

THE DISTRIBUTION OF PHYTOPHTHORA CINNAMOMI¹

by

Bowen S. Crandall and G. Flippo Gravatt

INTRODUCTION

Considerable changes in concept of the genus *Phytophthora*, as plant pathogens, have occurred in the past 30 years. In his Taxonomy in 1931 Tucker (281) reported 20 species in the genus. In his monograph of the genus (282) in 1933, using 524 references, he reported 216 hosts in 149 and 67 families. To these naturally infected hosts he added 82 additional in 45 genera and 6 families by artificial inoculation. In 1956 a total of 71 species were listed in the genus by Waterhouse (296). The present review of the single species, *Phytophthora cinnamomi* Rands, which in 1933 was reported on some 15 hosts, lists 212 species in 117 genera and 48 families. These reports occur in 316 selected references (about half of the total reviewed).

The history of Plant Pathology is the history of *Phytophthora*. Anton de Bary fathered the science and spanned the whole formative period. From "Untersuchungen über die Brandpilze" published in 1853 to "The Morphology and Biology of the Fungi, Mycetozoa and Bacteria" which appeared in 1884 we have Plant Pathology emerging as a science. The genus *Phytophthora*—for "plant killer"—was erected by de Bary in 1876 (J. R. Agric. Soc., 12 Ser. 2,1) to contain *P. infestans*. This fungus, or rather the losses from it, had been seen in America before 1845 but it first attracted attention in that year when it caused the great epiphytotic on potatoes in Ireland. Of 8,000,000 people over 1,000,000 died of famine and some 1,500,000 emigrated.³

Part I.—HOST DISTRIBUTION

P. cinnamomi, an immigrant to both Europe and the Americas, may not have killed its millions in a great epiphytotic, but it is or is well on the way to becoming the greatest of the plant killers. It is tragic that both these members of the genus *Phytophthora* were moved from their original home by men

1. For ease in publication the material is presented as Part I.—Host Distribution, Part. II.—Geographical Distribution, and Literature Cited. Part I will be followed by Part III and Literature Cited in a later volume.

2. The authors, during the period when the work presented was carried out, were Pathologists: Division of Forest Pathology; B. P. I. S. A. E.; United States Department of Agriculture.

3. See Niederhauser, John S. The Blight, The Blighter, and the Blighted, in Transactions of the New York Academy of Sciences, Ser. II, Vol. 19, No. 1, pp 55-63. 1956.

desiring to introduce plants for a better way of life. *P. cinnamomi* has been described as a primary cause in the decline and loss of American and European chestnuts and related species. It was first described on Cinnamon in Sumatra and subsequently showed up in the same family on the Avocado, causing a serious disease of this host whenever introduced where it was grown.

P. cinnamomi has an affinity for the members of some families, but many reports are single occurrences on single species in one genera. They serve to indicate, however, where trouble might subsequently be expected on native flora when conditions favorable for the fungus occurs. Most of the hosts are tropical or sub-tropical in their habitat. That such losses may well continue to occur, as the fungus reaches susceptible populations, is indicated by recent attack on pine in the southeast United States and New Zealand walnuts in the United States and Europe, Cork-oak in Europe, and Rhodendrons, azalias, heaths and other Ericaceae in many parts of the world. The present distribution is almost world-wide and dissemination of the pathogen, which probably started during the colonial era, can probably be expected to continue thru distribution of nursery stock which inadvertently carries it.

In general, for the host plants listed, *P. cinnamomi* is almost an obligate parasite of the rootlets, roots, and collar region. It attacks phloem and cambium tissue during periods of water saturation of the surrounding soil. Its isolation in pure culture is somewhat difficult as it is regularly overwhelmed by lesser parasites or saprophytes. Even in the host tissue it is often alive only in a zone 1 or 2 mm. wide penetrating healthy tissue. It will be followed closely by other fungi which are often mistaken and considered to be the primary parasite.

