

COTYLEDON NUMBERS IN CONIFERS

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A study was made of cotyledon numbers in the embryos dissected from seeds of more than 100 species of conifers. Many similar records from germinated seedlings have been made by others. Nearly all of our records were obtained from an examination of seeds that had been soaked in water. Samples ranging from 3 to more than 300 seeds per species were dissected and the cotyledons counted. When the number exceeded 40 or 50 the results could be tabulated statistically, showing the range in number of cotyledons, the mean number (m) and the standard deviation (σ). Many previous records have been summarized, extending the entire record to include 193 species in which the data on cotyledon numbers are known. The records, which were used as a basis of comparison, were taken from Hoopes 1868, Gordon 1880, Masters 1889, Dangeard 1892, Sargent 1896, Hill and DeFraine 1906-09, Buchholz 1919-39, Pilger 1926, Rehder 1927, Bailey 1933, Dallimore and Jackson 1931, and Boureau 1939. The appended tabular summary gives the details in these records.

In summarizing our own data together with all existing records, by genera and families, we find the greatest number and also the greatest variability recorded for the Pinaceae. *Pinus* and *Cedrus* have the largest mean number of cotyledons, the nine genera of Pinaceae appearing in the following order: *Cedrus* 9, *Pinus* 8.1, *Pseudotsuga* 6.8, *Picea* 6.4, *Abies* 5.9, *Larix* 5.7, *Pseudolarix* 4.4, *Keteleeria* 4.2, and *Tsuga* 3.7. It is even more illuminating to consider the range of variation found within each genus. It is as follows: *Cedrus* 13-5, *Pinus* 18-3, *Pseudotsuga* 12-4, *Picea* 15-2, *Abies* 10-2, *Larix* 8-3, *Pseudolarix* 7-4, *Keteleeria* 4-2, and *Tsuga* 7-2. No other family or sub-family of conifers includes species with such high numbers of cotyledons whether we consider the mean number or the maximum number of seed leaves.

In all of the remaining families or groups, it appears that certain primitive

genera may have 3 or more cotyledons, but the number tends to become reduced to 2 in the higher or more specialized genera. Among the Araucarians, we find from 4 to 2 cotyledons in four species of *Araucaria*. In *Agathis* the number is 2. Definite records for *Araucariaceae* are very scarce. The mean number for the family based on only four species is about 3 cotyledons.

In the *Taxodiaceae* we find the following numbers: *Taxodium* 5.4, *Cryptomeria* 3, *Taiwania* 2, *Cunninghamia* 2, *Sequoiadendron* 3.7, *Sequoia* 2.1, *Sciadopitys* 2.

In the *Cupressaceae* there are several species in each of several genera with higher numbers of cotyledons but in most of the species the number of cotyledons has become fixed at 2. *Cupressus*, *Juniperus*, *Chamaecyparis* and *Tetradclinus* include one or more species each, with cotyledon numbers in excess of 3. The genera *Libocedrus*, *Biota*, *Thuja*, *Thujaopsis*, *Fitzroya*, *Callitris*, *Widdringtonia* and *Actinostrobus* have uniformly 2 cotyledons.

The remaining conifers include several families of *Podocarps* and *Taxads*. *Taxus* has 2 cotyledons; very rarely 3 have been reported. Otherwise, our own investigations, as well as available records of previous workers, show that all of the conifers belonging to these families have 2 cotyledons.

In the following list, which for convenience is arranged alphabetically by genera, the records of previous investigators have been included. An effort has been made to merge names under the legitimate name of the species according to the current International Rules of Botanical Nomenclature, but the names under which the records were originally published have been retained, with entries given under the name of the original source as a synonym, in the categories that are considered legitimate names according to the present practice of taxonomists.

A few inconsistencies appear which we have not attempted to correct, though some may be explained. For example, Boureau (BO) reported only 5 cotyledons in *A. magnifica*, whereas Hickel (HI) reported 7-8, and Hill and DeFraigne (HF) reported 9. Our counts of 45 embryos in this species gave a mean of 8.7 cotyledons. It is possible that Boureau had obtained seeds of another species such as *A. nobilis*.

