

---

Volume 13  
Number 3  
2003

---

NOVON



---

A New Hard Pine (*Pinus*, Pinaceae) from Taiwan

*Roman Businský*

Silva Tarouca Research Institute for Landscape and Ornamental Gardening (RILOG),  
252 43 Průhonice, Czech Republic. businsky@vukoz.cz

---

**ABSTRACT.** *Pinus fragilissima* Businský (Pinaceae), a new species of *Pinus* subg. *Pinus*, is described from southeastern Taiwan. Comprised of trees with very sparse crown and fragile, symmetrical, 6–9 cm long cones with often flat apophyses, it appears to be most closely related to *P. luchuensis* Mayr, endemic to the Nansei Islands, and to *P. taiwanensis* Hayata. The latter is circumscribed here as a Taiwan endemic with the exclusion of superficially similar but probably unrelated mainland Chinese pines. These three allied species are classified here as the sole representatives of *Pinus* subg. *Pinus* ser. *Luchuenses* E. Murray.

**Key words:** Pinaceae, *Pinus*, *Pinus* subg. *Pinus* ser. *Luchuenses*, Taiwan.

The author has been studying natural populations of Eurasian pines for more than ten years, concentrating on East Asia. The main object of the study is a taxonomic revision of *Pinus* in that region, the Revision of Pines of East Asia (REPEA) Project. Within the framework of this project, the author undertook a series of research expeditions to East Asia: eight to the People's Republic of China (1990–2001), two to Japan (1991 and 1997), two to Vietnam (1994 and 1997), and one to Taiwan (1991), Indonesia (1994), and the Philippines (2000). The study has been designed to obtain good field knowledge, above all of variability within and between populations, and to collect representative herbarium and photographic material of all Asian species of the genus *Pinus*, allowing a more uniform approach to classification (see also Businský, 1999).

**TAXONOMY**

During an exploration in 1991 of forest stands in southern Taiwan, on the eastern (Pacific) side of the island's central mountain range, a remarkable population of a hard pine (= *Pinus* subg. *Pinus*) near Wulu village in the northern part of Taitung County was found. The only species known from Taiwan showing certain resemblance in general tree habit, external leaf characters, and some cone characters to this population is *Pinus massoniana* Lambert. Critchfield and Little (1966), using unpublished data at the Taiwan Forest Research Institute, reported *P. massoniana* only from northern Taiwan. However, Liu (1966) and Li (1975) also reported *P. massoniana* in the south, but only from the eastern coastal hills along the border between Taitung and Hualien Counties. Liu (1966: fig. 33) listed only one species of hard pine, *P. taiwanensis* Hayata, in the Wulu region. In a narrow taxonomic concept (excluding *Pinus hwangshanensis* W. Y. Hsia, see below), *P. taiwanensis* is confined to middle and high altitudes of Taiwan, widespread mainly between 2200 and 2900 m. However, the pine from the vicinity of Wulu occurs near or below 900 m, and differs from *P. taiwanensis* in several morphological characters (Table 1). No other indigenous hard pine is known from Taiwan. Outside of Taiwan, the Wulu population approaches *P. luchuensis* Mayr in some characters (leaf morphology and anatomy, distinctly broad tree crown); this is a species endemic to the nearby flat islands of the Nansei (Ryukyu) Archipelago, northeast of Taiwan (cf. Critchfield & Little, 1966; Yamazaki, 1995). The character set found in the Wulu pine is different from that of the three geographically closest spe-

cies: *P. massoniana*, *P. taiwanensis*, and *P. luchuenensis*. The Wulu pine also cannot be equated with any other pine indigenous to East Asia, either; so as discussed below it is described here as a new species.

***Pinus fragilissima*** Businský, sp. nov. TYPE: Taiwan, Taitung County: below the great bend of Southern Cross-Island Highway on S slopes about 1 km N of Wulu village, in mixed forest on W declivity of a stony ridge descending S, alt. 930 m, 23°10'40"N, 121°02'E, 18 Dec. 1991, R. Businský 32172 (holotype, PR; isotypes, B, BM, C, G, MO, P, PE, TAI & Herbarium of the RILOG). Figure 1.