HOST DISTRIBUTION¹

THALLOPHYTA no reports

BRYOPHYTA no reports

PTERIDOPHYTA 1 report

Class: FILICINAE (4 orders)

Order: Filicales

GLEICHENIACEAE

Dichanopteris emarginata Hawaii -173

SPERMATOPHYTA

s/d GYMNOSPERMAE (4 orders)

Order: Cycadales (1 family)

CYCADACEAE (9 genera and some 85 species)

Macrozamia reidii Australia (by inference) -228

Order: Coniferales (2 families with a high degree of susceptibility in some genera of each.)

1. Arranged according to class, order, family, genus and species in Bailey's Cyclopedia of Horticulture. Resistant species mentioned when known. Unidentified species reported only when they provide the only report to a genus or a locality.

TAXACEAE (8 genera & some 70 species)

- Podocarpus drouyniana* Australia (by inference) -228
Taxus baccata L. -English yew N. Z.-195, Neth.-51, U.S.(Md.)-73 (Ore.)-279
T. b. var. stricta (*fastigata*) -Irish yew U. S. (Ore.)-279
T. cuspidata Sieb. & Zucc. -Japanese yew U. S. (Md. & Va.-73) (Del.)-169, (Ore.)-279
T. media Rehd.-Anglojap yew U. S. (Md.)-74, (Del.)-169

PINACEA (25 genera and some 240 species)

- Abies fraseri* (Pursh) Poir -Fraser fir U. S. (N. C.-156)
A. nordmanniana Spach.-Nordman fir U. S. (Ore.-279)
A. pectinata D. C. -Silver fir U. S. (Ore.-279)
A. procera Rehd.-Nobel fir U. S. (Ore.-250)
A. siberica Ledeb. U. S. (Ore.-279)
Agathis australis Salisb. -Kawri pine or Dammarpine N. Z.-47,195
Cedrus atlantica Menetti -Atlas cedar U. S. (Ore.-279)
C. deodar (Roxb.) Loud. -Deodar cedar U. S. (Calif.-307)
Chamaecyparis lawsonia (L.) Parl. -Lawson cypress, Port Orford cedar U. S. Calif.-21, Fla. & La.-61, Ore.-130, 177, 181, 249, 250, 278) Canada-21, Nth.-51, N. Z.-195
C. l. var's allumni, elwoodi, fletcheri, lutea, and nestoides by inoculation -279
(*C. thyoides* (L.) B. S. P.-Atlantic white cedar; *C. obtusa* (Sieb. & Zucc.) Endl.-Hinoki cypress; *C. pisifera* (Sieb. & Zucc.) Endl. -Sawara cypress; and *C. nootkatensis* (Lamb.) Spach. -Alaska yellow cedar: reported resistant -279
Juniperus sp. Juniper U. S. (Md.-149)
(*J. chinensis* (L.) var. *pfitzeriana* Spaeth. -Chinese juniper; *J. excelsa* Bied. var. *stricta* Gord.; *J. sabina* L.; *J. squamata* Lamb. var. *meyeri* Rehd.: reported resistant -277
Cupressus lusitanica var. *benthami* Carr. -Portuguese cypress by symp-
tom only N. Z. -195.
C. macrocarpa Hartu (*C. lambertiana* Gord.) -Monterrey cypress N. Z. -195.
C. sempervirens L. -Italian cypress U. S. (Calif.-308)
C. sp. -Introduced oramental Argentina -117
Larix decidua Mill. -European larch U. S. (Md.-73)
L. kaempferi Sarg. (*L. leptolepis*) (S. & Z.) Gord. -Japanese larch England -5, U. S. (Md.-73)
Libocedrus decurrens L. -Incense cedar U. S. (Calif.-308)
Picea abies Mill. -Norway spruce U. S. (Md. & Va. -73) England -193
P. glauca Voss. (*P. canadensis* B. S. P. & *P. alba* Link) -White spruce U. S. (Ore. -250)
P. pungens Engelm. -Colorado spruce U. S. (Md.-73)
P. sitchensis (Bong.) Carr. -Sitka spruce England -6, 7, 193
Pinus canariensis C. Sm. -Canary pine U. S. (Calif. -308)
P. caribae Morel. -Slash pine Australia (more susceptible than *P. echinata*) -199

