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REVIEW

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Phylogenetic distribution and evolution of mycorrhizas in land plants

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Abstract A survey of 659 papers mostly published since 1987 was conducted to compile a checklist of mycorrhizal occurrence among 3,617 species (263 families) of land plants. A plant phylogeny was then used to map the mycorrhizal information to examine evolutionary patterns. Several findings from this survey enhance our understanding of the roles of mycorrhizas in the origin and subsequent diversification of land plants. First, 80 and 92% of surveyed land plant species and families are mycorrhizal. Second, arbuscular mycorrhiza (AM) is the predominant and ancestral type of mycorrhiza in land plants. Its occurrence in a vast majority of land plants and early-diverging lineages of liverworts suggests that the origin of AM probably coincided with the origin of land plants. Third, ectomycorrhiza (ECM) and its derived types independently evolved from AM many times through parallel evolution. Coevolution between plant and fungal partners in ECM and its derived types has probably contributed to diversification of both plant hosts and fungal symbionts. Fourth, mycoheterotrophy and loss of the mycorrhizal condition also evolved many times independently in land plants through parallel evolution.

Keywords Mycorrhizas · Land plants · Fungi · Parallel evolution

Introduction

Mycorrhizas, dual organs of absorption formed when symbiotic fungi inhabit healthy tissues of most terrestrial plants (Trappe 1996), have widespread occurrence among land plants and are increasingly believed to have played an important role in the successful colonization of the land by plants (Pirozynski and Malloch 1975; Malloch et al. 1980; Harley and Harley 1987; Trappe 1987; Selosse and Le Tacon 1998; Read et al. 2000; Brundrett 2002). Since Nägeli first described them in 1842 (see Koide and Mosse 2004), only a few major surveys have been conducted on their phylogenetic distribution in various groups of land plants either by retrieving information from literature or through direct observation (Trappe 1987; Harley and Harley 1987; Newman and Reddell 1987). Trappe (1987) gathered information on the presence and absence of mycorrhizas in 6,507 species of angiosperms investigated in previous studies and mapped the phylogenetic distribution of mycorrhizas using the classification system by Cronquist (1981). He found that 82% of the species were mycorrhizal. From the occurrence of various types of mycorrhizas in different subclasses and orders of angiosperms, he further inferred that the ancestral type was glomeromycetous (the original word "zygomycotous" is not used because fungi forming this type of mycorrhiza are now placed in the new phylum Glomeromycota, see Schussler et al. 2001) mycorrhiza, and ascomycetous and basidiomycetous mycorrhizas belong to the derived types, and that evolution of mycorrhizas in plants had progressed from obligate to facultative mycorrhizas and ultimately to nonmycorrhizas. In the same year, Harley and Harley (1987) published a checklist of the mycorrhizal status of 144 families of vascular plants in the British flora, documenting various types of mycorrhizas in an entire flora for the first time. More recently, Gemma et al. (1992) and Zhao (2000) investigated the mycorrhizal status of 89 and 256 species of pteridophytes in Hawaii and Yunnan, China, respectively. They found that the percentages of mycorrhizal species in pteridophytes (74 and 33%, respectively) were lower than in angiosperms as reported by Trappe (1987). Whether bryophytes have mycorrhizas or not is still a debatable issue, but many liverworts and hornworts have fungal associations (Read et al. 2000). In two surveys of British liverworts, Pocock and Duckett (1985) and Duckett et al. (1991) reported that among the 206 and 284 examined species, respectively, 16% contained fungal endophytes in their rhizoids or thalli.

Mycorrhizal research has advanced at an astonishing pace over the last two decades due to a recent surge of interest in

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the subject by botanists, mycologists, and ecologists. A large number of new reports on mycorrhizal occurrence in land plants, especially in pteridophytes and liverworts, have been published since the surveys by Trappe (1987) and Harley and Harley (1987). During the same period, our understanding of the land plant phylogeny was greatly improved through major efforts by molecular systematists. An explicit phylogenetic classification system of angiosperms is now available (Stevens 2004), and a nonflowering land plant phylogeny will be published soon (Qiu et al. unpublished data). Hence, reviewing mycorrhizal occurrence in land plants and mapping this information onto the newly available plant phylogeny will update our knowledge on mycorrhizal abundance in plants, facilitate examination of the origin and evolutionary pattern of mycorrhizal symbiosis in land plants, and enhance our understanding of this important biological interaction and its impact on evolution of both plants and fungi. Areas that require further study, especially the taxa that occupy critical positions in the land plant phylogeny and for which mycorrhizal information is still lacking, can also be identified through these efforts.

Materials and methods

In this review, we compiled information on mycorrhizal occurrence in land plants mostly from the papers published since 1987, as those published before were reviewed by Trappe (1987) and Harley and Harley (1987). First, a library consisting of 4,193 mycorrhiza-related references was established. After browsing the abstracts, 961 references that provided information on mycorrhizal occurrence in plant species from all the continents and all major habitats were selected. Due to time limitation and unavailability of some literature, 659 of these 961 references are reviewed here. Data on mycorrhizal status of each plant species were extracted from these references, based on whether the species was mycorrhizal or not, and if so, what type. An updated mycorrhizal classification system proposed by Smith and Read (1997) was used here. Seven types of mycorrhizas were all recognized (see the footnote b in Table 1), along with nonmycorrhiza and mycoheterotrophy. A species is considered to be obligately mycorrhizal if it is always found to form mycorrhiza, while a species is considered to be facultatively mycorrhizal if it is reported to form mycorrhizas in one habitat but not in another. If a plant species can form different kinds of mycorrhizas simultaneously or in different habitats, it is recorded as forming all relevant mycorrhizal types. All the data are presented in Table 1, which groups all the examined plant species into families that are further arranged according to the land plant phylogeny used in this study (Stevens 2004; Qiu et al. unpublished). The family definition for vascular plants generally follows Mabberley (1987), but for a small number of newly recognized families, the nomenclature of Stevens (2004) is used. For liverworts, the system by Grolle (1983) for family definition is followed. The data from Harley and Harley (1987), containing 1,101 species, were added to this table, but those of Trappe (1987) were not as they were not published. The information in Table 1 was then mapped onto a land plant phylogeny drawn according to a multigene analysis of nonflowering land plants (Qiu et al. unpublished) and the angiosperm classification system proposed by Stevens (2004). Family was used as the unit of reconstruction (i.e., terminal node) in this phylogeny. For each family, the percentages of obligate, facultative, and nonmycorrhizal species, and the percentage of each type of mycorrhizas among all mycorrhizal species were calculated and plotted onto the land plant phylogeny.

One major improvement of this review over those by Trappe (1987) and Harley and Harley (1987) is the use of a rigorously reconstructed land plant phylogeny to map the mycorrhizal information down to the family level for a worldwide coverage. Trappe (1987) covered only angiosperms, whereas Harley and Harley (1987) surveyed only the British vascular flora. Cronquist's (1981) classification system of angiosperms used by Trappe (1987) has been significantly revised by molecular systematists (Soltis et al. 2000; Stevens 2004). Another major improvement is that information on mycorrhizal occurrence, more precisely fungal association in bryophytes, is included for the first time. Hence, this review should allow a thorough examination of origin and evolution of mycorrhizal symbiosis in land plants.

Results and discussion

A total of 3,617 species from 263 families of land plants were covered in this survey of mycorrhizal status (Tables 1 and 2). For land plants as a whole, 80% of the recorded species and 92% of the families are mycorrhizal. When broken into four traditionally delimited groups (angiosperms, gymnosperms, pteridophytes, and bryophytes), these percentages vary from group to group. In angiosperms, the most species-rich clade of land plants and the dominant group in most terrestrial plant communities, 85 and 94% of species and families are mycorrhizal. These numbers are similar to those reported by Trappe (1987), whose study included more than twice as many species as this one. All of the 84 species of gymnosperms surveyed here are mycorrhizal, and almost all of them are obligately mycorrhizal. These two aspects of mycorrhizal status in gymnosperms highlight the essential role that mycorrhizas play in the life of these plants, which generally grow in nutrient-poor environments. For pteridophytes, 52 and 93% of the species and families are mycorrhizal. Finally, 46 and 71% of the bryophyte species and families have fungal associations.

When this body of information is projected in a plant phylogenetic perspective (Fig. 1), the origin and evolutionary patterns of mycorrhizas in land plants become quite clear. Below, we discuss these various aspects of mycorrhizal evolution in plants.