In the appended bibliography the letter symbols used to designate the author correspond to the entries giving the cotyledon numbers for each species. Our original entries are usually given: Cts. 57 gave 3-5 m $3.98 \pm .05 \sigma .35$, which should be read: Counts of 57 embryos gave 3-5 cotyledons, mean number 3.98 with probable error .05 and standard deviation .35. If all embryos had 2 cotyledons we state the number of embryos examined:—Cts. 20 gave 2. Abbreviations used are as follows:

Cts = counts of
sp = species
m = mean
rly = rarely
occ = occasionally
 σ = standard deviation

ABIES Mill. 24 sp m 5.9.

- A. alba* Mill. 3-7 P, (*A. pectinata*, DC.) 5-7 HI Cts 165 gave 4-6, $5.11 \pm .04 \sigma .49$.
A. amabilis (Dougl.) Forb. 8 HF.
A. arizonica See *A. lasiocarpa* v. *arizonica*
A. balsamea Mill. 4 (occ 5) B; 4 MO; 4 (rly 5) HI; 4 HF.
A. brachyphylla See *A. homolepis*.
A. bracteata See *A. venusta*.
A. cephalonica Loud. 5-6 EH; 6-7 (rly 8) HI; 6 BO; Cts 18 gave 4-8, m 6.06.
A. cilicica Carr. 7-8 (occ 9) HI.
A. concolor (Gord.) Engelm. 6 SU Cts 68 gave 2-7, $5.7 \pm .04 \sigma .36$.
A. concolor violacea (Roehl.) Beiss. Cts 112 gave 4-8, m $5.84 \pm .08 \sigma .74$.
A. firma Sieb. and Zucc. Cts 57 gave 3-5, $3.98 \pm .05 \sigma .35$.
A. Fraseri (Pursh.) Poir. 4-6 BO; 5 S; cts 71 gave 4-5, m $4.09 \pm .03 \sigma .40$.
A. grandis Lindl. 5-6 HI; 6 SU; cts 110 gave 7-12, m $8.58 \pm .10 \sigma 1.03$.
A. homolepis Sieb. and Zucc. (*A. brachyphylla* Maxim.) 4 BO.
A. lasiocarpa (Hook.) Nutt. 4-5 BO; 10 (error?) HI usually 4 SU cts 133 gave 3-8, m $4.44 \pm .15 \sigma 1.73$; cts of 33 by Mr. Phillip Haddock gave 4-6, m 4.85 (*A. subalpina* Engelm.) 5-6 DJ.
A. lasiocarpa var. *arizonica* (Merriam) Lemm. 4-5 HI; 4 SU.
A. magnifica Murr. 5 BO; 7-8 HI; 9 HF cts 45 gave 6-12, m $8.71 \pm .02 \sigma 1.09$.
A. magnifica shastensis Lemm. 9-13, usually 12 SU.
A. nobilis Lindl. 5-6 (occ 4 & 7) HI; 4-7 H; 6-7 SU; cts 57 gave 4-6, m $5.19 \pm .05 \sigma .43$.
A. Nordmanniana (Steven.) Spach. 6-7 (rly 4 and 5) HI; 5-7 BO.
A. numidica Carr. 6-7 HI.
A. pectinata DC. See *A. alba*.
A. Pindrow Royle 5 usually, HI.

- A. Pinsapo* Boiss. 7 CA; 5-7 BO; 7 HO; 5-7 HI. Cts 99 gave 4-8, m $6.34 \pm .09 \sigma .89$.
A. religiosa Lindl. 5 (occ 6 and 7) HI.
A. sibirica Ledeb. 4 HI; 3-4 BO. Cts 57 gave 3-5, m $3.95 \pm .08 \sigma .52$.
A. spectabilis (Don.) Spach. (*A. Webbiana* Lindl.) 5-7 BO; 4 M.
A. subalpina Engelm. See *A. lasiocarpa*.
A. Veitchii Lindl. 3-5, usually 4 BO; HI. Cts 25 gave 3-4, m 3.60.
A. venusta (Dougl.) K. Koch. (*A. bracteata* Nutt.) 5-7 HI, 7 SU; Cts 21 gave 5-7; cts 174 by Phillip Haddock gave 6-8, m 6.56.
A. Webbiana. See *A. spectabilis*.

ACTINOSTROBUS Miq 2.

- A. pyramidalis* Miq. 2 CC, G, L, HF, SA.

AGATHIS Salisb. (Dammara) 2 G, P.

- ARAUCARIA** Jusseau. 4 sp m. 3.
A. araucana (Moline) K. Koch. (*A. imbricata* Pav.) 2 D, HI, HF; 2-4 BA, 3 or 4 Strasb. Cts gave 2 and 4, m 3.60.
A. angustifolia O. Kuntze. (*A. brasiliensis* Rich.) 2 HF.
A. Bidwillii Hook. 2 HF.
A. excelsa Br. 4 HI.