Arbor usque 30 m alta, corona conspicue sparse dif-fusa, lata; folia (12–)16–20(–22) cm longa, canalibus resiniferis 4 ad 6(7), plerumque medialibus et interdum (sub)marginalibus; strobili ovuliferi hornotini fere 9–10 mm lati, pedunculis 5–10 mm longis, squamis mucronatis praeter partem strobilorum basalem; strobili maturi (5–)6–9(–10) cm longi, fragiles, patentes vel leviter reflexi; apophyses plerumque prominentes, non tumidae. A *Pinus massoniana* differt imprimis canalibus resiniferis foliorum plerumque medialibus et umbonibus strobilorum maturorum plerumque prominentibus, non planis et concavis; a *P. taiwanensis* differt imprimis foliis longioribus, strobilis maturis longioribus, fragilibus et coronis arborum sparse diffusis; a *P. luchuensis* differt imprimis strobilis maturis longioribus et fragilibus, non suberectis, apophysibus plerumque pyramidalibus, non rotundatis vel tumidis et coronis arborum sparse diffusis.

Tall trees attaining a height of 30 m with conspicuously sparse crowns 20 m or more wide, branches spreading, remarkably frangible, with leaves falling during the second to third year. *Bark* developing late, initially irregularly scaly, on trunks of old trees conspicuously thick, deeply longitudinally fissured and forming ribs often around 10 cm thick. Annual branches uninodal, relatively long; shoots of the current year relatively thin (fertile shoots with conelets 3–6 mm thick), yellow-brown, initially slightly pruinose, glossy, with inconspicuous shallow and narrow grooves formed by the decurrent bases of the primary bracts; areolae among them low and relatively flat. Shoots of the previous year gray-brown. *Buds* cylindrical, up to ca. 3 cm long, with scales in the upper half loose to erectopotent, narrowly lanceolate, with inconspicuous dorsal keel, brown in the middle, paler toward the lacerate margins, with long white fringes; scales not persistent at the bases of shoots. *Leaves* in fascicles of 2, occasionally in 3s on fertile shoots, (12–)16–20(–22) cm long, (0.9–)1.0–1.2(–1.35) mm wide (fresh), pale green, relatively fine and flexible, straight or slightly bent; amphistomatic; edges irregularly and rather densely acute-serrate, with (35

to)45 to 65(to 80) teeth per cm in the middle part; sheaths (8–)10–13(–15) mm long in the first year. Leaf resin ducts 4 to 6(7); two ducts near leaf edges always median, of largest diameter; 1 to 3(4) ducts dorsal, usually of smaller diameter, median or 1 to 2 of them marginal, occasionally submarginal, or near endodermis; usually one duct near the ventral side of small diameter, median to marginal (rarely larger and septal). Leaf hypodermis formed mostly by one layer of cells with relatively thin walls, sometimes a second layer in scattered patches on the dorsal side. *Pollen cones* ca. 2.5 cm long. *Ovulate cones* after the first growing season (conelets) on 5–10 mm long peduncles, 13–18(–20) mm long and ca. 9–10 mm wide, ovoid to elliptic cylindrical, erect, subterminal, usually in whorls of 3 to 5. The exposed part of the scales of the basal quarter of the conelet rounded, without a distinct keel or mucro; the other scales often show a considerably elevated area with a distinct transverse keel without discernible apex, dorsally depressed, with short mucro situated eccentrically on the ventral side, beginning from the swollen decurrent base and oriented backward over the keel. Mature seed cones spreading or slightly reflexed on slender 5–10 mm long peduncles, symmetrical, ovoid to oblong conical, fragile, (5–)6–9(–10) cm long, 5–8 cm wide when open; usually persistent for a few years, falling mostly without peduncle. Cone scales thin, densely arranged, 120 to 220, the largest 20–30 mm long and 12–15 mm wide, with length/width ratio 1.5–2.5, often broader below the middle than the apophysis width. *Apophyses* cinnamon brown, in outline irregularly transverse obtrullate, 11–14 mm wide, with rounded to broadly cuneate distal edge, ± broadly pyramidal (not rounded or tumid), with conspicuous, sharp transverse keel and generally concave, depressed proximal side (often with raised proximal corner). Umbo slightly sunken, but usually prominent, transverse, (2–)2.5–4(–4.5) mm wide on seed scales, pyramidal or rooflike, keeled, often depressed on the proximal side, with minute, slender, ca. 0.2–0.5 mm long, erect or recurved mucro. *Seeds* ca. 4–5.5 × 2.2–3 mm, with wings 11–25 × 4.5–7.5 mm.

*Etymology.* The specific epithet (denoting “fragilest”) refers to the remarkably frangible branches and branchlets, more so than for all other East Asian pines, and to the fragile consistency of the scales of mature seed cones.