Origin of mycorrhizal symbiosis in land plants

The continuous phylogenetic distribution of mycorrhizas throughout land plants, with the sole major exception of

Table 1 An updated checklist of mycorrhizal occurrence among land plants

Examined species[a]	Mycorrhizal status[b,c]	References
BRYOPHYTES		
Haplomitriaceae		
Haplomitrium gibbsiae	AM-like	107
Haplomitrium ovalifolium	AM-like	107
Blasiaceae		
Blasia pusilla	None	182, 328
Lunulariaceae		
Lunularia cruciata	Fungal association (G)	182
Marchantiaceae		
Marchantia foliacea	AM-like	505
Marchantia polymorpha	Fungal association (G)	182
Aytoniaceae		
Asterella wilmsii	AM-like	345
Conocephalaceae		
Conocephalum conicum	AM-like	346
	Fungal association (G)	182
Ricciaceae		
Riccia fluitans	None	182
Metzgeriaceae		
Apometzgeria pubescens	None	466
Metzgeria conjugata	None	466
Metzgeria fruticulosa	None	466
Metzgeria furcata	None	466
Metzgeria leptoneura	None	466
Metzgeria temperata	None	466
Aneuraceae		
Aneura pinguis	ORM-like (B)	347
Cryptothallus mirabilis	Fungal association	466
	ORM-like (B)	347
	Mycoheterotrophy (via ECM)	77, 483
Riccardia latifrons	None	466
Riccardia multifida	None	466
Riccardia palmate	None	466
Pelliaceae		
Pellia endiviifolia	AM-like	598
Pellia epiphylla	Fungal association (G)	182
Pellia fabbroniana	AM-like	483
Codoniaceae		
Fossombronia pusilla	Fungal association (G)	182
Fossombronia wondraczekii	Fungal association	328
Radulaceae		
Radula aquilegia	None	466
Radula complanata	None	466
Radula lindbergiana	None	466
Porellaceae		
Porella arboris-vitae	None	466
Porella cordaeana	None	466
Porella obtusata	None	466
Porella pinnata	None	466
Porella platyphylla	None	466
Jubulaceae		
Frullania dilatata	None	466
Frullania fragilifolia	None	466
Frullania microphylla	None	466
Frullania tamarisci	None	466
Frullania teneriffae	None	466
Jubula hutchinsiae	None	466
Lejeuneaceae		
Aphanolejeunea microscopica	None	466
Cololejeunea calcarea	None	466
Cololejeunea minutissima	None	466
Colura calyptrifolia	None	466
Drepanolejeunea hamatifolia	None	466
Harpalejeunea ovata	None	466
Lejeunea cavifolia	None	466
Lejeunea lamacerina	None	466
Lejeunea patens	None	466
Lejeunea ulicina	None	466
Marchesinia mackaii	None	466
Pseudolepicoleaceae		
Blepharostoma trichophyllum	None	466
	Fungal association	328
Herbertaceae		
Herbertus borealis	None	466
Plagiochilaceae		
Pedinophyllum interruptum	None	466
Plagiochila asplenioides	None	466
Plagiochila porelloides	None	466
Plagiochila punctata	Fungal association	466
Plagiochila spinulosa	None	466
Arnelliaceae		
Southbya nigrella	Fungal association (B)	182
Geocalycaceae		
Chiloscyphus pallescens	None	466
Chiloscyphus polyanthus	None	466
Geocalyx graveolens	Fungal association	466
Harpanthus flotovianus	None	466
Harpanthus scutatus	Fungal association	466
Leptoscyphus cuneifolius	None	466
Lophocolea bidentata	None	466
Lophocolea cuspidate	None	466
Lophocolea heterophylla	None	182, 466
	Fungal association	328
Saccogyna viticulosa	Fungal association	466

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Lepidoziaceae		
Bazzania flaccida	None	328
Bazzania tricrenata	None	466
Bazzania trilobata	None	328, 466
Kurzia pauciflora	Fungal association	466
	Fungal association (A)	182, 328
Kurzia sylvatica	Fungal association	466
Kurzia trichoclados	Fungal association	466
Lepidozia reptans	Fungal association	466
	Fungal association (A)	182, 328
Telaranea murphyae	Fungal association	466
Telaranea nematodes	Fungal association	466
Scapaniaceae		
Diplophyllum albicans	None	182, 466
	Fungal association	328
Diplophyllum obtusifolium	Fungal association	328
Douinia ovata	None	466
Scapania calcicola	None	466
Scapania cuspiduligera	None	466
Scapania gracilis	None	466
Scapania scandica	None	466
Scapania umbrosa	None	466
Cephaloziellaceae		
Cephaloziella baumgartneri	None	466
Cephaloziella divaricata	Fungal association	466
	Fungal association (A)	182, 328
Cephaloziella exiliflora	Fungal association (A)	118
Cephaloziella hampeana	Fungal association	466
Cephaloziella massalongi	None	466
Cephaloziella rubella	Fungal association	466
Cephaloziaceae		
Cephalozia bicuspidate	Fungal association	466
	Fungal association (A)	182, 328
Cephalozia catenulate	None	466
	Fungal association	328
Cephalozia connivens	Fungal association	466
	Fungal association (A)	182
Cephalozia leucantha	Fungal association	466
Cephalozia loitlesbergeri	Fungal association	466
	Fungal association (A)	182
Cephalozia lunulifolia	Fungal association	328, 466
Cephalozia macrostachya	Fungal association	466
Cephalozia pleniceps	Fungal association	466
Cladopodiella fluitans	None	466

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Cladopodiella francisci	Fungal association	466
Nowellia curvifolia	Fungal association (A)	182, 328, 466
Odontoschisma denudatum	None	466
	Fungal association (A)	182
Odontoschisma elongatum	None	466
Odontoschisma sphagni	Fungal association	466
	Fungal association (A)	182
Calypogeiaceae		
Calypogeia arguta	Fungal association	466
Calypogeia azurea	Fungal association (A, B)	328
Calypogeia fissa	Fungal association	466
	Fungal association (A)	182
Calypogeia integristipula	Fungal association	328
Calypogeia muellerana	Fungal association	466
	Fungal association (A)	182
	Fungal association (A, B)	328
Calypogeia neesiana	Fungal association	328, 466
Calypogeia sphagnicola	Fungal association	466
Calypogeia trichomanis	Fungal association	466
Jungermanniaceae		
Anastrophyllum minutum	Fungal association	328
Barbilophozia barbata	Fungal association (A, B)	328
Barbilophozia hatcheri	None	466
Jamesoniella autumnalis	Fungal association	466
Jamesoniella undulifolia	None	466
Jungermannia atrovirens	None	466
Jungermannia borealis	None	466
Jungermannia exsertifolia	None	466
Jungermannia gracillima	None	182, 466
Jungermannia obovata	None	466
Jungermannia pumila	None	466
Leiocolea turbinata	None	466
Lophozia incisa	Fungal association (B)	328
Lophozia sudetica	Fungal association (B)	328
Lophozia ventricosa	Fungal association (B)	182
Mylia anomala	Fungal association	328, 466
Mylia taylorii	Fungal association	328
Nardia breidleri	Fungal association	466
Nardia scalaris	Fungal association (B)	182, 328
Sphenolobus helleranus	None	466