BIOTA Endl. 2.

- B. orientalis* Endl. 2-3 HI (*Thuja orientalis* L.) 2 D; 2-3 C, L. Cts 33 gave 2-3, m 2.06.

CALLITRIS Vent. 2.

- C. sp.* 2 SA, HF (Frenela) 3 G.
C. quadrivalvis See *Tetraclinis articulata*.

CALLITROPSIS Compton 2.

- C. araucarioides* Compton. 2 P.

CEDRUS Trew. 3 sp. m. 9.

- C. atlantica* Manetti. 7-11 BO; 8-10 BA; 8-10 (M9) B; 8-10 (4 rly) HI; 10-11 HF. Cts 7 gave 7-10, m 8.86.
C. Deodara (Roxb.) Loud. 9-15 BO; Up to 13 HI. Cts 105 gave 7-12 (rly 14) m $9.99 \pm .13 \sigma 1.36$.
C. libani Loud. 8-10 (m 8.8) B; 9-14 (m 10.90) B; 8-9 BO; 9-10 DJ; 9 G, HO. Cts 251 gave 5-13, m $9 \pm .08 \sigma 1.23$.

CEPHALOTAXUS Seib. & Zucc. 2.

- C. drupacea* Sieb. and Zucc. (including var. *pedunculata* (Sieb. & Zucc.) Miq.) 2 HF; B.

CHAMAECYPARIS Spach. sp m 2.25.

- C. Lawsoniana* (A. Murr.) Parl. 2; 2 (rly 3 or 4) S; 3 HI; 2 SU. Cts 200 gave 2-4, m $2.05 \pm .04 \sigma .29$.
C. nootkatensis (Lamb.) Spach. (*Cupressus nootkatensis* Lamb.) 2 rly 3-4) S; 3 HI.
C. obtusa (Sieb. and Zucc.) Endl. (*Cupressus obtusa* K. Koch.) 2 G, HF.
C. pisifera (Sieb. & Zucc.) Endl. Cts 64 gave 2.
C. thyoides (L.) B. S. P. (*Cupressus thyoides* L.) 2 (rly 3 or 4) S.

CRYPTOMERIA D. Don. 3.

- C. japonica* (L. f.) Don. 3 BO; 2-3 LU; 2 or 3 HF. Cts 168 gave 2-4, m $3.03 \pm .03 \sigma .30$.

CUNNINGHAMIA R. Br. ex Rich. 2 +.

- C. lanceolata* (Lamb.) Hook. (*C. sinensis* R. Br.) 2-3 BO; 2 HO. Cts 43 gave 2-4, m $2.07 \pm .07 \sigma .45$.

CUPRESSUS L. 11 sp m 2.7.

- C. arizonica* Greene. 4 HI; 3-5 SU. Cts 55 gave 2-5, m $3.78 \pm .12 \sigma .87$.
C. arizonica bonita Lemm. (*C. glabra* Sudw.) 3-4 SU. Cts 51 gave 3-5, m $3.90 \pm .08 \sigma .58$.