- P. echinata* Mill. -Shortleaf pine U. S. (Southeast) -55, 56, 57, 54, 59, 60, 141; Australia -199
- P. muricata* Don. -Bishop pine N. Z. -195
- P. nigra* Arnold var. *poiretiana* (Ant.) Asc. & Gra. -Corsican pine England -6
- P. pinaster* Sol. (*P. maritima* Poir.) -Cluster pine N. Z. -195
- P. radiata* Don -Monterrey pine N. Z. -10, 15, 46, 195, 241, 242; Argentina -117; U. S. (Calif. -308)
- P. resinosa* Ait. -Red pine U. S. (Md., Del., Pa. -73, 93, 148; N. Y. -271)
- P. strobus* L. -White pine U. S. (Md.-73)
- P. sylvestris* L. -Scots pine England -6; U. S. (Md. & Va. -73, 93)
- P. taeda* L. -Loblolly pine U. S. (southeast) -55, 56, 57, 59, 60; Australia -199 (as in the U. S. more resistant than *P. echinata*)
- (*P. mugo* Turra var. *mughus* (Scop.) Zenari: Reported resistant in U. S. (Ore.-277; Md.-74)
- Pseudotsuga menziesii* (Mirb.) Franco (*P. taxifolia* (Poir.) Britt. -Douglas fir U. S. (Md.-74, 130, 79; Ore.-250, 279); N. Z.-195; Portugal -221
- Thuja occidentalis* L. var. *compacta* Carr. -Parsons arbovitae U. S. (Calif.-303): but note that the varieties *fastigata* Joeg; *aureovariegata* Henk. & Hocht.; *pyramidalis* Hort.; and *Woodwardii* Spaeth. are reported resistant -277
- T. orientalis* L. var. *compacta* Buss. -Oriental arbovitae U. S. (Ore. -279): var *aurea* Senecl. reported resistant -277
- T. sp.* -Arbovitae Argentina -117.
- Tsuga heterophylla* (Raf.) Sarg. -Western hemlock U. S. (Ore.-250)

s/d ANGIOSPERMAE

Class: MONOCOTYLEDONAE

Order: Farinosae

BROMELIACEAE (40 genera and some 900 species)

- Ananas comosus* (L.) Merr. -Pineapple Hawaii -31, 164, 175; Australia 13, 163, 164, 175; Cuba & Jamaica -50, 175; Puerto Rico, Costa Rica & Phillipines -175; Fiji -188

Order: Liliiflorae

LILIACEAE (200 genera & some 2,000 species)

- Allium cepa* L. -Onion Hawaii -262, 263
- Lilium philippinense* -Philippine lily Australia -10
- Xanthorhaea preissii* -Australia (by inference) 228

Order: Microspermae

ORCHIDACEA (400 genera and from 6-10 thousand species)

- Oncidium* sp. -Java 258, 282

Class: DICOTYLEDONAE

Order: Verticillales (1 family)

CASUARINACEAE (1 genus & some 25 species)

- Casuarina fraseriana* -Australia (by inference) 228

(Note that *C. equisetifolia* in Florida and California is reported susceptible to *Armillaria* and *Clitocybe* root rot.)