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Sphenolobus minutus	None	466
Gymnomitriaceae		
Gymnomitrion concinnatum	None	466
Gymnomitrion crenulatum	None	466
Gymnomitrion obtusum	None	466
Marsupella adusta	None	466
Marsupella alpina	None	466
Marsupella emarginata	None	466
	Fungal association	328
Marsupella stableri	None	466
Anthocerotaceae		
Anthoceros punctatus	AM-like	525
Phaeoceros laevis	AM-like	344
PTERIDOPHYTES		
Lycopodiaceae		
Diphasiastrum alpinum	AM + NM	260, 261
Diphasiastrum complanatum	NM	654
Diphasiastrum issleri	AM	260, 261
Huperzia australiana	AM	342
Huperzia phyllantha	AM	226
Huperzia selago	AM + NM	260, 261
Huperzia serrata f. longipetiolata	NM	654
Lycopodiastrum casuarinoides	NM	654
Lycopodiella inundata	AM	212
	AM + NM	260, 261
Lycopodium alpinum	NM	594
Lycopodium annotinum	AM	260, 261
Lycopodium cernuum	AM	181, 226
Lycopodium clavatum	AM	521, 594
	AM + NM	260, 261
Lycopodium japonicum	AM	654
Lycopodium selago	NM	594
Palhinhaea cernua	NM	654
Phlegmariurus henryi	NM	654
Isoetaceae		
Isoetes echinospora	NM	260, 261
Isoetes histrix	NM	260, 261
Isoetes lacustris	NM	260, 261
Selaginellaceae		
Selaginella arbuscula	AM	226
Selaginella biformis	AM	654
Selaginella chrysocaulos	NM	654
Selaginella davidii	AM	653, 654
Selaginella delicatula	AM	654
Selaginella frondosa	AM	654
Selaginella helferi	NM	654
Selaginella involvens	AM	654
Selaginella kraussiana	AM + NM	260, 261
Selaginella mairei	AM	343
Selaginella moellendorfii	AM	653
Selaginella monospora	NM	654
Selaginella picta	AM	654
Selaginella pulvinata	AM	343, 654
Selaginella remotifolia	AM	654
Selaginella sanguinolenta	AM	654
Selaginella selaginoides	AM	260, 261
Equisetaceae		
Equisetum arvense	NM	307, 594, 260, 261
	AM	599
Equisetum debile	NM	654
Equisetum diffusum	AM	343
	NM	654
Equisetum fluviatile	NM	260, 261
Equisetum hyemale	AM	653, 260, 261
Equisetum palustre	NM	260, 261
Equisetum pratense	NM	260, 261
Equisetum ramosissimum	NM	368, 260, 261
	AM	653
Equisetum sylvaticum	AM + NM	260, 261
Equisetum telmateia	AM	260, 261
Equisetum × trachydon	AM	260, 261
Equisetum variegatum	NM	594
	AM	260, 261
Marattiaceae		
Angiopteris caudatiformis	AM	654, 655
Angiopteris evecta	AM	226
Angiopteris hokouensis	AM	654
Angiopteris wangii	AM	654
Angiopteris yunnanensis	AM	654
Archangiopteris bipinnata	AM	654
Archangiopteris henryi	AM	654
Archangiopteris hokouensis	AM	654
Archangiopteris subrotundata	AM	654
Calathea sp.	AM	510
Christensenia assamica	AM	654
Ctenanthe sp.	AM	510
Ischnosiphon gracilis	AM	510
Marattia douglasii	NM	226
Monotagma plurispicatum	AM	510
Saranthe compositae	NM	510
Stromanthe porteana	AM	510
Psilotaceae		
Psilotum complanatum	NM	226
Psilotum nudum	AM	226
Psilotum sp.	AM	483
Ophioglossaceae		
Botrychium lanuginosum	AM	653
Botrychium lunaria	AM	194, 260, 261
Botrychium ternatum	AM	653
Botrychium virginianum	AM	329

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Ophioglossum concinnum	AM	226
Ophioglossum lusitanicum	AM	260, 261
Ophioglossum pendulum	AM	226
Ophioglossum petiolatum	AM	654
	NM	226
Ophioglossum reticulatum	AM	522, 654
Ophioglossum themale	AM	654
Ophioglossum vulgatum	AM	653, 260, 261
Osmundaceae		
Osmunda cinnamomea	AM	140
Osmunda japonica	AM	653, 654
Osmunda regalis	AM + NM	260, 261
Hymenophyllaceae		
Crepidomanes latealatum	NM	654
Hymenophyllum tunbrigense	M (endo)	260, 261
Hymenophyllum wilsonii	M (endo)	260, 261
Mecodium badium	NM	654
Mecodium blumeanum	NM	654
Mecodium recurvum	AM	226
Sphaerocionium lanceolatum	AM	226
Trichomanes auriculatum	NM	654
Trichomanes speciosum	NM	260, 261
Vandenboscia cyrtotheca	NM	226
Vandenboscia davalliodes	NM	226
Gleicheniaceae		
Dicranopteris dichotoma	AM	653
Dicranopteris gigantea	NM	654
Dicranopteris linearis	AM	226
Dicranopteris pedata	NM	654
Dicranopteris splendida	NM	654
Diplopterygium glaucoides	NM	654
Diplopterygium glaucum	NM	654
Diplopterygium pinnatum	AM	226
Sticherus laevigatus	NM	654
Sticherus owhyhensis	AM	226
Schizaeaceae		
Anemia phyllitidis	AM	31
Lygodium conforme	AM	654
Lygodium japonicum	AM	653
	NM	654
Schizaea robusta	AM	226
Marsileaceae		
Pilularia globulifera	AM + NM	260, 261
Azollaceae		
Azolla filiculoides	NM	226, 260, 261
Plagiogyriaceae		
Plagiogyria distinctissima	AM	654
Cyatheaceae		
Alsophila constularis	NM	654
Alsophila spinulosa	AM	654
Cyathea cooperi	AM	226

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Gymnosphaera gigantea	NM	654
Gymnosphaera podophylla	NM	654
Sphaeropteris brunoniana	NM	654
Dicksoniaceae		
Cibotium barometze	NM	654
Cibotium chamissoi	AM	226
Cibotium glaucum	AM	226
Cibotium st.-johnii	AM	226
Pteridaceae		
Doryopteris decipiens	AM	226
Doryopteris decora	AM	226
Histiopteris incisa	AM	654
Pellaea mairei	AM	654
Pellaea ternifolia	AM	226
Pteridium aquilinum	AM	653
Pteridium revolutum	NM	654
Pteris aspericaulis	AM	653
Pteris aspericaulis var. tricolor	NM	654
Pteris cretica	AM	226
Pteris cretica var. laeta	NM	654
Pteris cretica var. nervosa	NM	654
Pteris dissitifolia	NM	654
Pteris ensiformis	NM	654
Pteris esquirolii	NM	654
Pteris excelsa	AM	226
	NM	654
Pteris irregularis	AM	226
Pteris linearis	NM	654
Pteris semipinnata	NM	654
Pteris setulosocostulata	AM	654
Pteris venusta	AM	655
Pteris vittata	AM	226, 653
	NM	654
Pteris wangiana	NM	654
Vittariaceae		
Antrophyrum henryi	NM	654
Vittaria elongata	AM	226
Vittaria flexuosa	NM	654
Adiantaceae		
Adiantum bonatianum	AM	654
Adiantum capillus-veneris	AM + NM	260, 261
Adiantum edgewothii	AM	654
Adiantum flabellulatum	AM	654
Adiantum malesianum	NM	654
Adiantum philipense	AM	343
	NM	654
Aleuritopteris albomarginatata	AM	654
Aleuritopteris argentea	AM	654
Aleuritopteris duclouxii	NM	654
Aleuritopteris pseudofarinosa	NM	654

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Anogramma leptophylla	NM	260, 261
Cheilosoria hancockii	AM	654
Coniogramme intermedia	AM	654
Coniogramme rosthorni	NM	654
Coniogramme simillima	AM	654
Cryptogramma crispa	AM + NM	260, 261
Gymnopteris bipinnata var. auriculata	NM	654
Gymnopteris vestita	AM	654
Leptolepidium subvillosum	NM	654
Onychium angustifrons	NM	654
Onychium contigium	AM	654
Onychium japonicum var. lucidum	NM	654
Onychium lucidum	AM	654
Sinopteris grevilleoides	NM	654
Dennstaedtiaceae		
Dennstaedtia melanostipes	AM	654
Dennstaedtia scabra	AM	654
Hypolepis punctata	NM	654
Lindsaea cultrata	AM	653
Lindsaea ensifolia	NM	654
Lindsaea javanensis	NM	654
Lindsaea odorata	NM	654
Lindsaea orbiculata	AM	654
Microlepia hookeriana	AM	654
Microlepia marginata	AM	654
Microlepia marginata var. calvescens	AM	654
Microlepia pilosissima	AM	654
Microlepia platyphylla	NM	654
Microlepia rhomboidea	NM	654
Microlepia strigosa	AM	226
Monachosorum henryi	AM	654
Pteridium aquilinum	AM + NM	260, 261
Pteridium decompositum	AM	226
Schizoloma heterophyllum	NM	653
Stenoloma chusanum	AM	653, 654
Aspleniaceae		
Acrophorus stipellatus	NM	654
Acystopteris tenuisecta	AM	654
Allantodia alata	NM	654
Allantodia chinensis	AM	653
Allantodia dilatata	AM	654
Allantodia doederleinii	NM	654
Allantodia laxifrons	AM	654
Allantodia megaphylla	NM	654
Allantodia spectabilis	AM	654
Allantodia stenochlamys	NM	654
Asplenium adiantum-nigrum	AM	226
	AM + NM	260, 261
Asplenium billotii	NM	260, 261
Asplenium cheilosorum	AM	654