#### DISTRIBUTION AND ECOLOGY

*Pinus fragilissima* was observed only in a relatively small valley system of the Hsinwulu River,

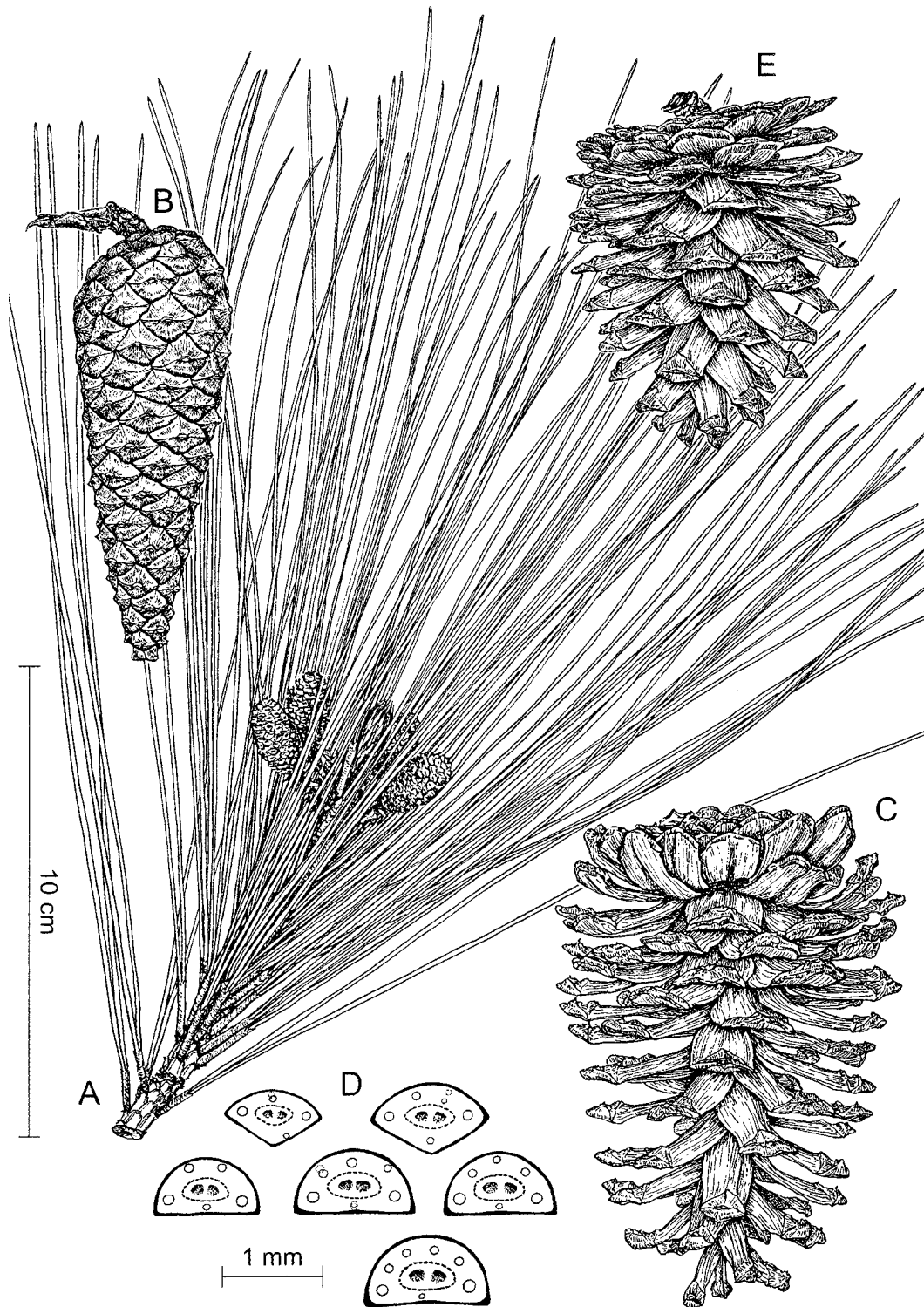


Figure 1. *Pinus fragilissima* Businský. —A. Fertile branchlet in winter season (current shoot, with top of previous year's shoot) with leaf fascicles, terminal bud and ovulate cones. —B. Mature closed cone. —C. Open seed cone. —D. Cross sections at the middle of leaves showing position of resin ducts. —E. Open seed cone of another individual. A–D from *R. Businský* 32172, holo- and isotypes, and E from *R. Businský* 32173, paratype. A, B, C, E: the same scale bar. All drawn by Ludmila Businská.