- C. *Benthamii* Endl. See *C. lusitanica* var. *Benthamii*.
 C. *Corneyana* Knight. See *C. Duclouxiana* Hickel.
 C. *funebrils* Endl. 3 HI; 2 BO; 2-4 S.
 C. *glabra*. See *C. arizonica* bonita.
 C. *Goveniana* Gord. 3 rly 4 G; 2 S; 3, occ 4, SU. Cts 63 gave 2.
 C. *Lawsoniana* (L.) See *Chamaecyparis Lawsoniana*.
 C. *Lindleyi*. See *C. lusitanica*.
 C. *lusitanica* Mill. var. *Benthamii* Carr. (*C. thurifera* B.S.P.) 2 BO; 3 HI. Cts 22 gave 2-4, m 3.05. (*C. Lindleyi*) 3 BO; 3 or 4 HI; 3 or 6 D.
 C. *Macnabiana* A. Murr. 2 BO; 3 (occ 4) HI; 2 (rly 3-4) S.
 C. *macrocarpa* Hartw. 3-4 DJ; 3-4 G; 2-4 BO; 3 HI; 2 (rly 3-4) S; 3 SU. Cts 18 gave 3-4, m 3.61.
 C. *nootkatensis*. See *Chamaecyparis nootkatensis*.
 C. *obtusa*. See *Chamaecyparis obtusa*.
 C. *pisifera*. See *Chamaecyparis pisifera*.
 C. *sempervirens* L. 2 HI; 3-4 (5 rly) P. Cts 62 gave 2-5, m 2.25 ± .08 σ .63.
 C. *sempervirens* var. *horizontalis* Gord. Cts 90 gave 2.
 C. *sempervirens* var. *stricta* Ait. (*C. fastigata* DC.) Cts of 76 gave 2.
 C. *thurifera*. See *C. lusitanica* var. *Benthamii*.
 C. *thyoides*. See *Chamaecyparis thyoides*.
 C. *Duclouxiana* Hickel. (*C. torulosa* Rehd. and Wils.) 2-5 BO; 2 G; 3-4 (rly 5) HF. (*C. torulosa* Corneyana Carr.) 2 D.
 DAMMARA Rum. (See AGATHIS).
 FRENELA Mir. (See CALLITRIS).
 FITZROYA Hook. 2.
 F. *cupressoides* (Molina) Johnston 2 DJ, P.
 JUNIPERUS L. 17 sp m. 2.3.
 J. *californica* Carr. 4-6 HI, SU, S. Cts 45 gave 3-6, m 4.29 ± .09 σ .58.
 J. *Cedrus* Webb. Cts 72 gave 2-3, m 2.03 ± .02 σ .21.
 J. *chinensis* L. Cts 8 gave 2.
 J. *communis* L. 2 (occ 3-4) B; 2 HI, Cook. Cts 46 gave 2.
 J. *conferta* Parl. Cts 51 gave 2.
 J. *flaccida* Schecht. 2 S, SU.
 J. *macrocarpa* Sibth. Cts 53 gave 2.
 J. *monosperma* (Engelm.) Sarg. 2 S, SU.
 J. *occidentalis* Hook. 2 S, SU.
 J. *Oxycedrus* L. 2 G.
 J. *pachyphloea* Torr. 2 S.
 J. *rigida* Sieb. & Zucc. Cts 88 gave 2-3, m 2.02 ± .01 σ .15.
 J. *Sabina* L. 8 G, MO. Cts 15 gave 2.
 J. *sabinooides*. See *J. thurifera*.
 J. *scopulorum* Sarg. Cts 24 gave 2 and 4, m 2.08.
 J. *thurifera* L. (*J. sabinooides*, Endl.) 2 S, SU.
 J. *utahensis* (Engelm.) Lemm. 4-6 HI, S, SU.
 J. *virginiana* L. 2 BO, HI, S.
 KETELEERIA Carr. 2-4.
 K. *Davidiana* (Franch.) Beiss. 2-3 (occ. 4) HI.
 K. *Fortunei* (A. Murr.) Carr. 2 HI; 4 B, HU.
 LARIX Mill. 5 sp m 5.7.
 L. *decidua* Mill. (*L. europea* DC.) 4-7 (rly 7) BO; 5-7 B; 4-7 HI; 5-7 HO; 5 or 6 SH. Cts 100 gave 4-7, m 5.94 ± .07 σ .70.
 L. *leptolepis* (Sieb. & Zucc.) Gord. (*L. Kaempferi* Sarg.) 5-7 (rly 4) BO. Cts of 56 gave 4-8, m 6.09 ± .11 σ .83.
 L. *laricina* (Duroi.) K. Koch. 5 SU. Cts 21 gave 5-7, m 5.57.
 L. *Kaempferi*. See *L. leptolepis*.
 Larix *Lyallii* Paul 5 SU.
 L. *occidentalis* Nutt. 5-6 SH, 6 SU. Cts 81 gave 3-7, m 5.12 ± .11 σ 1.02.
 L. *sibirica* Ledeb. 5-8 ? BO.