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Asplenium excisum	NM	654
Asplenium finlaysonianum	NM	654
Asplenium florentinum	AM	226
Asplenium fuscipes	NM	654
Asplenium griffithianum	NM	654
Asplenium horridum	NM	226
Asplenium lushanense	AM	654
Asplenium macraei	AM	226
Asplenium marinum	NM	260, 261
Asplenium nidus	NM	226
Asplenium normale	AM	226
	NM	654
Asplenium onopteris	NM	472
Asplenium pekinense	NM	654
Asplenium praemosum	NM	654
Asplenium prolongatum	NM	654
Asplenium ruta-muraria	AM + NM	260, 261
Asplenium septentrionale	NM	260, 261
Asplenium sphenotomum	AM	226
Asplenium tenuicaule	NM	654
Asplenium trichomanes	AM + NM	260, 261
Asplenium unilaterale	AM	226
	NM	654
Asplenium varians	NM	654
Asplenium viride	AM + NM	260, 261
Asplenium wrightioides	NM	654
Asplenium yunnanense	NM	654
Athyriopsis longipes	AM	654
Athyriopsis ptersennii	AM	654
Athyrium anisopterum	NM	654
Athyrium biserrulatum	AM	654
Athyrium delicatulum	NM	654
Athyrium dissitifolium	AM	654
Athyrium distentifolium	AM + NM	260, 261
Athyrium esculentum	AM	226
Athyrium filix-femina	AM + NM	260, 261
Athyrium japonica	AM	226
Athyrium mackinnonii	NM	654
Athyrium macraei	AM	226
Athyrium mengtzeense	AM	654
Athyrium microphyllum	AM	226
Athyrium niponicum	NM	654
Athyrium sandwichianum	AM	226
Athyrium stigillosum	AM	654
Athyrium wardii	AM	653
Bolbitis heteroclita	NM	654
Bolbitis hokouensis	NM	654
Callipteris esculenta	AM	653
	NM	654
Ceterach officinarum	NM	260, 261
Ctenitis mariformis	AM	653
Ctenitis membranifolia	NM	654
Ctenitopsis devexa	NM	654

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Ctenitopsis glabra	NM	654
Ctenitopsis sagenioides	NM	654
Ctenitopsis setulaosa	NM	654
Ctenitopsis subsageriacea	NM	654
Cystopteris fragilis	AM + NM	260, 261
Cystopteris montana	NM	260, 261
Cystopteris pellucida	AM	653
Diacalpe christensenae	NM	654
Diplazium donianum	AM	653
	NM	654
Diplazium lanceum	AM	653
Diplazium splendens	AM	654
Dryoathyrium boryanum	NM	654
Dryoathyrium edentulum	AM	654
Egenolfia sinensis	AM	654
Egenolfia tokinensis	AM	654
Gymnocarpium dryopteris	AM + NM	260, 261
Hypodematium crenatum	AM	654
Lomariopsis spectabilis	NM	654
Lunathyrium dolosum	NM	654
Monomelangium pullingeri var. daweishannicolum	AM	654
Neottopteris antrophyoides	NM	654
Neottopteris simonsiana	NM	654
Phyllitis scolopendrium	AM	260, 261
Pleocnemia winitei	NM	654
Pseudocystopteris atkinsonii	NM	654
Quercifilix zeylanica	NM	654
Tectaria coadunata	NM	654
Tectaria decurrens	NM	654
Tectaria dubia	NM	654
Tectaria hainanensis	NM	654
Tectaria hokouensis	NM	654
Tectaria simonii	NM	654
Tectaria variolosa	NM	654
Tectaria yunnanensis	NM	654
Woodsia alpina	NM	260, 261
Woodsia ilvensis	NM	260, 261
Thelypteridaceae		
Ampelopteris prolifera	NM	654
Dictyocline wilfordii	AM	653
Cyclogramma auriculata	AM	654
Cyclosorus acuminatus	NM	654
Cyclosorus dentatus	NM	654
Cyclosorus hokouensis	AM	654
Cyclosorus mollicesculus	NM	654
Cyclosorus parasiticus	NM	654
Cyclosorus subnigrescens	NM	654
Cyclosorus truncatus	NM	654
Dictyocline griffithii	AM	654
Glaphylopteridopsis erubescens	AM	654
Macrothelypteris torressiana	AM	654
Metathelypteris flaccida	NM	654
Oreopteris limbosperma	AM	260, 261
Parathelypteris beddomei	NM	654
Parathelypteris hirsutipes	AM	654
Parathelypteris nipponica	NM	653
Phegopteris connectilis	AM + NM	260, 261
Pronephrium gymnopteridifrons	NM	654
Pronephrium nudotum	NM	654
Pronephrium simplex	NM	654
Pseudocyclosorus esquirolii	AM	654
Pseudocyclosorus subochthodes	NM	654
Pseudophegopteris pyrrhorachis	NM	654
Pseudophegopteris yunkweiensis	NM	654
Thelypteris cyatheoides	NM	226
Thelypteris globulifera	AM	226
Thelypteris hudsoniana	AM	226
Thelypteris interrupta	NM	226
Thelypteris parasitica	AM	226
Thelypteris sandwicensis	NM	226
Thelypteris thelypteroides	AM + NM	260, 261
Blechnaceae		
Blechnum occidentale	AM	226
Blechnum orientale	AM	654
Blechnum penna-marina	NM	342
Blechnum spicant	AM + NM	260, 261
Brainea insignis	NM	654
Doodia kunthiana	AM	226
Sadleria cyatheoides	AM	226
Sadleria squarrosa	AM	226
Woodwardia japonica	AM	654
Woodwardia orientalis	AM	653
Woodwardia unigemmata	NM	654
Dryopteridaceae		
Acrorumohra diffraeta	AM	654
Arachniodes festina	AM	653
Arachniodes globisora	AM	654
Arachniodes rhomboidea	AM	653
Arachniodes simplicior	AM	653
Arachniodes sporadosora	NM	654
Cyrtomium caryotideum f. caryotideum	AM	654
Cyrtomium fortunei	NM	654
Dryopteris basisora	NM	654
Dryopteris caroli-hopei	NM	654
Dryopteris carthusiana	AM	598
	AM + NM	260, 261
Dryopteris chrysocoma	NM	654

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Dryopteris cochleata	NM	654
Dryopteris cristata	AM	260, 261
Dryopteris dilatata	AM	260, 261
Dryopteris filix-mas	AM + ECM + NM	260, 261
Dryopteris fructuosa	AM	654
Dryopteris fuscipes	AM	653
Dryopteris fusco-atra	AM	226
Dryopteris glabra	AM	226
Dryopteris lepidopoda	NM	654
Dryopteris marginata	AM	654
Dryopteris odontoloma	NM	654
Dryopteris sparsa	AM	654
Dryopteris stenolepis	NM	654
Dryopteris sublacera	AM	654
Dryopteris thelypteris	AM	140
Dryopteris unidentata	AM	226
Dryopteris wallichiana	AM	226
Nothoperanema hendersonii	NM	654
Polystichum aculeatum	AM + NM	260, 261
Polystichum alteruatum	NM	654
Polystichum chingae	NM	654
Polystichum dielsii	NM	654
Polystichum eximium	NM	654
Polystichum jizhushanense	AM	654
Polystichum lonchitis	AM	260, 261
Polystichum pycnopterum	NM	654
Polystichum tsus-simense	AM	654
Polystichum vestitum	NM	342
Tectaria gaudichaudii	AM	226
Nephrolepidaceae		
Arthropteris palisotii	NM	654
Nephrolepis biserrata	AM	35
Nephrolepis faleata	NM	654
Polypodiaceae		
Arthromeris mairei	NM	654
Cheilanthes lanosa	AM	449
Colysis diversifolia	NM	654
Colysis hemitoma	NM	653
Colysis hokouensis	NM	654
Colysis pentaphylla	NM	654
Drynaria propinqua	NM	654
Lepidogrammitis rostrama	NM	654
Lepisorus contortus	NM	654
Lepisorus macrosphaerus	NM	654
Lepisorus scolopendrium	NM	654
Microsorium carinatum	NM	654
Microsorium henryi	NM	654
Microsorium membranaceum	NM	654
Microsorium punctatum	NM	654
Microsorium spectrum	NM	226
Neocheiropteris palmatopedata	NM	654
Neolepisorus ovatus	NM	654
Neolepisorus sinensis	NM	654
Onoclea sensibilis	AM	140
Phlebodium aureum	NM	226
Phymatopsis crenatopinnata	NM	654
Phymatopsis nigrovenia	NM	654
Phymatopsis trisecta	NM	654
Phymatosorus scolopendria	NM	226
Pleopeltis thunbergiana	NM	226
Polypodiodes amoenum	NM	654
Polypodium pellucidum	NM	226
Polypodium vulgare	AM + NM	260, 261
Pyrrosia adnaseens	NM	654
Pyrrosia gralla	NM	654
Pyrrosia lingua	NM	654
Pyrrosia mollis	NM	654
Pyrrosia subfurfuracea	NM	654
Pyrrosia tonkinensis	NM	654
Tricholepidium maculosum	NM	654
Grammitidaceae		
Adenophorus abietinus	AM	226
Adenophorus pinnatifidus	NM	226
Adenophorus tamariscinus	AM	226
Grammitis baldwinii	NM	226
Grammitis poeppigeana	NM	342
Grammitis tenella	AM	226
Loxogramme ensiformis	NM	654
Xiphopteris saffordii	NM	226
Davalliaceae		
Araiostegia perdurans	NM	654
Nephrolepis cordifolia	AM	226
Nephrolepis exaltata	AM	226
Nephrolepis multiflora	AM	226
GYMNOSPERMS		
Cycadaceae		
Cycas circinalis	AM	423
Cycas revoluta	AM	423
Zamiaceae		
Ceratozamia mexicana	AM	616
Dioon edule	AM	203, 616
Lepidozamia hopei	AM	484
Macrozamia reidlei	AM	93
Zamia pumila	AM	203
Ginkgoaceae		
Ginkgo biloba	AM	206
Pinaceae		
Abies alba	ECM	189
Abies grandis	ECM	375
Abies lasiocarpa	ECM	314
Abies spp.	ECM	260, 261
Cedrus atlantica	ECM	431