Table 1. Comparison of *Pinus fragilissima* with three morphologically most similar species: *P. taiwanensis*, *P. luchuensis*, and *P. massoniana* (compiled from the author's field collections of natural populations, see Appendix 1).

Character	<i>P. fragilissima</i>	<i>P. taiwanensis</i>	<i>P. luchuensis</i>	<i>P. massoniana</i>
Tree habit	tall trees with conspicuously sparse crown and spreading branches	usually tall trees with medium dense crown	usually low trees with relatively dense crown and conspicuously spreading branches	tall trees with medium dense crown
Leaf length (cm)	(12-)16-20(-22)	(6.5-)9-14(-17)	(7-)12-18(-21)	(10-)12-20(-22)
Number of leaf resin ducts	4 to 6(7)	4 to 6(7)	2 to 6(7)	(4)6 to 11(13)
Position of leaf resin ducts	largely median, some (sub)marginal	largely median, some (sub)marginal	median, rarely some internal or (sub)marginal	always marginal
Mature seed cone length (cm)	(5-)6-9(-10)	(4-)4.5-6(-8)	4-6(-6.5)	4-7(-9)
Mature seed cone symmetry	symmetrical	subsymmetrical or asymmetrical	symmetrical	symmetrical or subsymmetrical
Mature seed cone orientation	spreading or slightly reflexed	± reflexed	suberect to spreading	± reflexed
Consistency of mature seed cone scales	fragile	firm	fairly firm	rather fragile
Apophyses	± broadly pyramidal	broadly pyramidal or roundly prominent to tumid	± roundly prominent to tumid	flat or slightly, ± roundly prominent
Umbo	± pyramidal or rooflike, often with depressed proximal side	± pyramidal or rooflike, sometimes with depressed proximal side	± pyramidal	flat, generally concave as a whole

descending east-southeast from the Kuan Shan massif (3666 m) within the Chungyang Shanmo mountain region, in the vicinity of and below Wulu village in the northern part of Taitung County, Taiwan, on the eastern side of the island's central mountain range. The population of the new pine in the main valley of this system (i.e., along the Southern Cross-Island Highway) occurs in elevations between 500 and 1000 m, but it cannot be excluded that it reaches slightly higher altitudes in some of the side valleys of the system. The valley is characterized by steep, rocky slopes predominantly covered with broad-leaved woodlands. *Pinus fragilissima* prefers slopes of southern to western exposures, confined to rocky sites with reduced competition from broad-leaved trees. Potentially, the new pine may be found in suitable habitats in other less easily accessible valley systems in the Chungyang Shanmo mountains in Taitung and Hualien Counties.

Another population of pines occurs in similar altitudes eastward, opposite the slopes of the Chungyang Shanmo mountains, i.e., in a narrow belt of coastal hills (situated between ca. 23°00' and 23°25'N) called Haiian Shanmo. This population was identified as *Pinus massoniana* by Liu (1966) and Li (1975). Earlier on, Li (1963) cited a single specimen, *Tanaka 10453*, from southern Taiwan, at "Taitung," as *P. massoniana*. Liu's map (1966: fig. 31) of *P. massoniana* in Taiwan includes an isolated area in these coastal hills as a narrow strip about 60 km long following the main ridge of the range. A single dot representing a herbarium specimen is in the middle of this strip, in the vicinity of Mt. Xingang Shan (1682 m, on the border of Taitung and Hualien Counties, above the port of Chengkung), about 20 km east of the observed site of *P. fragilissima* in the Hsinwulu valley. No herbarium specimens are cited by Liu, but Li (1963) is cited, and thus it is presumed here that the dot refers to the specimen cited by Li (*Tanaka 10453*). A duplicate of *Tanaka 10453* (C), determined as *P. massoniana* by the collector, was examined and undoubtedly is *P. fragilissima*; consequently the whole population of pines in the Haiian Shanmo is considered here belonging to this species. This mountain range reaches the highest elevation in Xingang Shan, which is close to the Hsinwulu River system. The region with *P. fragilissima* as a whole is characterized by dry winters and wet summers (Walter & Lieth, 1964: part 2.4).

*Paratypes.* TAIWAN. Taitung County, below the great bend of Southern Cross-Island Highway on S slopes about 1 km N of Wulu village, in sparse mixed forest on S stony declivity, alt. 930 m, 23°10'40"N, 121°02'E, 18 Dec.