 LIBROCEDRUS Endl. 2 +.
 L. *decurrens* Torr. 2 BA, G, HO, HI, S; 2 or 3 CC; 2, (occ 3) HF, SU. Cts 92 gave 2-3, m 2.04 ± .02 σ .21.
 PICEA A. Deitr. 13 sp m 6.4.
 P. *Abies* (L.) Karst. 6-10 BO; 6-11 P; (*P. exelsa*) 7-9 G, HO. Cts 90 gave 3-4; 6-11, m 7.66 ± .18 σ 1.19.
 P. *alba*. See *P. glauca*.
 P. *ajanensis*. See *P. jezoensis*.
 P. *asperata heterolepis* (Rehd. & Wils.) Cheng. (*P. heterolepis*) 7-9 LU.
 P. *Breweriana* S. Watts. 6 SU.
 P. *canadensis*. See *P. glauca*.
 P. *Engelmanni* (Parry) Englm. 6 SU.
 P. *exelsa*. See *P. Abies*.
 P. *glauca* (Moench) Voss. (*P. alba*, Link.) 5-7 D, HF; 4-7 (rly 4 and 7) HI. (*P. canadensis* P.S.P. 6-9 SU. Cts 122 gave 2-8, m 5.01 ± .13 σ 1.49. (*P. canadensis horizontalis*.) Cts. 152 gave 5-8, 6.12 ± .05 σ .62.
 P. *Glehnii* (Fr. Schmidt) Mast. Cts 191 gave 4-7, m 5.42 ± .91 σ .11.
 P. *Jezoensis* (Sieb. & Zucc.) Carr. Cts. 4-7 m, 5.13 ± .10 σ .78. (*P. ajanensis* Fisch.) 4-7 (4 and 7 rly) HI; 6-9 HF.
 P. *mariana* (Mill.) B.S.P. 6 SU; 3-6 (m 4.93) B. (*P. nigra* Link.) 6 or 7 HF.
 P. *Morinda*. See *P. Smithiana*.
 P. *orientalis* (L.) Link 6-10 L; 14 HF. Cts 90 gave 7-10, m 8.28 ± .08 σ .77.
 P. *pungens* Engelm. 6-7 (occ 8) HI. Cts 44 gave 5-8, m 6.39 ± .11 σ .68. (*P. parryana*) 5-6 SU.
 P. *rubens* Sarg. (*P. rubra* Link) 6-7 HI. *P. sitchensis* (Boug.) Carr. 4-6 HI; 4-5 SU. *P. Smithiana* Boiss. (*P. Morinda* Link.) 8-10 HI; HF.
 PINUS L. 64 sp m 8.12.
 P. *albicaulis* Engelm. 7-9 SU.
 P. *apachea* Lemm. 8-10 SU.
 P. *aristata* Engelm. 7 G; 6-8 M, 6-7 SU. Cts. 104 gave 5-9, m 7.41 ± .08 σ .85.
 P. *Armandi* Franch. 11-13 HI.
 P. *attenuata* Lemm. 5-8 M. (*P. tuberculata* Gord.) 7-8 G; 5-6 HI; 5-8 SU. Cts of 136 gave 6-8, m 7.08 ± .07 σ .74.
 P. *Ayacahuite* Ehrenb. 12-15 M.
 P. *Balfouriana* A. Murr. 5 M, SU.
 P. *Banksiana* Lamb. 3-5 BO; 4 HI; 4-5 SU. Cts 35 gave 4-6, mean 4.86. (*P. divaricata* Dum.-Cours.) 12-16 H; 15-14 M.
 P. *Benthamiana* Hartw. See *P. ponderosa*.
 P. *Bungeana* Zucc. 11-12 M, Cts 28 gave 8-12, m 10.61.
 P. *canariensis* Smith. 6-8 (9 and 11 rare) BO; 6-8 M; 9 HF; 6-9 HI; 9-12 T.
 P. *caribaea* Morelett. Cts 82 gave 5-10, m 7.73 ± .11 σ 1.02.
 P. *Cembra* L. 9-13 HI; 8-14 M; 8-14 P; 9-12 T. Cts 67 gave 6-12, m 9.63 ± .15 σ 1.25.
 P. *cembroides* Zucc. 10-12 G. 8-10 M, 8-15 SU.
 P. *cembroides edulis* (Engelm.) Voss. (*P. edulis* 6-10 (11 and 13 rly) BO; 6-10 HI; 7-10 M, SU. Cts 319 gave 6-12, m 8.19 ± .06 σ 1.07.
 P. *cembroides monophylla* (Torr & Frem.) Voss (*P. monophylla*, Torr.) 6-8 HI; 7-10 BO; SU; 8-10 C; (*P. Fremontiana*, Endl.) 8-10 G.
 P. *cembroides Parryana* (Engelm.) Voss (*P. quadrifolia* Parr., *P. Parryana* Engelm.) 8 M, 6-8 SU.
 P. *contorta* Loud. 3-4 (rly 2 and 5) HI; 2-6 BO; 3-4 DJ; 3-6 (usually 5) SU. Cts 54 gave 4-8, m 5.63 ± .14 σ 1.09.