Order: Salicales

SALICACEAE (2 genera & some 180 species)

Salix caprea L. -Goat willow Argentina -117

Order: Juglandales

JUGLANDACEAE (6 genera & 35 species)

Juglans californica Wats. -California walnut U. S. (Calif. -257)

J. hindsii Jepson -Hinds walnut U. S. (Calif. -185, 257)

J. nigra L. -Black walnut U. S. (Md., N. C., S. C. (symptoms), Ark. La. -73); France -257

J. regia L. -English (Persian) walnut U. S. (east & west coast) 73, 129, 130, 183, 279; Portugal -220, 221; France -19, 42, 129, 257; Italy -42, 85, 90, 122, 218; Germany -42; Spain -288, Australia -94 Switzerland -129; Europe, historic -231

Order: Fagales

BUXACEAE (about 30 species)

Buxus sempervirens L. -Boxwood U. S. (Ga.) -140

BETULACEA (6 genera & 75 species)

Betula alba L. -White birch U. S. (Md. -73)

B. papyrifera Marsh. -Paper birch U. S. (Md. -73)

B. pendulata Roth -European white birch Portugal -269

FAGACEAE (5 genera & some 600 species)

Castanea alabamensis Ashe -Alabama chinquapin U. S. (Ala. -74, 126)
ALMOST EXTINCT BECAUSE OF HIGH DEGREE OF SUSCEPTABILITY.

C. alnifolia Nutt. -Chinquapin U. S. -74, 126

C. ashei Sudw. -Ashe chinquapin U. S. -74, 126

C. crenata Sieb. & Zucc. Japanese chestnut U. S. -74, 126; England -4; Italy -210, 211, 212, 215, 218, 244 ONLY SLIGHTLY SUSCEPTABLE.

C. dentata (Marsh.) Borkh. -American chestnut U. S. (south & south-east to Tennessee & Maryland) -74, 126, 179; U. S., historic -33, 68, 186, 194, 242, 253. ALMOST EXTINCT BECAUSE OF SUSCEPTABILITY TO THIS DISEASE AND TO BLIGHT (*Endothia paratitica*) A loss attributed to *Armillaria mellea* in Chenango Co., New York by W. H. Long may well represent an area invaded by *P. cinnamomi* (Bull. 89, U. S. D. A., 1914)

C. margaretta arcuata Ashe -Chinquapin U. S. -74, 126

C. mollissima Blume -Chinese chestnut U. S. 74, 126, 138, 179
ONLY SLIGHTLY SUSCEPTABLE.

C. ozarkensis Ashe -Ozark chinquapin U. S. (Ark., Mo., Okla.) -74, 126 HIGHLY SUSCEPTABLE-SURVIVES ONLY AS ATYPICAL MATERIAL ON HIGH, DRY RIDGES.

C. pumila (L.) Mill. -Allegheny chinquapin U. S. -179.

C. sativa Mill. -European chestnut U. S. -74, 126; Argentina -229; Australia 8; England -3, 4, 32, 95; France -17, 25, 102, 104, 105, 106, 107, 150, 157, 168, Greece -22, 24; Italy -40, 41, 48, 49, 64, 84, 89, 111, 167, 210, 211, 212, 215, 218; Portugal -121, 122, 221; & Azores -123; Spain -63; Switzerland -129; Turkey -128; Yugoslavia 22, 155, ALSO SUSCEPTABLE TO A SIMILAR DISEASE CAUSED BY *Phytophthora cambivora*, WITH WHICH IT IS CONFUSED. Europe historic (France) -81, 82, 83, 219.

(*C. henryi* Skan.) Rehd. & Wils. -Henry or Asiatic chinquapin & *C. seguinii* Dode -Chinese chinquapin. HIGHLY RESISTANT -74, 126. In the U. S. (Georgia & Florida) *C. floridana* (Sarg.) Ashe -Florida tree chinquapin & *C. alnifolia* Nutt. -Alderleaf chinquapin (an evergreen, small shrub propagated by stolons) have not been found with root disease in nature but are probably susceptible and not reported due to confusion in names -74.)