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Larix decidua	ECM	260, 261
Larix kaempferi	ECM	644, 260, 261
Larix occidentalis	ECM	156
Picea abies	ECM	8
	ECM + EEM	260, 261
Picea engelmannii	ECM	314
Picea glauca	ECM	285, 338, 414, 470
Picea glehnii	ECM	308
Picea mariana	ECM	91
Picea rubens	ECM	232
Picea sitchensis	ECM	13, 205, 260, 261
Pinus banksiana	ECM	91
Pinus cembra	ECM	498
Pinus contorta	ECM	98, 156, 403
Pinus densiflora	ECM	228, 309, 634, 635
Pinus echinata	ECM	444
Pinus edulis	ECM	223, 265, 470
Pinus elliottii	ECM	470, 564
Pinus halepensis	ECM	411, 590
Pinus jeffreyi	ECM	617
Pinus lambertiana	ECM	617
Pinus massoniana	ECM	323, 564
Pinus montezumae	ECM	509
Pinus muricata	ECM	218, 280
	ECM + AM	281
Pinus nigra	ECM	260, 261
Pinus patula	ECM	487
Pinus pinaster	ECM	458, 260, 261
Pinus pinea	ECM	368, 451
Pinus ponderosa	AM	550
	ECM	156, 188, 375, 506, 618
Pinus radiata	ECM	184
Pinus resinosa	ECM	363, 470
Pinus rigida	ECM	152
Pinus sylvestris	ECM	239, 320, 420
	ECM + EEM + NM	260, 261
Pinus tabulaeformis	ECM	634, 635
Pinus taeda	ECM	139, 160, 190
Pinus thunbergii	ECM	364
Pseudotsuga menziesii	ECM	70, 156, 236, 259, 280, 375
	AM	550
	AM + ECM	116
	ECM + EEM	260, 261
Tsuga heterophylla	ECM	9, 313
	AM + ECM	116

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Ephedraceae		
Ephedra trifurca	AM	137
Welwitschiaceae		
Welwitschia mirabilis	AM	296
Gnetaceae		
Gnetum africanum	ECM	445
Gnetum buchholzianum	ECM	445
Gnetum sp.	AM + ECM	445
Araucariaceae		
Agathis robusta	AM	388
Araucaria angustifolia	AM	31, 89, 650
Araucaria cunninghamii	AM	388
Wollemia nobilis	AM + EEM	388
Wollemia sp.	ECM	656
Podocarpaceae		
Dacrycarpus dacrydioidies	AM	504
Dacrydium cupressinum	AM	504
Parasitaxus ustus	Mycoheterotrophy via AM?	659
Podocarpus falcatus	AM	637, 638
Prumnopitys ferruginea	AM	504
Prumnopitys taxifolia	AM	504
Taxodiaceae		
Metasequoia glyptostroboides	AM	559
Sequoia sempervirens	AM	6
Sequoiadendrom giganteum	AM	6
Cupressaceae		
Austrocedrus chilensis	AM	207
Chamaecyparis thyoides	AM	106
Juniperus communis	AM + ECM	260, 261
Juniperus communis ssp. nana	AM + ECM	260, 261
Juniperus monosperma	AM	470
Juniperus oxycedrusL. ssp. macrocarpa	AM	368
Juniperus procera	AM	637, 638
Libocedrous decurrens	AM	6, 25
Tetraclinis articulata	AM	169, 412
Thuja occidentalis	AM	81, 385
Thuja plicata	AM	100
Taxaceae		
Taxus baccata	AM	637, 638, 260, 261
Taxus × media	AM	515
ANGIOSPERMS		
Nymphaeaceae		
Nuphar × intermedia	NM	260, 261
Nuphar lutea	NM	62, 260, 261
Nuphar pumila	NM	260, 261
Nymphaea alba	NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Nymphaea sp.	AM	656
Acoraceae		
Acorus calamus	AM	531
	NM	260, 261
Tofieldiaceae		
Tofieldia pusilla	AM	260, 261
Araceae		
Aglaonema modestum	AM	655
Alocasia longiloba	AM	655
Alocasis macrorrhiza	AM	422
Amorphophallus bannaensis	AM	422
Anthurium affine	AM	510
Anthurium pentaphyllum	AM	510
Anthurium pitteri	AM	474
Arum italicum	AM	260, 261
Arum maculatum	AM	260, 261
Arum neglectum	AM	260, 261
Caladium bicolor	AM	510
Calla palustris	NM	260, 261
Colacasia esculenta	AM	531
Dieffenbachia amoena	AM	510
Philodendron ornatum	NM	510
Philodendron undulatum	NM	510
Pistia stratiotes	NM	510
Rhaphidophora decursiva	AM	422
Hydrocharitaceae		
Egreria densa	NM	510
Elodea canadensis	NM	62, 260, 261
Hydrilla verticillata	NM	260, 261
Vallisneria americana	AM	631, 632
Butomaceae		
Butomus umbellatus	NM	260, 261
Alismataceae		
Alisma lanceolatum	AM + NM	260, 261
Alisma plantago-aquatica	AM	58
	NM	62, 260, 261
Alisma subcordatum	Weak AM	626
Alisma triviale	AM	140
Baldellia ranunculoides	AM	368
Echinodorus grandiflorus	NM	510
Sagitaria latifolia	AM	626
Limnocharitaceae		
Hydrocleys nymphoides		
Juncaginaceae		
Triglochin maritima	AM + NM	260, 261
Triglochin palustris	NM	260, 261
Potamogetonaceae		
Potamogeton crispus	NM	62, 260, 261
Potamogeton gramineus	NM	62
Potamogeton lucens	NM	62
Potamageton natans	AM	58
	NM	62, 260, 261
Potamogeton perfoliatus	NM	62
Potamogeton polygonifolius	NM	260, 261
Potamogeton praelongus	NM	62
Petrosaviaceae		
Petrosavia sakuraii	Mycoheterotrophy	657, 658
Petrosavia stellaris	Mycoheterotrophy	657, 658
Nartheciaceae		
Narthecium ossifragum	AM + NM	260, 261
Burmanniaceae		
Burmannia tenella	Mycoheterotrophy (via AM)	290
Thismia sp.	Mycoheterotrophy	656
Dioscoreaceae		
Tacca chantrieri	NM	655
Tamus communis	AM	260, 261
Triuridaceae		
Sciaphila polygyna	Mycoheterotrophy	291
Sciaphila tosaensis	Mycoheterotrophy (via AM)	642
Pandanaceae		
Freycinetia arborea	AM	326
Pandanus furcatus	NM	655
Pandanus tectorius	NM	326
Cyclanthaceae		
Asplundia gardneri	NM	510
Corsiaceae		
Arachnitis uniflora	Mycoheterotrophy (via AM)	79
Alstroemeriaceae		
Alstroemeria aurea	AM	207
Colchicaceae		
Colchicum autumnale	AM	260, 261
Melanthiaceae		
Paris quadrifolia	AM + NM	260, 261
Trillium flexipes	AM	165
Veratrum viride	AM	140
Smilacaceae		
Smilax aspera	AM	63, 368
Smilax corbularia	AM	422
Smilax hypoglauca	AM	422
Smilax indica	AM	422
Liliaceae		
Gagea lutea	AM + NM	260, 261
Lilium martagon	AM	260, 261
Muscari comosum	AM	260, 261
Muscari neglectum	AM	260, 261
Smilacina racemosa	AM	165
Orchidaceae		
Aceras anthropophorum	ORM	260, 261
Anacamptis pyramidalis	ORM	260, 261
Anoectochilus burmannicus	ORM	422
Anoectochilus roxburghii	ORM	422