1991, *R. Businský 32173* (PR); Tai tô-chô [Taitung], Kaede, 7 Mar. 1931, *T. Tanaka 10453* (C).

#### DISCUSSION

*Pinus fragilissima* is similar to *P. luchuensis*, particularly in leaf size and anatomy. However, they otherwise differ morphologically and in their ecological requirements. The new species differs from *P. massoniana* in several characters, notably in the position of the resin ducts, a character usually given as important in the classification and determination of the Asian hard pines (cf. Gausсен, 1960; Kwei & Lee, 1963; Cheng et al., 1975; Law et al., 1978). On the other hand, both species occupy a similar altitudinal range; according to Liu (1966) and Mirov (1967), *P. massoniana* in Taiwan is confined to 300–1300 m. The new species is distinct from *P. taiwanensis* in general habit (sparse broad crowns), but further differences exist in leaf length, cone size, and scale fragility. Although both species occur in the same mountain region, their altitudinal ranges are different and barely overlap. The altitude of 750 m recorded as the lower limit for *P. taiwanensis* by Li (1963: 51), Liu (1966: 17), and Mirov (1967: 284) is in conflict with field observations of the present author in several regions. Even isolated trees of *P. taiwanensis* below its main zone of occurrence were above 1500 m in most of these regions. The 750 m record may be a result of the inclusion of *P. fragilissima* or *P. massoniana* in the distribution of *P. taiwanensis*. Sheue et al. (2000) analyzed variation of leaf anatomy attributed to *P. taiwanensis* in the Tachia river system (mainly in Taichung County on the west side of northern Taiwan) in five localities from an altitude of 700 m (Kukuan) to 3100 m (Konankaun). Li (1963, 1975) and Liu (1966) reported from this region also an occurrence of *P. massoniana*. The present author studied pine populations and collected samples of trees in the Tachia river system in the mentioned altitudinal range as well. The population of a hard pine in the vicinity of Kukuan (occurring between 500 and 1000 m) is, however, considered to be *P. massoniana*, comprising also some individuals morphologically transitional to *P. taiwanensis* (probably of hybrid origin). On the basis of a suite of morphological and anatomical characters, ranges of variability, and the geographic distribution, the trio of *Pinus luchuensis*, *P. taiwanensis*, and *P. fragilissima* appears as a related group, accepted here as the series *Luchuenses* E. Murray within the typical section and subsection of the genus.

Some Chinese authors, e.g., Law et al. (1978) and Fu and Li in Fu et al. (1999), include mainland populations described (and accepted here) as *Pinus*

*hwangshanensis* W. Y. Hsia in *P. taiwanensis*. However, *P. hwangshanensis* appears more closely related to the Japanese *P. thunbergii* Parlatore (Wang & Szmidt, 1993). Field and herbarium studies of *P. hwangshanensis* (see Appendix 1) show it to be different from *P. fragilissima* in general habit, morphology, and anatomical characters, and also in ecological requirements. While *P. hwangshanensis* prefers exposed rocks on the tops and ridges of continental mountains predominantly above 900 m, *P. fragilissima* prefers sheltered rocky sites in valleys of (sub)coastal mountains predominantly below 900 m.