- P. contorta latifolia* S. Wats. (*P. Murrayana* Balf.) 4-5 HI; 3-5 HF. Cts 111 gave 4-7, m 5.47 ± .07.
- P. Coulteri* Don. 12-13 (10 and 15 occ) HI; 8-11 CA; 10-14 P, M; 13 HF; 9-14 SU. Cts 7 gave 12-14, m 12.43.
- P. densiflora* Sieb. & Zucc. 6-7 (5 and 8 rly) BO; 6 G. Cts 99 gave 5-8, m 6.69 ± .08 σ .77.
- P. divaricata*. See *P. Banksiana*.
- P. echinata* Mill. 4-7 M; 6 MO (*P. mitis* Michx.) 5-6 HI; 6 G.
- P. edulis*. See *P. cembroides edulis*.
- P. excelsa* Wall. 10 BO; 10-12 (6 and 14 occ) CA; 9-11 (8, 12, 13 occ) HI; 8-10 D; 8-12 M, P; 9-11 T.
- P. flexilis* James. 8-9 HO, M; 9-14 HI; 6-9 SU.
- P. Fremontiana*. See *P. cembroides monophylla*.
- P. Gerardiana* Wall. 10 BO, HF; 10 (8 and 13 rare) HI; 3-8 M.
- P. glabra* Walt. 5-6 M.
- P. Gordoniana*. See *P. Montezumae*.
- P. halepensis* Mill. 6-8 (9 rly) BO; 7 G, HO; 6 HI; 6-9 M. Cts 100 gave 6-9, m 7.17.
- P. inops*. See *P. virginiana*.
- P. insignis*. See *P. radiata*.
- P. Jeffreyi* Murr. 10-13 (9 and 14 rly) HI; 10 T; 7-11 SU. Cts of 98 gave 7-13, m 9.82 ± .11 σ 1.08.
- P. koraiensis* Sieb. & Succ. 10-14 HI; 11-13 HO. Cts 49 gave 9-13, m 11.08 ± .09 σ .96.
- P. Lambertiana* Dougl. 12-13 G; 10-16 HI; 12-16 H; 12-15 M, SU. Cts 97 gave 11-18, m 13.58 ± .14 σ 1.45.
- P. Laricio*. See *P. nigra*.
- P. leucodermis* Antoine cts 72 gave 5-8, m 6.75 ± .08 σ .73.
- P. longifolia*. See *P. Roxburghii*.
- P. maritima*. See *P. Pinaster*.
- P. Massoniana*. 6 G, HO, M.
- P. mitis*. See *P. echinata*.
- P. monophylla*. See *P. cembroides monophylla*.
- P. montana*. See *P. mugo*.
- P. montana*. *Mughus*. See *P. mugo mughus*.
- P. montana uncinata*. Ram. See *P. mugo rostrata*.
- P. monticola* Lamb. 7-9 (rly 10) BO; 6-9 H, SU.
- P. Montezumae* Lamb. 6-8 G; 7-10 (rly 6 or 11) HI.
- P. Mugo Turra*. (*P. montana* Mill.) 3-4 HF; 5 M; 6 (rly 4 and 7) T. (*P. montana* *Mughus* Willk. 4-6 (3 rly) BO; 3-5 6 rly) HI. Cts 134 gave 3-7, m 4.69 ± .06 σ .74.
- P. mugo Mughus* (Scop.) Zenari 4-5 HI.
- P. mugo pumilio* (Haenke) Zenari 5-7 HO.
- P. mugo var. rostrata* (Ait.) HO (*P. uncinata* Ramond) 6 (5 & 7 rly) BO.
- P. muricata* D. Don. 4-6 BO, HI; 5 G; 4-5 SU.
- P. Murrayana*. See *P. contorta latifolia*.
- P. nigra* Arnold Cts 99 gave 6-10 (rly 4) m 7.61 ± .10 σ 1.01 (*P. Laricio* Poir.) 6-8 (9 and 10 rly) BO; 8 D; 6-8 G, H; 7-8 HI; 8-10 HF; 4-8 M. Cts 99 gave 5-10 (13 rly) m 7.45 ± .12 σ 1.21.
