations of var. *bidoupensis* while, on the contrary, very rare trees with wholly glabrous shoots occur in the populations of subsp. *procera* (in fact, only a single tree characterized by this feature was ascertained, R. Businský 44118).

Herbarium material

Specimens collected (excluding the types)

Notes:

Our collection numbers below are not preceded by the name "R. Businský", and the entry "coll. Roman Businský" is omitted from before collection dates. Localization of a collection by means of geographic position is based on the maps 1:50 000 or on a navigation satellite receiver (GPS). The abbreviation "t.c." in brief descriptions of sampled trees means a trunk circumference at 1.3 m height; "diam." refers to the crown's maximum diameter. Specimens marked with an asterisk were collected as representative gatherings after climbing up to the crown of the selected trees (this applies to both type specimens without asterisk, as well).

Selected, fully representative specimens from the herbarium material listed below are deposited in the herbarium HN, K, MO, P & PR and their duplicates and the remaining specimens are deposited in the herbarium of the author, Kodaňská 51, CZ-101 00 Praha 10, Czech Republic.

Pinus dalatensis var. *dalatensis*

24108: Vietnam, Lam Dong Prov., Dalat, Trai Mat (Ap Da Phuoc) village sit. 7 km E of Dalat centre, around brook in a steep rocky valley descending to S approx. 1 km S of the road from Dalat to Don Duong; 1470 m a.s.l.; 11°56'00"N & 108°30'05"E (the type locality); 20.11.1986; tree: 155 cm t. c., 23 m h. (trunk 15 m h.).*

Pinus dalatensis var. *bidoupensis*

39151: Vietnam, Lam Dong and Thuan Hai Prov. border NE of Dalat, Bi Doup (2287 m) mt. region, W slopes of massif 2010 m sit. 6 km SE of Bi Doup, 1.1 km W of elev. point 1978 m; dense mixed forest of W inclination, together with *Pinus krempfii* & *Fokienia hodginsii*; 1860 m a.s.l.; 12°02'20"N & 108°41'50"E; 15.2.1994; tree: 440 cm t. c., 30 m h., 22 m diam., very old; first-year shoots pubescent.*

39152: the same locality, but – 1.2 km W of elev. point 1978 m; 1850 m a.s.l.; tree: 270 cm t. c., 24 m h., 16 m diam., old.*

39158: the same region, but – about 1 km WNW of elev. point 1978 m; dense mixed forest on a flat ridge, together with *Pinus krempfii*, *Fokienia hodginsii* & *Dacrycarpus imbricatus*; 1880-1895 m a.s.l.; 12°02'30"N & 108°41'50-55"E; 16.-17.2.1994; mixture of cones from 11 trees from group of ~30 trees with (60)150-300(450) cm t. c. & 20-30 m h.

39159: the same locality, but – 1895 m a.s.l.; 12°02'30"N & 108°41'55"E; 17.2.1994; tree: 240 cm circ., 23.5 m h., 17 m diam., old.*

39161: the same locality, but – 1.2 km WNW of elev. point 1978 m; 1880 m a.s.l.; 12°02'30"N & 108°41'47"E; tree: 470 cm t. c., ~25 m h., 27 m diam., very old.

Pinus dalatensis subsp. *procera*

44101: Vietnam, Gia Lai – Kon Tum Prov. (N corner), Ngoc Linh (2598 m) mt. region, Dak Glei (Dak Pek), Mt. Ngok Niay (2259 m) – NW ridge; in mixed forest on a narrow ridge of N inclination; 2060 m a.s.l.; 15°02'24"N & 107°49'45"E (GPS); 23.1.1997; tree: 150 cm t.c., 20 m h., middle aged.*

44102: the same locality, but – in mixed forest on a steep NE declivity below the ridge; 2050 m a.s.l.; 15°02'25"N & 107°49'45"E (GPS); coll. Ludmila Businská, 23.1.1997; mixture of cones from 3 old trees.

44103: the same region, but – Mt. Ngok Niay – N near the summit; among shrubby vegetation on a top ridge in beginning E declivity; 2250 m a.s.l.; 15°02'30"N & 107°50'05"E (GPS); 25.1.1997; tree: 30 cm t.c., 6 m h., young, already fertile.*

44104: the same region, but – Mt. Ngok Niay – main N top ridge; in low shrubby forest on a mountain ridge; 2240 m a.s.l.; 15°02'32"N & 107°50'07"E (GPS); 25.1.1997; tree: 480 cm t.c., 11 m h., 30 m diam., very old.*

44105: the same locality, but – 15°02'33"N & 107°50'08"E (GPS); coll. Ludmila Businská, 25.1.1997; mixture of cones from 5 old trees.