Fagus sylvatica L. -European beech England -4, 95, 201; Germany? -1; RESISTANT in U. S. -74, 126

(*F. grandifolia* Ehrl. -American beech RESISTANT in U. S. -74, 126)

Lithocarpus densiflorus (H. & A.) Rehd. -Tanbark oak U. S. -74, 126

(*L. cuspidatus* (Thunb.) Nakai RESISTANT in U. S. -74, 126)

Quercus alba L. -White oak U. S. (Md. -73, 74, 126.; N. C. -181)

Q. borealis -Red oak U. S. (Md.-73, 74, 126; but RESISTANT Ore. -277); France -34, 187, 247

Q. falcata Michx. f. (*Q. rubra* L.) -Southern red oak U. S. (Md. & Ga. -72) EPIDEMIC DYING DURING THE RECESSION OF THE AMERICAN CHESTNUT.

Q. pedunculata Ehrl. -Peduncle oak France-187

Q. pyrenaica L. -Pyrenees oak France -269

Q. robur L. -England oak Portugal -221

Q. suber L. -Cork oak Portugal -221, 222; Russia -125

Q. toza Bosc. -Tauzin oak France -187

(*Q. agrifolia* Nee., *Q. coccinea* Muench., *Q. garryana* Dougl. *Q. macrocarpa* Michx., *Q. marilandica* Muench., *Q. palustris* Muench., *Q. phellos* L., *Q. prinus* L., *Q. velutina* Lam. RESISTANT in U. S. -74, 126; *Q. agrifolia* Nee. & *Q. stellata* Waugh. doubtful susceptible in N. C. -181, 182)

Q. velutina Lam. -Black oak U. S. (Calif. -181)

Order: Urticales (3 families)

MORACEAE (55 genera & 950 species)

Artocarpus communis Forst. (*A. incisa* L.) -Breadfruit Dom. Rep. -66; Peru symptoms only

Morus alba L. -Mulberry Italy -292

Order: Proteales

PROTEACEAE (49 genera & 1000 species)

- Banksia* sp. -Chilean nut N. Z. -47
- B. grandis* -Australia -228
- Dryandra sessilis* -Australia (inference) -228
- Embothrium coccineum* -Chilean firebush Australia -10
- Grevillea robusta* A. Cunn. -Silkoak El Salvador -symptoms
- Isopogon* sp. -N. Z. -47
- Leucodendron adscandens* R. Br. -Silver tree N. Z. -47
- Macadamia integrifolia* Maiden & Betche (*M. ternifolia* F. Muell.)
-Queensland nut Hawaii -135, 142; U. S. (Calif.) -313
- Persoonia elliptica* -Australia by inference -228
- P. longifolia* -Australia by inference 228
- Xylomeum occidentale* -Australia by inference -228

Order: Centrospermales (8 families)

AMARANTACEAE (40 genera & 450 species)

- Tresine lindeni* Lem. -Aguranto rojo Argentina -117

Order: Ranales (12 families -INCLUDING THE **LAURACEAE** in which
P. cinnamomi was first described).

CALYCANTHACEAE (2 genera & 8 species)

- Calycanthus floridus* L. -Carolina allspice (medicinal) Argentina -117

ANNONACEAE (46 genera & 500 or more species)

- Cananga odorata* Hook & Thomas -Ylang-Ylang (perfume) Dom.

MYRISTACEAE (1 genus & 80 species)

- Rep. -66

- Myristica fragrans* Houtt. -Nutmeg (spice) Dom. Rep. -66

LAURACEAE (39 genera & 900 or more species)

- Cinnamomum camphora* (L.) Nees. & Eberm. -Camphor tree Java-289

- C. culilawan* Blume -Culiban cinnamon Java-289

- C. glanduliferum* Meissn. -Nepal camphor tree Java -289.