- P. occarpa* Schiede. 7-8 G.
- P. orientalis* L. 6-10 LU.
- P. Orizabae* Gord. 7-8 G, HO.
- P. palustris* Mill. 7-8 (5 occ 9 rly) BO; 7-10 M. Cts 125 gave 6-11 m 8.01 ± .08 σ .94.
- P. Parryana*. See *P. cembroides Parryana*.
- P. parviflora* Sieb. & Zucc. 8-10 CA; 8-12 (11, 12 rly) HI; 8-10 GO, HO. Cts 104 gave 7-13, m 9.55 ± .13 σ 1.33.
- P. patula* Schlech. 4-7 (mean 4.93) BO. Cts 99 gave 4-7, m 5.24 ± .7 σ .71.
- P. Peuce* Griseb. 9-10 M. Cts 104 gave 8-12 (6 rly) m 9.92 ± .10 σ 1.01.
- P. Pinaster* Ait. 7-8 G, HO; 6-8 HI; 6-7 LU; 7-9 T. (*P. maritima* Dur.) 9 (occ 7) D. Cts 125 gave 6-10 (12 rly) m 7.65 ± .09 σ .97.
- P. Pinea* L. 9-10 G, HI 7-13 HI; 11-13 D; 9-11 HO; 10-13 T; 11 BO. Cts 22 gave 9-14, m 12.14.
- P. ponderosa* Laws. 9 BO; 6-11 M; 9 T; 5-9 SU. Cts 94 gave 6-10, m 7.93 ± .09 σ .86.
- P. pumilio*. See *P. mugo pumilio*.
- P. pungens* Lamb. 6-8 G, HO; 7-8 M; 6-7 (5 occ) HI.
- P. quadrifolia*. See *P. cembroides Parryana*.
- P. radiata* Don. 8 G; 7-8 HO; 6-9 M; 5-7 SU. (*P. insignis* Dougl.) 5-8 (9 rly) HI, HF. Cts 100 gave 5-9, m 7.31 ± .10 σ .99.
- P. resinosa* Ait. 5-7 H; 6 MO; 6-7 M.
- P. rigida* Mill. 5-6 HI; 6-10 HO; 4-6 LU; 5 M; 8-11 T. Cts 87 gave 4-8, m 5.55 ± .07 σ .64.
- P. Roxburghii* Sarg. (*P. longifolia*, Rox.) 10-14 BO, HI.
- P. Sabiniana* Dougl. 12-15 (16, 17 and less than 12 rare) HI; 11-18 Carriere; 15-18 DJ; 8-10 G; 7-12 HO; 12-18 M; 12-18 P; 15-16 SU. Cts 33 gave 12-18, m 14.06.
- P. Strobilus* L. 9 BO; 8-10 (7 and 11 rly) HI; 7-9 CA; 7-14 M. Cts 101 gave 7-10, m 8.43 ± .09 σ .95.
- P. strobiliformis* Engelm. 10-12 SU.
- P. sylvestris* L. 3-8, (m 7) BO; 6 CV; 6-9 D; 5-7 G; 5-7 HO; 4-7 H; 3-8 HF. Cts 89 gave 4-8, m 6.01 ± .08 σ .74, combined results, 1023 gave 3-8, m 6.97 ± .04.
- P. sylvestris rigensis* Loud. Cts 125 gave 4-7, m 5.93 ± .06 σ .62.
- P. Taeda* L. 7-8 HI; 4-7 P; 5-10 LU. Cts 88 gave 5-9, m 6.87 ± .09 σ .84
- 8-10 G; 7-12 HO; 12-18 M; 12-18 P; 16-16 T.
- P. Torreyana* Parr. 12-14 SU.
- P. Thunbergii* Parl. 6-7 (8 rly) BO; 7-8 HF; 6-8 T; 6-7 HI. Cts 99 gave 4-9, m 6.78 ± .09 σ .91.
- P. tuberculata*. See *P. attenuata*.
- P. uncinata*. See *P. mugo rostrata*.
- P. virginiana* Mill. 4-6 M. (*P. inops* Ait.) 6-8 G.