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Anoectochilus tortus	AM	655
Apostasia odorata	AM	422
Arundina graminifolia	ORM	326
Caladenia formosa	ORM	286
Calypso bulbosa	ORM	153
Cephalanthera austinae	Mycoheterotrophy (via ECM)	569
Cephalanthera damasonium	ORM + ECM	78
	ORM	260, 261
Cephalanthera longifolia	ORM	260, 261
Cephalanthera rubra	ORM + ECM	78
	ORM	368, 260, 261
Chloraea virescens	ORM	207
Coeloglossum viride	ORM	260, 261
Corallorhiza maculata	Mycoheterotrophy (via ECM)	569, 570, 571
Corallorhiza mertensiana	Mycoheterotrophy	570
Corallorhiza trifida	Mycoheterotrophy	392, 260, 261
Corybas dienemus	ORM	342
Cypripedium calceolus	ORM	540
	ORM + NM	260, 261
Cypripedium californicum	ORM	540
Cypripedium candidum	ORM	540
Cypripedium fasciculatum	ORM	540
Cypripedium guttatum	ORM	540
Cypripedium montanum	ORM	540
Cypripedium parviflorum	ORM	540
Dactylorhiza fuchsia	ORM	260, 261
Dactylorhiza incarnara	ORM	173, 260, 261
Dactylorhiza maculata	ORM	260, 261
Dactylorhiza maculata ssp. ericetorum	ORM	260, 261
Dactylorhiza majalis	ORM	78, 334, 480, 260, 261
Dactylorhiza praetermissa	ORM	260, 261
Dactylorhiza praetermissa var. junialis	ORM	173
Dactylorhiza purpurella	ORM	260, 261
Epipactis atrorubens	ORM + ECM	78
	ORM	304, 260, 261
Epipactis distans	ORM + ECM	78
Epipactis helleborine	ORM + ECM	78
	ORM	260, 261
Epipactis microphylla	ORM + ECM	530
Epipactis palustris	ORM	78, 481
	ORM + NM	260, 261
Epipactis purpurata	ORM	260, 261
Epipogium aphyllum	ORM	260, 261
Goodyera repens	ORM	260, 261
Gymnadenia conopsea	ORM	260, 261
Gymnadenia odoratissima	ORM	260, 261
Haemaria discolor var. dawsoniana	ORM	122

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Hammarbya paludosa	ORM	260, 261
Herminium monorchis	ORM	260, 261
Hexalectris spicata	Mycoheterotrophy (via ECM)	572
Himantoglossum hircinum	ORM	260, 261
Ionopsis utricularioides	ORM	448
Liparis loeselii	ORM	260, 261
Listera cordata	ORM	260, 261
Listera ovata	ORM	260, 261
Malaxis latifolia	ORM	422
Microtis parviflora	ORM	459
Neotinea maculata	ORM	260, 261
Neottia nidus-avis	ORM + ECM	78
	ORM	260, 261
Newiedia veratrifolia	ORM	333
Ophrys apifera	ORM	260, 261
Ophrys fuciflora	ORM	260, 261
Ophrys insectifera	ORM	260, 261
Ophrys lutea	ORM	56
Ophrys sphegodes	ORM	260, 261
Orchis mascula	ORM	260, 261
Orchis militaris	ORM	260, 261
Orchis morio	ORM	75, 173, 260, 261
Orchis palustris	ORM	195
Orchis purpurea	ORM	260, 261
Orchis simia	ORM	260, 261
Orchis ustulata	ORM	260, 261
Phaius mishmensis	AM	655
Platanthera bifolia	ORM	260, 261
Platanthera chlorantha	ORM	78, 260, 261
Platanthera leucophaea	ORM	652
Pseudorchis albida	ORM	260, 261
Pterostylis acuminata	ORM	460
Serapias vomeracea ssp. vomeracea	ORM	195
Spathoglottis plicata	ORM	326, 534, 565
Spiranthes aestivalis	ORM	260, 261
Spiranthes sinensis var. amoena	ORM	376
Spiranthes spiralis	ORM	368, 260, 261
Stanhopea tigrina	ORM	196
Tolumnia variegata	ORM	448
Asteliaceae		
Astelia menziesiana	AM	326
Hypoxidaceae		
Curculigo capitulata	AM	422
Iridaceae		
Crocus vernus	AM	260, 261
Gladiolus segetum	AM	260, 261
Iris foetidissima	AM	260, 261
Iris germanica	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Iris pseudacorus	AM	368
	AM + NM	260, 261
Sisyrinchium atlanticum	AM	643
Sisyrinchium sp.	NM	207
Sparaxis tricolor	AM	514
Hemerocallidaceae		
Dianella sandwicensis	AM	326
Asphodelaceae		
Asphodelus fistulosus	AM	114, 115
Bulbine alata	AM	438
Haworthia tortuosa	AM	417
Alliaceae		
Allium ampeloprasum	AM	260, 261
Allium canadense	AM	140
Allium cepa	AM	7, 349, 260, 261
Allium oleraceum	AM + NM	260, 261
Allium porrum	AM	272, 260, 261
Allium sativum	AM	260, 261
Allium schoenoprasum	AM	3, 260, 261
Allium scorodoprasum	AM	260, 261
Allium sphaerocephalon	AM	472, 260, 261
Allium subhirsutum	AM	472
Allium triquetrum	AM	260, 261
Allium ursinum	AM	260, 261
Amaryllidaceae		
Galanthus nivalis	AM	260, 261
Leucojum aestivum	AM	260, 261
Leucojum vernum	AM + NM	260, 261
Narcissus poeticus	AM	260, 261
Narcissus pseudonarcissus	AM	260, 261
Themidaceae		
Brodiaea laxa	AM	513
Hyacinthaceae		
Hyacinthoides non-scripta	AM	398, 399, 260, 261
Ornithogalum nutans	AM	260, 261
Ornithogalum pyrenaicum	AM	260, 261
Ornithogalum umbellatum	AM	260, 261
Scilla autumnalis	AM	260, 261
Agavaceae		
Agave americana	AM	343
Agave datylio	Weak AM	112
Agave deserti	AM	151
Agave marmorata	AM	103
Agave salmiana	Weak AM	103
Agave univittata	AM	417
Yucca elata	AM	137
Yucca periculosa	Weak AM	103
Yucca valida	AM	417
Asparagaceae		
Asparagus acutifolius	AM	368, 472
Asparagus officinalis	AM	192, 383, 260, 261
Ruscaceae		
Convallaria majalis	AM + NM	260, 261
Maianthemum bifolium	AM + NM	260, 261
Polygonatum multiflorum	AM + NM	260, 261
Polygonatum odoratum	AM + NM	260, 261
Polygonatum verticillatum	AM + NM	260, 261
Ruscus aculeatus	AM	368, 260, 261
Arecaceae		
Astrocaryum mexicanum	AM	436
Bactris gasipaes	AM	135
Caryota monostachya	AM	655
Cocos nucifera	AM	326, 580
Euterpe edulis	AM	651
Euterpe oleracea	AM	130
Serenoa repens	AM	201
Syagrus romanzoffiana	Weak AM	651
Wallichia mooreana	NM	655
Sparganiaceae		
Sparganium angustifolium	NM	62
Sparganium chlorocarpum	AM	58
Sparganium emersum	NM	62
Sparganium erectum	NM	62
	AM	260, 261
Sparganium eurycarpum	Weak AM	626
Typhaceae		
Typha angustifolia	NM	62, 368
	Weak AM	557
	AM	566, 260, 261
Typha latifolia	NM	62
	Weak AM	557
	AM	140, 185, 599
Typha × glauca	Weak AM	557
Bromeliaceae		
Aechmea stelligera	NM	510
Ananas comosus	AM	44, 246
Hechtia aff. podantha	Weak AM	103
Vriesea limae	AM	510
Juncaceae		
Juncus acutiflorus	AM + NM	260, 261
Juncus alpinus	AM + NM	260, 261
Juncus articulatus	AM	260, 261
Juncus biglumis	NM	260, 261
Juncus bufonius	AM + NM	260, 261
Juncus bulbosus	NM	62, 260, 261
Juncus dudleyi	AM	599
Juncus effuses	NM	62
	AM	140
	AM + NM	260, 261
Juncus filiformis	Weak AM	194
	NM	260, 261
Juncus gerardi	AM + NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Juncus inflexus	AM	260, 261
Juncus maritimus	NM	368, 260, 261
Juncus nodosus	AM	599
Juncus planifolius	AM	326
Juncus roemerianus	AM	278
Juncus scheuchzerioides	AM	342
	NM	560
Juncus squarrosus	AM + NM	260, 261
Juncus torreyi	AM	599
Juncus trifidus	AM	260, 261
Luzula campestris	AM + NM	260, 261
Luzula crinita var. crinita	NM	342
Luzula hawaiiensis	AM	326
Luzula luzuloides	NM	260, 261
Luzula pallescens	NM	260, 261
Luzula pilosa	AM + NM	260, 261
Luzula spicata	AM	260, 261
Luzula sylvatica	NM	260, 261
Cyperaceae		
Bequerelia cymosa	AM	426
Bulboschoneus maritimus	AM	426
Bulbostylis barbata	Facultative AM	426
Bulbostylis capillaris	NM	326
	AM	149
	Facultative AM	426
Bulbostylis cf. conifera	AM	358
Bulbostylis densa	AM	426
Bulbostylis paradoxa	AM	358
Bulbostylis puberula	NM	426
Carex acnescens	NM	426
Carex acuta	NM	62, 260, 261
Carex acutiformis	NM	260, 261
Carex albonigra	NM	426
Carex amphibola	NM	402
Carex annectens	AM	402
Carex aphylla	NM	207
Carex aquatilis	NM	426
Carex arenaria	AM + NM	260, 261
Carex atherodes	NM	402
	Facultative AM	426
Carex baccans	AM	426
Carex bicknellii	AM	402
Carex bigelowii	NM	501, 594, 426
Carex blanda	AM	402
Carex boelckeiana	NM	207
Carex brevior	AM	402
Carex brizoides	NM	426
Carex brunnescens	AM	194
Carex buxbaumii	AM	402
	NM	260, 261
Carex caryophyllea	NM	456, 260, 261
Carex cephalophora	AM	402