- C. sintok* Blume -Java -289

- C. zeylanicum* Nees. (*C. burmanni* Blume) -Cinnamon tree, Sumatra
(Original host on which *P. cinnamomi* was described) -136, 239;
Java -272, Dom. Rep. -66

- Nectandria sinuata* Mez. -Honduras -269

- Ocotea architectorum* Mez. Peru -39

- O. obovata* (Ruiz & Pavon) Mez. Perú -38, 39

- Persea americana* Mill. -Avocado Africa-Transval -86, 100, 165;
N. Rhodesia -245; Argentina -118; Australia, NSW -15; Bolivia
24; Brazil -26; Chile -189; Costa Rica -306, 310; El Salvador -28;
Honduras -307, 310; México -306, 310; Perú -37, 38, 39, 75, 76,
99; Puerto Rico -280; U. S. (Calif. -18, 88, 137, 145, 153, 154,
202, 312; Fla. -301; Cuba.

- (*P. amplifolia* Nez. -Cachimbo RESISTANT El Salvador -23)

- P. indica* Spreng. -Madera bay U. S. (Calif. -316).

- P. schiedeana* Ness. -Chucte or chinini Costa Rica, Honduras, Mé-
xico -310; El Salvador -23.

- (*P. floccosa* RESISTANT -132)

Order: Rhoeadales

CRUCIFERAE (208 genera & some 1000 species)

Mathiola sp. -Stock Eng. -300

Order: Rosales (100 families)

GRASSULACEAE (13 genera & 500 species)

Echeveria gibbiflora DC Argentina -117

Sedum sp. Argentina -117

PITTOSPORACEAE (9 genera & 90 species)

Pittosporium tabira Ait. -Azarero Argentina -117

PLATANACEAE (1 genus with 6 species)

Platanus orientalis L. -Oriental planetree U. S. (Md.-72); Argentina-117

ROSACEAE (90 genera & 1500 species)

Prunus armeniaca L. -Apricot Australia, NSW -11

P. cerasifera Ehrh. (grafted with Mariana plumb) -Cherry or myro-bolan plumb Australia, NSW -11

P. laurocerasus L. -Cherry laurel U. S. (Ga. -140)

P. persica (L.) Batsch -Peach Australia, NSW-9, 11, 15, 16; U. S. (Ga.) -230

Pyrus communis L. -Pear U. S. (Ore. -53)

Rubus ideacus L. Blackberry New Zeland -47

Spirea cantoniensis Loureira -Spirea Argentina -117

LEGUMINOSAE (429 genera & some 7000 species)

Acacia verticillata Willd. -Whorl-leaved acacia

New Zealand -47

Dillwynia ericifolia -Australia, NSW -10

Lupinus angustifolius L. -Blue lupine New Zealand -47, 195

Mucuna gigantea (Willd.) DC Hawaii -282

Phaseolus lunatus L. -Lima bean Argentina -117

Phyllota phylloides Australia, NSW -10

Pultenaea elliptica Australia, NSW -10

Robinia pseudoacacia L. -Black locust U. S. (Md.-73)

Vicia faba L. -Broad bean England-300

Order: Geraniales (14 families)

RUTACEAE (100 genera & 900 species)

Boronia megastigma Nees. -Sweet boronia New Zeland -47

Citrus aurantium L. -Sour orange Brazil-114

Eriostemon crowei -Rue Australia, NSW -10

EUPHORBIACEAE (208 genera & 400 species)

Aleurites fordii Hemsl. -Tung-oil tree U. S. (La.-158, 225)

Micranthemum ericoides Australia, NSW -10

Ricinus communis L. -Castor-bean Hawaii-175

Order: Sapindales (15 families)

ANACARDIACEAE (58 genera & 400 species)

Schinus molle L. -California peppertree, Aquaribay Argentina -117

AQUIFOLIACEAE (3 genera & 280 species)

Ilex crenata Thunb. -Japanese holly U. S. (Md. -149)

ACERACEAE (2 genera & 110 species)

Acer platanoides L. -Norway maple Reported as susceptible to *P. cam-vora* and resistant to *P. cinnamomi* U. S. (N. J.-144)

Order: Malvales (2 families)