KEY TO THE SPECIES MORPHOLOGICALLY SIMILAR TO *PINUS FRAGILISSIMA*

1. Leaves with resin ducts always marginal, usually less than 1 mm wide and more than 12 cm long; apophyses of seed cones relatively thin, flat or slightly prominent, umbo flat and generally concave as a whole, with indistinct or depressed transversal keel . . . . . *P. massoniana*
- 1'. Leaves with resin ducts only or largely median, often more than 1 mm wide or less than 14 cm long; apophyses of seed cones usually broadly pyramidal or roundly prominent to tumid, umbo prominent (although sometimes sunken), generally pyramidal and pointed or rooflike (sometimes  $\pm$  depressed on the proximal side or on the top), with distinct and usually raised transversal keel . . . . . 2
- 2(1). Leaves of mature trees (7–)12–20(–22) cm long; seed cones generally symmetrical, early deciduous or persistent for a few years; branchlets remarkably frangible; species of flat islands, hills, and submontane valleys; only or predominantly below an altitude of 900 m . . . . . 3
- 2'. Leaves of mature trees (4–)5–14(–18) cm long; seed cones generally asymmetrical, usually firmly persistent for more years; branchlets relatively firm; species of mountain tops, ridges, and slopes, predominantly above an altitude of 900 m . . . . . 4
- 3(2). Bud scales persistent at the bases of shoots; mature seed cones suberect to spreading, 4–6 (–6.5) cm long, with apophyses  $\pm$  roundly raised, usually at first pruinose; usually low trees with relatively dense crown . . . *P. luchuensis*
- 3'. Bud scales not persistent at the bases of shoots; mature seed cones spreading or slightly reflexed, (5–)6–9(–10) cm long, with apophyses  $\pm$  pyramidally prominent, not pruinose; tall trees with conspicuously sparse crown . . . . . *P. fragilissima*
- 4(2). Apophyses of seed cones usually light brown, not contrasting in color with indistinct sealing band on scales, proximal side of apophyses generally convex (sometimes convex only near umbo and concave toward the proximal apophysis corner), umbo  $\pm$  sunken but not flat . . . . . *P. hwangshanensis*
- 4'. Apophyses of seed cones usually cinnamon brown, contrasting in color with distinct, lighter

sealing band on scales, the proximal side of apophyses generally concave (sloped almost from the umbo, sometimes with raised proximal apophysis corner), umbo usually not sunken . . . . . *P. taiwanensis*

*Note.* R. R. Mill in the *Flora of China* (Fu et al., 1999) gave the following diagnostic characters of *Pinus hwangshanensis* and *P. taiwanensis*: length of needle sheaths, number of teeth per cm in the middle part of needle margins, color of pollen cones, and umbo morphology of seed scales. These characters, except for color of pollen cones, were tested by the author in detail in 44 individuals of the former species and in 32 of the latter, in both cases from several regions (see Appendix 1 for herbarium material examined). Only the umbo morphology was found partly in correspondence with Mill (in Fu et al., 1999)—i.e., umbo sunken (“depressed”) but not flat versus not sunken (“not flat”). The difference in quality of mucro (“prickle”) reported there was not found. Moreover, both leaf characters were found entirely insignificant for discrimination between these species. That is to say: the reported number of teeth does not agree for *P. taiwanensis* (it does not even correspond with both the type specimens), with the found range of (25–)32–55(–70), not “26–35(–39)”; the reported length of sheaths does not agree, either, for *P. hwangshanensis*, with the found range of (6–)10–14(–17) mm, not “0.5–1 cm” (sheaths longer than 12 mm were found in populations in the Dabie Shan Mts. north of the Yangtze River).

*Acknowledgments.* The author is grateful to the management of the Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Práhonice, Czech Republic, for administration of the REPEA Project with the support of the Czech–East Asian Research Fund (grant No. 32), and to the staff of Herbarium PR, Botany Department, National Museum in Prague, for their help with the distribution of herbarium specimens abroad. The author wishes especially to thank his wife, Ludmila Businská, for many years of her infinite help, above all in the field during the above-mentioned research expeditions to East Asia.

Literature Cited

Businský, R. 1999. Taxonomic revision of Eurasian pines (genus *Pinus* L.)—Survey of species and infraspecific taxa according to latest knowledge. *Acta Pruhon.* 68: 7–86.  
 Cheng, W. C., L. K. Fu & C. Y. Cheng. 1975. Gymnospermae Sinicae. *Acta Phytotax. Sin.* 13(4): 56–90, pl. 1–66.  
 Critchfield, W. B. & E. L. Little. 1966. *Geographic Dis-*