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Carex chordorrhiza	NM	260, 261
Carex crawei	AM	402
Carex cristatella	AM	58, 402
Carex curta	NM	260, 261
Carex davalliana	AM	260, 261
Carex digitata	NM	260, 261
Carex dioica	NM	260, 261
Carex distans	NM	260, 261
Carex disticha	AM + NM	260, 261
Carex divulsa	AM	260, 261
Carex ebenea	NM	426
Carex echinata	NM	260, 261
Carex elongata	NM	260, 261
Carex ericetorum	NM	456, 260, 261
Carex fillifolia	NM	426
Carex flacca	NM	426
	AM + NM	260, 261
Carex flava	AM	140
	NM	426
	AM + NM	260, 261
Carex fuscula	AM	426
Carex gayana	NM	426
Carex grannularis	AM	402, 599
Carex gravida	AM	402
Carex hallerana	NM	472
Carex hirta	AM	456
	NM	260, 261
Carex hostiana	NM	260, 261
Carex humilis	NM	260, 261
Carex hystericina	NM	426
Carex interior	NM	402
Carex lachenalii	NM	426, 260, 261
Carex lanuginosa	NM	599
Carex lasiocarpa	AM	58
	Weak AM	626
	Facultative AM	426
	NM	426, 260, 261
Carex lepidocarpa	NM	260, 261
Carex limosa	NM	260, 261
Carex lindleyana	AM	426
Carex lurida	AM	58, 140
Carex madoviana	NM	426
Carex maritime	NM	426
Carex membranacea	NM	426
Carex mertensii	NM	584
Carex meyenii	AM	326
Carex microchaeta	NM	594
Carex misandra	NM	426
Carex montana	NM	260, 261
Carex muricata	NM	426
	AM + NM	260, 261
Carex myosurus	AM	426

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Carex nardina	NM	426
Carex nigra	AM	140, 194
	AM + NM	260, 261
Carex otrubae	NM	260, 261
Carex oxyandra	NM	587
Carex pallescens	AM	194
	NM	260, 261
Carex panacea	AM	194
Carex panicea	AM + NM	260, 261
Carex paniculata	NM	260, 261
Carex pellita	NM	402
Carex pendula	NM	368, 260, 261
Carex pensylvanica	AM	402
Carex pilulifera	NM	260, 261
Carex podocarpa	NM	594
Carex pulicaris	NM	260, 261
Carex remota	AM + NM	260, 261
Carex riparia	NM	260, 261
Carex rosea	AM	402
Carex rostrata	NM	260, 261
Carex scoparia	AM	402
	NM	140
Carex serotina	NM	260, 261
Carex speciosa	AM	426
Carex sprengelii	NM	402
Carex stenophylla ssp. eleocharis	NM	426
Carex sterilis	NM	426
Carex stipata	AM	140, 402
Carex stricta	NM	140, 402
	AM	626
	Facultative AM	426
Carex aff. subantarticata	NM	426
Carex subspathecea	NM	426
Carex sylvatica	NM	426, 260, 261
Carex tenera	NM	402
Carex tetanica	AM	402
Carex tribuloides	AM	58, 140
Carex trichocarpa	AM	599
Carex trifida	NM	342
Carex ursine	NM	426
Carex urticulata	NM	426
Carex vaginata	NM	503, 260, 261
Carex vesicaria	AM	626
	AM + NM	260, 261
Carex vulpina	NM	260, 261
Carex vulpinoidea	AM	58, 140, 402
Carex wahuensis	AM	326
	NM	426
Caustis dioica	NM	426
Caustis flexuosa	AM	67
Cladium amaicense	AM	426
Cladium jamaicense	AM	297

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Cladium mariscus	NM	368
	AM + NM	260, 261
Cyathochaeta avenccea	NM	426
Cyperus arenarius	AM	426
Cyperus articulatus	Weak AM	143
	Facultative AM	426
Cyperus brevifolius	AM	426
Cyperus bulbosus	NM	426
Cyperus castaneous	NM	426
Cyperus clarkei	AM	426
Cyperus compressus	Facultative AM	426
Cyperus cyperinus	AM	426
Cyperus decompositus	NM	426
Cyperus difformis	Facultative AM	426
Cyperus distans	Facultative AM	426
Cyperus dubius	AM	426
Cyperus esculentus	NM	426
Cyperus exaltatus	NM	426
Cyperus flavescens	AM	599
Cyperus halpan	Facultative AM	426
	NM	426
Cyperus iria	AM	424, 426
Cyperus javanicus	NM	426
Cyperus kyllinga	Facultative AM	355, 426
Cyperus laevigatus	AM	426
Cyperus ligularis	AM	426
	Facultative AM	426
Cyperus luzulae	NM	426
Cyperus microiria	NM	643
Cyperus niveus	AM	343
Cyperus nutans	AM	426
Cyperus odoratus	AM	426
Cyperus paniceus	AM	426
Cyperus pilosus	AM	426
Cyperus platyphyllus	AM	426
Cyperus pohlii	NM	426
Cyperus pygmaeus	AM	426
Cyperus rotundus	NM	326
	AM	343, 424, 425
	Facultative AM	426
Cyperus squarrosus	AM	426
Cyperus stoloniferous	AM	426
Cyperus strigosus	AM	599
	NM	426
Cyperus surinamensis	Facultative AM	426
Cyperus tenuispica	NM	426
Cyperus triceps	AM	426
Eleocharis acutangula	AM	426
Eleocharis dulcis	AM	426
Eleocharis erythropoda	NM	599
Eleocharis geniculata	AM	426
	NM	426
Eleocharis multicaulis	NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Eleocharis ovata	AM	140
Eleocharis aff. pachycarpa	NM	426
Eleocharis palustris	NM	62
	AM + NM	260, 261
Eleocharis quinqueflora	NM	260, 261
Eleocharis scheuchezeri	NM	426
Eleocharis tenius	NM	426
Eleocharis triste	NM	426
Eleocharis uniglumis	NM	260, 261
Eleocharis vaginatum	NM	426
Eriophorum angustifolium	AM + NM	260, 261
Eriophorum latifolium	NM	260, 261
Eriophorum vaginatum	AM + NM	260, 261
Fimbristylis consanguinea	AM	426
Fimbristylis cymosa	NM	326, 355
Fimbristylis eragrostis	AM	426
Fimbristylis falcata	Facultative AM	426
Fimbristylis miliacea	Facultative AM	426
Fimbristylis ovata	Facultative AM	426
Fimbristylis schoenoides	NM	426
Fimbristylis trachycarya	NM	426
Fimbristylis triflora	NM	426
Frimbristyllis complanata	NM	149
Fuirena ciliaris	NM	426
Gahnia gahiniformis	NM	426
Gahnia vitiensis	AM	326
Gahnia vitiensis ssp. kauaiensis	AM	326
Hypolytrum bullatum	AM	426
Hypolytrum pulchrum	AM	149, 358
Isolepis antartica	NM	426
Isolepis aucklandica	NM	342
Isolepis nodosa	AM	426
Kobresia bellardii	AM	426
Kobresia myosuroides	Facultative AM	426
	ECM	656
Kobresia simpliciuscula	NM	426, 260, 261
Kyllinga brevifolia	NM	422, 426
Kyllinga bulbosa	NM	426
Kyllinga nemoralis	NM	426
Lagenocarpus guianensis	AM	358
Lagenocarpus sphacelata	NM	426
Lepidosperma gracile	AM	397
Machaerina augustifolia	NM	326
Machaerina mariscoides	AM	326
Mariscus dubius	NM	426
Mariscus mariscoides ssp. meyenii	AM	426
Mariscus meyenianus	AM	326
Mariscus paniceus	NM	426
Mariscus squarrosus	NM	426
Mesomelaena pseudostygia	NM	426
Oreobolus furcatus	AM	326