STERCULIACEAE (48 genera & 750 species)

Cola acuminata Schott. & Endl. (*C. vera*) Sudan cola-nut Dom. Rep. 66

Order: Hypericales (16 families)

THEACEAE (16 genera & 174 species)

Camelia japonica L. -Camellia U. S. (Fla., Ala, La., Ga., Calif. -124, 297, 134, 307)

C. magnoliaeflora (and other spp.) Australia, NSW -10, 15, 16

C. sasanqua Thunb. *Sasanqua camellia* U. S. (Fla. & N. C.-133, 297)

Gordonia altamaha Sarg. (*Franklinia altamaha* Marsh.) SUSPECTED SUSCEPTABLE AS IT DISAPPEARED WITH CHINQUAPIN IN GEORGIA COASTAL AREAS AFTER 1790. U. S. (Ga. -35, 147, 151; N. C.)

Stewartia malacodendron L. SUSPECTED AS A HOST BY SYMPTOM ONLY U. S. (Miss.)

DIPTERIOCARPACEAE

Dipterocarpus turbinatus -Common gurjonoil tree U. S. (La. -158, 225)

CARICACEAE (2 genera & 27 species)

Carica papaya L. -Papaya Dom. Rep. -66; Peru -38, 39

Order: Myrtiflorae (12 families)

THYMELEACEAE (37 genera & 425 species)

Daphne cneorum L. -Rose thyme-oil U. S. (Ore. -277)

D. odora Thunb. Winter thyme-oil U. S. (Ore.-277)

PUNICACEAE (1 genus with 2 species)

Punica sp. (*P. granatum* L. ?).-Pomegranate Australia, NSW -10

MYRTACEAE (72 genera & 2,750 species)

Baeckea brevifolia Australia, NSW-10

Chamaelawcium uncinatum Australia, NSW -10

Eucalyptus marginata -Jarrah EPIDEMIC LOSSES Australia, West. -228

E. rostrata Schlecht. -Red gum Argentina -117

E. spp. -Gum tree Australia, NSW -10

(*E. calophylla* RESISTANT Australia, West. -228)

Myrtus communis L. -Myrtle (*M. compacta* Ridley) U. S. (Calif.-308)

Thryptomene sp. New Zeland -47

Order: Umbelliflorae (3 families)

CORNACEAE (15 genera & 120 species)

Cornus florida L. -Dogwood U. S. (N. C. -133)

Order: Ericales (6 families)

ERICACEAE (67 genera & 1400 species)

Brunkenthalia spiculifolia (Salisb.) Reinchenb. -Spike heath U. S. -279

Calluna vulgaris Salisb. -Heather Scotland-44; vars. *alba* (West) Don & *aurea* Don U. S. (Ore. -279)

Daboecia cantabrica (L.) K. Koch -Irish heath var. *alba* (Don) Dipp U. S. (Oreg. -279)

Erica arborea L. var *alpina* Bean -Tree heath (Pipe bowl) U. S. (Oreg. -279)