- tribution of the Pines of the World. U.S.D.A., Forest Serv., Misc. Publ. 991. Washington, D.C.
- Fu, L. K., N. Li & R. R. Mill. 1999. Pinaceae. Pp. 11–52 in Z. Y. Wu & P. H. Raven (editors), *Flora of China*, Vol. 4. Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis.
- Gaussen, H. 1960. Les Gymnospermes actuelles et fossiles. Fasc. VI, Chap. XI. Généralités, Genre *Pinus*. Trav. Lab. Forest. Toulouse, t. II, sect. 1, vol. 1, part. 2: 1–272.
- Kwei, Y. L. & C. L. Lee. 1963. Anatomical studies of the leaf structure of Chinese pines. *Acta Bot. Sin.* 11: 44–60, pl. I–VI.
- Law, Y. W., W. C. Cheng, L. K. Fu, C. D. Chu & C. S. Chao. 1978. *Pinus*. Pp. 204–281 in W. C. Cheng & L. K. Fu (editors), *Flora Reipublicae Popularis Sinicae* Vol. 7. Science Press, Beijing.
- Li, H. L. 1963. *Woody Flora of Taiwan*. Livingston Publishing, Narberth, Pennsylvania.
- . 1975. Pinaceae. Pp. 514–529 in H. L. Li, T. S. Liu, T. C. Huang, T. Koyama & C. E. De Vol (editors), *Flora of Taiwan* Vol. 1. Epoch Publishing, Taipei.
- Liu, T. 1966. Study on the phytogeography of the conifers and taxads of Taiwan. *Bull. Taiwan Forest. Res. Inst.* 122: 1–33.
- Mirov, N. T. 1967. *The Genus Pinus*. Ronald Press, New York.
- Sheue, C. R., Yang, Y. P., Kuo-Huang, L. L. 2000. Structural variation of the needles of *Pinus taiwanensis* Hay. along an elevational gradient. *Taiwan J. Forest. Sci.* 15: 337–349.
- Walter, H. & H. Lieth. 1964. *Klimadiagramm–Weltatlas*. 2. Lieferung. VEB G. Fischer Verlag, Jena.
- Wang, X. R. & A. E. Szmidi. 1993. Chloroplast DNA-based phylogeny of Asian *Pinus* species (Pinaceae). *Pl. Syst. Evol.* 188: 197–211.
- Yamazaki, T. 1995. Pinaceae. Pp. 266–277 in K. Iwatsuki, T. Yamazaki, D. E. Boufford & H. Ohba (editors), *Flora of Japan* Vol. 1. Kodansha, Tokyo.
- Island Highway, Kaohsiung & Taitung Co., Taiwan; alt. 2600–2800 m [Dec. 1991: *R. B.* 32164, 32165, 32166, 32167]
- Pinus luchuensis* Mayr:
- Naha City suburbs, Okinawa Island, Nansei Islands, Japan; alt. 20–30 m [Nov. 1991: *R. B.* 32120, 32121, 32122, 32123, 32124]
  - Ishigaki town environs, Ishigaki Island, Nansei Islands, Japan; alt. 80 m [Nov. 1991: *R. B.* 32125, 32126, 32127]
- Pinus massoniana* Lambert:
- Kukuan environs, Tachia valley, Taichung Co., Taiwan; alt. 500–1000 m [Nov. 1991: *R. B.* 32131, 32132, 32133]
  - Lechang Co., Guangdong, China; alt. 900–1200 m [Jan. 1994: *R. B.* 39121, 39124, 39125]
  - Kingshan Co., W Hubei, China; alt. about 1400 m [July 1995: *R. B.* 42115]
  - Tianzhu Shan massif (1488 m), Qianshan Co., SW Anhui, China; alt. 300–700 m [July 1995: *R. B.* 42116]
  - Longming environs, Tiandeng Co., SW Guangxi, China; alt. 500 m [Aug. 1998: *R. B.* 46121, 46122, 46123]
  - Between Longming & Shangying, Tiandeng Co., SW Guangxi, China; alt. 600 m [Aug. 1998: *R. B.* 46124]
  - Daming Shan Mts., S slopes, Wuming Co., Guangxi, China; alt. 400–1000 m [Sep. 1998: *R. B.* 46126, 46127]
  - Laibang environs, Dabie Shan Mts., Yuexi Co., Anhui, China; alt. 700 m [Sep. 1998: *R. B.* 46134]
- Pinus hwangshanensis* W. Y. Hsia:
- SW boundary of Rucheng Co. (Hunan) with Guangdong, China; alt. 1500 m [Jan. 1994: *R. B.* 39126, 39128, 39129]
  - Tianzhu Shan massif (1488 m), Qianshan Co., SW Anhui, China; alt. 600–1450 m [July 1995: *R. B.* 42117, 42118, 42119]
  - Miaodao Shan massif (1432 m), Yuexi Co., SW Anhui, China; alt. 800–1400 m [July 1995: *R. B.* 42120, 42121]
  - Mt. Tiantangzhai (1729 m), Yingshan Co., E Hubei, China; alt. 700–1500 m [July 1995: *R. B.* 42124, 42125, 42126]
  - Yaoluoping environs, Dabie Shan Mts., Yuexi Co., Anhui, China; alt. 900–1300 m [Sep. 1998: *R. B.* 46135, 46141, 46142, 46143]
  - Between Laibang and Huo Shan massif, Dabie Shan Mts., Yuexi Co., Anhui, China; alt. 1300 m [Sep. 1998: *R. B.* 46144, 46145]

#### APPENDIX I. HERBARIUM MATERIAL EXAMINED

##### HERBARIUM SAMPLES COLLECTED:

List of herbarium samples collected by the author is ordered chronologically below according to localities where natural populations of relevant species were studied and representative trees sampled (month, year, and collection numbers are in brackets; R. B. is an abbreviation of R. Businský). Collections listed are stored in the herbarium of the Silva Tarouca Research Institute for Landscape and Ornamental Gardening (RILOG), 252 43 Průhonice, Czech Republic.