44106: the same locality, but – tree: 100 cm t.c., 9.5 m h., middle aged.*

44107: *the same region, but* – Mt. Ngok Niay – S ridge; in low shrubby forest at flat saddle on a mountain ridge; 2160 m a.s.l.; 15°02'20"N & 107°49'54"E (GPS); 25.1.1997; tree: 740 cm t.c., 18 m h., 28 m diam., very old.*

44108: *the same locality, but* – group of 4 young trees among bamboo & shrubby (formerly burnt) vegetation on a ridge; 2160 m a.s.l.; 15°02'18"N & 107°49'54"E (GPS); 26.1.1997; tree: 45+40 cm t.c., 7 m h., young.*

44109: *the same locality, but* – tree: 87 + 45 cm t.c., 10 m h., young, already fertile.*

44110: *the same region, but* – Mt. Ngok Niay – NW ridge; in mixed forest on a narrow mountain ridge; 2120 m a.s.l.; 15°02'23"N & 107°49'50"E (GPS); 26.1.1997; tree: 450 cm t.c., 22 m h., trunk hollow, very old.

44111: *the same locality, but* – in mixed forest on a narrow ridge of NNW inclination; 2070 m a.s.l.; 15°02'24"N & 107°49'46"E (GPS); 26.1.1997; tree: 340 cm t.c., 28 m h., old.

44112: *the same locality, but* – coll. Ludmila Businská; tree: 350 cm t.c., 22 m h., trunk hollow, very old.

44113: *the same locality, but* – in mixed forest on a mountain ridge; 2020 m a.s.l.; 15°02'30"N & 107°49'40"E; 26.1.1997; mixture of cones from 3 old trees with 300-350 cm t.c., ~30 m h.

44115: *the same locality, but* – in mixed forest on a ridge of N-S bearings; 1920 m a.s.l.; 15°02'45"N & 107°49'30"E (GPS); 27.1.1997; mixture of cones from 5 old trees with 300-400 cm t.c., ~25 m h.

44116a: *the same region, but* – Mt. Ngok Niay – W slopes of NW ridge; in mixed forest on elevation of a lateral W ridge; 1720 m a.s.l.; 15°02'50"N & 107°48'55"E (GPS); 28.1.1997; tree: ~400 cm t.c., ~25 m h., trunk hollow, very old.

44116b: *the same locality, but* – below elevation of a lateral W ridge, S to W exposure; mixture of cones from 3 old trees with 300-450 cm t.c., 25-30 m h.

44117: *the same locality, but* – SW exposure; coll. Ludmila Businská; tree: 350 cm t.c., 28 m h., very old.

44118: *the same locality, but* – 15°02'48"N & 107°49'00"E (GPS); 28.1.1997; tree: 300 cm t.c., 29 m h., old; first-year shoots wholly glabrous.*

44119: *the same locality, but* – on elevation of a lateral W ridge; 1730 m a.s.l.; 15°02'50"N & 107°49'03"E (GPS); 29.1.1997; tree: 390 cm t.c., 27 m h., very old.*

Other specimens examined

Pinus dalatensis var. *dalatensis*

DESCHAMPS [s.n.]: [Annam,] Yang Sin, 2400 m alt., 50 km Sud est d'Ban Methuot, pin en mélange avec *Fokienia Hodginsii*; without date. Paratype of *P. dalatensis*, det. by Y. de Ferré in 1960 [P].

V. N. LONG 205: [Vietnam,] Prov. Daklac, Mt. Chu Yang Sinh; 6.12.1993 [HN].

Unnumbered material (more specimens) of several trees: Vietnam, Dac Lac and Lam Dong Prov. border, Chu Yang Sinh massif, above 2000 m a.s.l.; coll. N. C. Lam & al., Jan. 1994. Only specimens of typical trees are included [Institute of Tropical Biology, Ho Chi Minh City].

Pinus dalatensis var. *bidoupensis*

E. POILANE 32581: Annam, sud de la pro. du Darlac, massif du Chu Yang Sinh, sol granitique médiocre bien que couvert de vieille forêt, 1800 m alt.; 24.4.1941. Conifère de 10 à 12 m de h., t. de 2 m de circ. Paratype of *P. dalatensis*, det. by Y. de Ferré in 1960; det. as *P. kwangtungensis* Chun ex Tsiang by L. K. Fu & N. Li, 28.9.1995 [P].