- E. carnea* L. -Spring heath U. S. (Ore. -279)
E. ciliaris L. -Fringed heath U. S. (Ore. -279)
E. cinerea L. -Twisted heath U. S. (Ore. -279)
E. gracilis Salisb. Cornish heather England; Germany -139, 251,
 U. S. (Ore. -279)
E. hymalis Nichols -Heather England -200
E. mediterranea -Biscay heath U. S. (Ore. -279)
E. nivalis -Heather England-200
E. regerminans L. -Heather U. S. (Calif. -259, 308)
E. terminalis Salisb. (*E. stricta* Andr.) -Corsican heath U. S. (Ore.
 -279)
E. tetralix L. -Cross-leaved heath U. S. (Ore. -279)
E. willmorei Knowls & Weste -Wilmore heather England -200
E. spp. -Heath U. S. (N. Y. -282); Spain -287
Gautheria shallon -Salal U. S. (Ore. -251)
Pieris floribunda (Pursh.) Benth. & Hook Mountain pieris U. S. (N.
 C. -133)
P. japonica D. Don -Japanese pieris U. S. (N. C. -133)
Rhododendron californicum Hook -Coast rhododendron U. S. (N. J. -299)
R. carolinianum Rehd. -Carolina rhododendron U. S. (N. J., N. C. -134,
 299)
R. catawbiense Michx. -Catawa rhododendron U. S. (N. J., N. C.
 134, 299)
R. caucasicum Pall. -Causasian rhododendron -U. S. (N. J. -299)
R. indicum L. -Indica or sweet azalia Australia, NSW-14
R. maximum L. -Rosebay rhododendron U. S. (N. J. -299)
R. molle (Bl.) D. Don (*R. sinense*) -Chinese azalia Australia, NSW-
 11, 12
R. mucronulatum Turcz. -Snow azalia U. S. (Md & Va. -73)
R. ponticum L. -Ponticum rhododendron U. S. (N. J. Oreg. -279, 299)
R. simsii Planch. Germany-134
R. spp. -Rhododendrons & azalias Argentina -117; U. S. (Mo., S. C.
 -134, 283)
Vaccinium australe -Blueberry U. S. (N. C. -67)
V. corymbosum L. -Highbush blueberry U. S. (N. J., N. C. -60, 62,
 235, 252)
EPACRIDACEAE (21 genera & 300 species)
Epacris microphylla -Australia heath Australia, NSW -10
E. pulchella -Australia heath Australia, NSW-10
Sprengelia elliptica Australia, NSW-10
Styphelia longiflora Australia, NSW-10
Leucopogon microphyllus Australia, NSW-10

Order: Contortate (5 families)

OLEACEAE (20 genera & 400 species)

Olea sp. -Olive Australia, NSW-11

Order: Tubiflorae (18 families)

SOLANACEAE (70 genera & 1600 species)

Lycopersicum esculentum Mill. -Tomato Fruit-281, Argentina-117

Nicotiana glutinosa L. -Tobacco England-200

Schizanthus pinnatus Ruiz. & Pavon -Butterfly flower England-200

Solanum lycopersicum Ait. Argentina -117

SCROPHULARIACEAE (179 genera and 2500 species)

Antirrhinum majus L. -Snapdragon England-200

Calceolaria sp. -Slipperwort England-200

BIGNONIACEAE

Jacaranda sp. Australia, NSW -10, 16

Order: Rubiales (4 families)

RUBIACEAE (343 genera & 4,500 species)

Cinchona calasaya Weddell -Cinchona or quina-quina Peru-75, 79 This is the unselected, wild cinchona from which the Ledger type was selected.

C. micrantha Ruiz & Pavon -Red cinchona Peru 76, 80

C. officinalis L. -Ledger selection, known in some areas as *C. ledgeriana* Moens. -Cinchona Africa (Fr. Guinea -65); Guatemala -80, 91, 92; India -237; Malaya -272; Peru -76, 80, 77

C. pubescens Vahl. (*C. succirubra* Pavon) -Cinchona India -237; Malaya -272; Guatemala -80, 91, 92; Peru -76, 77, 80.

Coutarea hexandra (Jacq.) K. Shum -El Salvador -28

Richardia scabra St. Hill Hawaii -175

CAPRIFOLIACEAE

Viburnum sp. U. S. (Md. -149)

Order: Campanulales (3 families)

COMPOSITAE

Chrysanthemum cinerariifolium (Trev.) Vis. -Pyrethrum India -237

Doubtful as between *P. cambivora* and *P. cinnamomi*.

Parthenium argentatum Gray -Guayule U. S. (Calif., Texas, Ariz. -45, 88, 267)

Cineraria stellata Hort. (*C. grandiflora* Hort. also *Seneco cinneraria*)

-Cineraria Belgium-227; Scotland-192; Hawaii-29