PODOCARPUS Pers. 2.

- P. Blumei* Endl. Cts 3 gave 2-3.
- P. coriaceus* L. C. Rich. Cts 11 gave 2.
- P. chilina* Rich. Cts 4 gave 2.
- P. imbricatus* Bl. Cts 3 gave 2.
- P. nagi* Zoll & Moritz Cts 9 gave 2
- P. macrophyllus* (Thunb.) Lamb. (*P. chinensis*) 2 HF. Cts 14 gave 2.
- P. nankoensis* Hayata Cts 5 gave 2.

PSEUDOLARIX Gord. 1 sp m 4.4.

- P. usumbarensis* Pilger. Cts 15 gave 2.
- P. amabilis* Rehd. (*P. Kaempferi* Gord.) 4-5 BU; 5 G; 4-5 HF.

PSEUDOTSUGA Carr.

Mean of 2 sp m 6.8.

- P. macrocarpa* (Torr.) Mayr. 6-7 SU.
- P. taxifolia* (Pair.) Britton. (*P. Douglassi* Carr.) 5-8 (9 rly) BO; 6-8 (rly 5) HI; 6-7 SU. Cts of 43 gave 5-9, m 6.87 ± .08 σ .76.

SAXEGOTHAEA Lindl. 2.

- S. conspicua* Lindl. 2 DJ, G. Cts 4 gave 2.

SCIADOPITYS Sieb. & Zucc. 1 sp 2 ±

- S. verticillata* Sieb. & Zucc. 2 Hikel; 2-3 (m 2.08) B. Cts 76 gave 2-4, m 2.07 ± .04 σ .34.

SEQUIADENDRON Buchholz

- S. giganteum* (Lindl.) Buchholz. 3-6 G, CC; 4 (rly 3 or 5) HI; 2-6 B. Cts 234 gave 3-6, m 3.68 ± .03 σ .27.

SEQUIOIA Endl. 1 sp m 2.1.

- S. sempervirens* Endl. 2 BO, CC, HF; 2 or 3 HI, G; 4-6 (error) S, P; 2-3 (m 2.1) B. Cts 113 gave 2-4, m 2.14 ± .03 σ .35.

- TAIWANIA** Hayata. 2 +.
- T. cryptomerioides* Hayata. 2 B, P. Cts 4 gave 2, 1 had 3.
- TAXODIUM** Rich. 2 sp m 5.4.
- T. distichum* Rich. 5-9 G; 5-6 (4 and 7 rare) HI; 2-3 HO; 4-9 S; 6 MO. Cts 400 gave 4-8 m 6.09 by K.
- T. mucronatum* Tenore. Cts 78 gave 3-5 m $4.12 \pm .04 \sigma$.37.
- TAXUS** L. 2 +.
- T. baccata* L. 2 DJ, D, G, HO, LU, P, S; 2-3 HI. Cts 91 gave 2-3, m $2.07 \pm .03 \sigma$.25.
- T. brevifolia* Nutt. 2 S, SU.
- T. canadensis* Marsh. 2 HO.
- T. cuspidata* Sieb. & Zucc. Cts 51 gave 2-3, m $2.02 \pm .02 \sigma$.14.
- TETRACLINIS** Masters. about 4.
- T. articulata* (Vahl) Mast. (*Callitris quadrivalis* Vent.) 3-5 P, BO; 4 HI.
- THUJA** L. 2.
- T. occidentalis* L. 2 BO, CO, D, L. Cts 77 gave 2.
- T. orientalis* L. See *Biota orientalis*.
- T. plicata* Lamb. (*T. gigantea* Nutt.) 2 HI, D, S, SU. Cts 66 gave 2.
- T. Standishii* Carr. (*T. japonica* Maxim.) 2 HF.
- THUJOPSIS** Seib. & Zucc. 2.
- T. dolobrata* Sieb. & Zucc. 2 G, HI. Cts 29 gave 2.
- TSUGA** Carr. 4 sp m 3.7.
- T. canadensis* (L.) Carr. 3 D; 3-4 HI. Cts 217 gave 2-7, m $4.24 \pm .08 \sigma$ 1.19.
- T. heterophylla* (Raf.) Sarg. 2-3 (4 rly) BO; 3-4 SU.
- T. Mertensiana* (Bong.) Carr. 3-4 HI; 3-5 H; 4 SU. Cts 74 gave 3-4, m $3.09 \pm .04 \sigma$.29.
- T. Sieboldii* Carr. 3-4 BO. Cts 41 gave 3.
- TORREYA** Arn. 2.
- T. californica* Torr. 2 S, SU. Cts 3 gave 2.
- T. nucifera* (L.) Sieb. & Zucc. 2 C, G. Cts 20 gave 1-2, m 1.95.
- T. taxifolia* Arn. 2 C, G, HO, S.
- WIDDRINGTONIA** Endl. 2.
- W. cupressoides* Endl. 2 (rly 3) SA.
- W. Whytei* Rendle. 2 HF.
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