Pinus dalatensis subsp. *procera*

A. CHEVALIER 38353: Annam, Thua Luu, Forêt de Duông; coll. Service forestier, 14.5.1918. The oldest determination: “Pin du groupe de *Pinus parviflora*, *Pinus Fenzeliana* ?, mais rameau pubescent, Y. de Ferré” [P].

V. X. PHUONG 375: [Vietnam,] Gia lai – Kong tum [province], Dak Lay, Ngoc linh; 21.3.1978. Det. as *P. dalatensis* by N. T. Hiệp, 24.11.1992 [HN – 3 specimens].

V. X. PHUONG 381: [Vietnam,] Gia lai – Kong tum [province], Dac lay, Ngoc linh; 21.3.1978. Det. as *P. dalatensis* by L. K. Bien, 19.4.1979 [HN].

Notes

The recognition of *Pinus dalatensis* var. *bidoupensis* Businský, and *P. dalatensis* subsp. *procera* Businský in particular, considerably extends and completes the known overall range of character variation and geographic distribution of the species. The recorded quantitative character values in the northern new subsp. *procera* show a striking shift towards the characters of *P. wallichiana*. It also documents the presumed relationships of both species. On the other hand, a more detailed knowledge of *P. dalatensis* gives satisfactory arguments to state that it is a morphologically and geographically distinct, well differentiated species, despite the doubts expressed by some authors in the 1980's (cf. FARJON, 1984: 67; SILBA, 1984: 59).

Only recently, new stations of *P. dalatensis* have been detected, and it is likely that additional ones remain unknown. However, it is quite certain that *P. dalatensis* is represented by a limited number of isolated populations with a specialized ecology and reproduction strategy. In this context, the extensive morphological variation encountered within individual populations should be emphasized. The variation can primarily be observed in the morphology and size of cones and qualitative features of young branchlet surface. On the other hand, the general habit of trees, as a result of the ecological strategy, is relatively uniform within the whole species. The general habit of old trees of *P. dalatensis*, characterized by straight smooth trunks and broad umbrella-like crowns, is very exceptional in the genus *Pinus*. In addition to *P. dalatensis*, it is found in two species with the same ecological strategy (broad crowns overtopping the dense canopy of the broad-leaved woodlands in mountain regions of the Tropics). This feature is most distinctly developed in the second S Vietnamese *Haploxyton* pine, *P. krempfii* Lecomte (this species coexists with *P. dalatensis* at least at one site). In the S Chinese *P. fenzeliana* Hand.-Mazz. (of the group of *P. armandii* Franch.; not "*P. fenzeliana*" in the sense of FERRÉ, 1960 or CRITCHFIELD & LITTLE, 1966) this type of general habit is not so pronounced.

ACKNOWLEDGEMENTS

The author is grateful to the Management of the Research Institute of Ornamental Gardening, Průhonice, Czech Republic for administration of the REPEA Project (see a note below) with the support of the Czech – East Asian Research Fund, and to the staffs of Herbarium, Botany Department, National Museum in Prague for their help with the distribution of herbarium specimens abroad.

The author is indebted to Prof. Ngo Ke Suong, director of the Institute of Tropical Biology of Vietnam Natl. Center for Nat. Sci. & Technol., Ho Chi Minh City (Saigon) for arranging the field research and collection permits. Thanks are also due to Prof. Doan Canh, the same institute, and his collaborators for providing the author with unpublished recent data and the documentation relevant to the distribution of *P. dalatensis* in the mountain regions of Bi Doup and Chu Yang Sinh. In particular, the author is grateful for the opportunity to study fresh gatherings from these localities. Sincere thanks are due to Dr. Nguyễn Tiên Hiệp, Institute of Ecology and Biological Resources, Hanoi, for putting a manuscript of Vol. 28 of the new "Flore du Cambodge, du Laos et du Vietnam" at the author's disposal, for additional information, and for making the herbarium studies possible at HN. Prof. Phan Ke Loc, Dept. of Botany, University of Science, Hanoi, kindly helped the author to obtain a copy of his rare paper cited below. The author is also indebted to Ing. J. Dejeumont, Comité Français de Cartographie, Paris, and Mr. J.-Cl. Dupuis, Institut Géographique National, Service de la Docum. Géogr., Saint-Mandé, for their effort in the identification of local names and for copies of many detailed and often historical maps of the territory of C and S Vietnam from numerous editors.

Note: The research summarized in the present paper was carried out within the framework of the REPEA Project (i.e., "Revision of Pines of East Asia Project") and funded by grant No. 39 & 44 of CEAR Foundation. Distribution of herbarium specimens abroad is supervised by Herbarium, Botany Department, National Museum in Prague.

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