##### *Pinus taiwanensis* Hayata:

- Central Cross-Island Highway SSE near Lishan, Nantou Co., Taiwan; alt. about 2050 m [Nov. 1991: *R. B.* 32137]
- Hsuehshan massif (3884 m), SE slopes, Taichung Co., Taiwan; alt. 2400–3400 m [Nov./Dec. 1991: *R. B.* 32140, 32141a–d, 32142, 32144a–i]
- Central Cross-Island Highway at Tayuling, Hualien Co., N part, Taiwan; alt. about 2600 m [Dec. 1991: *R. B.* 32146, 32147, 32148, 32158, 32159]
- Along the road from Tayuling to Wushe, Nantou & Hualien Co. boundary, N part, Taiwan; alt. 2700–3200 m [Dec. 1991: *R. B.* 32152, 32153, 32154, 32155]
- Both sides of central ridge along the Southern Cross-

*Pinus fragilissima* Businský—additional field label information:

*R. Businský* 32172 (holotype)—old tree with 270 cm trunk circumference (at 1.3 m height), 23 m high, crown about 20 m in diameter

*R. Businský* 32173 (paratype)—old tree with 220 cm trunk circumference, branches to 12 m long

##### OLDER SPECIMENS EXAMINED:

*Pinus hwangshanensis* W. Y. Hsia:

**K. K. Tsoong 4495:** Anhwei [= Anhui], Hwangshan; 9.10.1924. Det. as *P. hwangshanensis* by W. Y. Hsia. [PE]

**M. Chen 703:** Chekiang [= Zhejiang], Tianmu Shan; 1.7.1933. Det. as *P. tabulaeformis* Carr. by? W. C. Cheng, and as *P. hwangshanensis* by W. Y. Hsia. [PE]

**M. Chen 1267:** Anhwei [= Anhui], Hwangshan, Shizi

- Feng, 6200 ft.; 4.10.1933. Det. as *P. tabulaeformis* Carr. by W. C. Cheng, and as *P. hwangshanensis* by W. Y. Hsia / H. H. Hu. [PE: two specimens]
- H. H. Hu 2621**: Kiangsi [= Jiangxi], [Jiujiang Co.], Lu Shan, Kuling [= Guling], trees 30–40 m high; Aug. 1934. Det. as *P. tabulaeformis* Carr. by H. H. Hu, and as *P. hwangshanensis* by W. Y. Hsia in 1936. “Paratype.” [PE]
- P. C. Tsoong 3111**: Anhwei [= Anhui], Hwangshan, Hsi-hai-men; coll. N. T. Liou & P. C. Tsoong, 28.8.1935. Det. as *P. hwangshanensis* by W. Y. Hsia. [PE]
- P. C. Tsoong 3461**: Anhwei [= Anhui], upper slope of Mt. Tientu near summit; 13.6.1936. Det. as *P. hwangshanensis*. [PE]
- P. C. Tsoong 3919**: Anhwei [= Anhui], on approaching Shin-Jin, in wood; 9.7.1936. Det. as *P. thunbergii*, and later, in 1956, as *P. hwangshanensis*. [PE]
- X. Y. He 30300**: Zhejiang, Tianmu Shan; **s. a.** Det. as *P. hwangshanensis* in 1964. [In Chinese; PE: specimens of five individuals]
- P. taiwanensis* Hayata:
- T. Kawakami & U. Mori 2097**: Taiwan, Central Mts; Nov. 1906. Lectotype of *P. taiwanensis* Hayata, designated by A. Farjon, 4.3.1992. [TI]
- B. Hayata & U. Mori 7142**: Taiwan, Randaizan; 9.8.1908. Syntype of *P. taiwanensis* Hayata. [TI]
- U. Mori, s. n.**: Taiwan; **s. a.** Type of *P. brevispica* Hayata. [TI]