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Pleurostachys cephalotes	Facultative AM	426
Pycreus flavidus	AM	426
Pycreus polystachyos	Facultative AM	426
	AM	326
Pycreus pumilus	AM	426
Pycreus puncticulatus	NM	426
Rhynchospora barbata	AM	149, 358
Rhynchospora brasiliensis	AM	358
Rhynchospora cephalotes	Facultative AM	426
Rhynchospora ciliata	NM	426
Rhynchospora cormbosa	AM	426
Rhynchospora longisetis	NM	426
Rhynchospora pubera	AM	426
Rikliella squarrosa	AM	426
Schoenoplectus grossus	NM	426
Schoenoplectus juncoides	NM	426
Schoenoplectus senegalensis	NM	426
Schoenoplectus supinus	AM	426
Schoenus ferrugineus	AM + NM	260, 261
Schoenus nigricans	AM + NM	260, 261
Scirpus acutus	AM	58, 626
Scirpus atrovirens	AM	58, 140, 599, 626
Scirpus cespitosus	NM	426
Scirpus cyperinus	AM	58, 140
Scirpus fluviatilis	AM	426
Scirpus holoschoenus	NM	368
Scirpus maritimus	AM	626
	NM	260, 261
Scirpus pendulus	AM	599
Scirpus aff. perpusillus	NM	426
Scirpus pungens	AM	599
Scirpus robustus	AM	426
Scirpus sylvaticus	NM	260, 261
Scirpus tabernaemontani	AM	599
Scirpus validus	AM	58
Scleria latifolia	Facultative AM	426
Scleria lithosperma	AM	426
Scleria melaleuca	Facultative AM	426
Tetraria capillaris	AM	397
Trichophorum alpinum	NM	260, 261
Trichophorum cespitosum	AM + NM	260, 261
Uncinia richleriana	NM	207
Uncinia uncinata	NM	326
Restionaceae		
Alexgeorgea nitens	AM	397
Lyginia barbata	AM	397
Poaceae		
Aeluropus littoralis var. sinensis	AM	620
Agropyron desertorum	AM	183
Agropyron repens	AM	307

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Agropyron smithii	AM	354
Agropyron trachycaulum	AM	132
Agropyron tsukushiense var. pransiens	AM	643
Agropyron tsukushiense var. transiens	AM	294
Agrostis alba	AM	140
Agrostis canina	AM + NM	260, 261
Agrostis capillaris	AM	242
	AM + NM	260, 261
Agrostis gigantea	AM	260, 261
Agrostis magellanica	AM	560
	NM	342
Agrostis palustris	AM	126
Agrostis scabra	AM	95, 587
Agrostis stolonifera	AM	456, 467
	AM + NM	260, 261
Agrostis stolonifera ssp. stolonifera	NM	307
Aira caryophyllea	NM	207
	AM + NM	260, 261
Aira praecox	AM + NM	260, 261
Alopecurus aequalis	NM	260, 261
Alopecurus geniculatus	AM	260, 261
Alopecurus myosuroides	AM	260, 261
Alopecurus pratensis	AM	260, 261
Ammocalamagrostis baltica	AM + NM	260, 261
Ammophila arenaria	AM	331, 368
	AM + NM	260, 261
Ammophila breviligulata	AM	224, 225, 324, 352
Ampelodesmos mauritanicus	AM	472
Andropogon capillipes	AM	415
Andropogon gerardii	Facultative AM	29
	AM	168, 263, 276, 524
Andropogon gerardii var. paucipilus	AM	88
Andropogon virginicus	AM	326, 415
Anthoxanthum odoratum	AM	194
	AM + NM	260, 261
Apera spica-venti	AM	260, 261
Aristida adscensionis	AM	479
Aristida contorta	Weak AM	438
Aristida holathera	NM	438
Aristida longiseta	AM	604
Aristida mutabilis	AM	567
Aristida aff. romeriana	AM	143
Aristida stricta	NM	30, 415
Arrhenatherum elatius	AM + NM	260, 261
Avena barbata	AM	472

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Avena fatua	AM	260, 261
Avena sativa	AM	15
	AM + NM	260, 261
Avena strigosa	AM	260, 261
Avenula pratensis	AM	260, 261
Avenula pubescens	AM	260, 261
Axonopus pruinosus	AM	358
Beckmannia syzigachne	AM	294
Bothriochloa pertusa	AM	343
Bouteloua eripoda	AM	137
Boutelous repens	AM	143
Brachiaria decumbens	AM	150, 358
Brachiaria humidicola	AM	150, 358
Brachypodium pinnatum	AM + NM	260, 261
Brachypodium ramosum	AM	472
Brachypodium sylvaticum	AM	260, 261
Briza maxima	AM	472, 260, 261
Briza media	AM + NM	260, 261
Briza minor	AM	643, 260, 261
Bromus erectus	AM	260, 261
Bromus hordeaceus	AM	493
	AM + NM	260, 261
Bromus inermis	AM	260, 261
Bromus madritensis ssp. rubens	AM	646
Bromus sterilis	NM	260, 261
Bromus tectorum	Facultative AM	237
Calamagrostis canescens	AM	260, 261
Calamagrostis epigejos	AM	307
	AM + NM	260, 261
Calamagrostis stricta	AM	260, 261
Calamagrostis villosa	AM	54, 366, 615
Calamovilfa longifolia	AM	88
Catapodium rigidum	AM	472
Cenchrus ciliaris	AM	20
Cenchrus setigerus	AM	567
Chusquea culeou	AM	207
Cinna arundinacea	AM	140
Corynephorus canescens	AM	81
	AM + NM	260, 261
Cymbopogon jwarancusa	AM	567
Cymbopogon winterianus	AM	327
Cynodon dactylon	AM	294, 260, 261
Cynosurus cristatus	AM	260, 261
Dactylis glomerata	AM	497
	AM + NM	260, 261
Danthonia decumbens	AM	194, 260, 261
Dendrocalamus asper	AM	608
Dendrocalamus strictus	AM	482
Deschampsia antarctica	Facultative AM	166
	NM	560
Deschampsia caespitosa	NM	342

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Deschampsia cespitosa	AM	194, 293, 260, 261
Deschampsia chapmanii	AM	342
Deschampsia flexuosa	AM	194, 270, 366, 615, 260, 261
Desmazeria rigida	AM	260, 261
Dichanthelium cynodon	AM	326
Dichanthelium lanuginosum	AM	95
Digitaria adscendens	AM	294
Digitaria chinensis	AM	422
Digitaria ciliaris	Weak AM	129
	AM	643
Digitaria eriantha	AM	23
Digitaria sanguinalis	AM	260, 261
Digitaria violascens	AM	422
Distichlis spicata	AM	278
Distichlis stricta	AM	302
Echinochloa crus-galli	AM	140
	AM + NM	260, 261
Echinolaena inflexa	AM	358
Eleusine coracana	AM	576
Eleusine indica	AM	422
Elymus canadensis	AM	263, 274
Elymus caninus	AM	260, 261
Elymus farctus	AM + NM	260, 261
Elymus pycnanthus	AM + NM	260, 261
Elymus repens	AM	260, 261
Enneapogon avenaceus	AM	438
Eragrostis dielsii	Facultative AM	438
Eragrostis ferruginea	AM	643
Eriachne aristidea	Weak AM	438
Festuca altissima	NM	260, 261
Festuca argentina	AM	207
Festuca arundinacea	AM	275, 260, 261
Festuca baffinensis	AM	158
Festuca brachyphylla	AM	158
Festuca brigantina	AM	235
Festuca contracta	NM	342
Festuca erecta	AM	560
Festuca gigantea	NM	260, 261
Festuca hyperborea	NM	158
Festuca idahoensis	AM	109, 371
Festuca juncifolia	AM	260, 261
Festuca lemanii	AM	260, 261
Festuca ovina	AM	194, 456
	AM + NM	260, 261
Festuca pallescens	AM	207
Festuca pratensis	AM	194
	AM + NM	260, 261
Festuca pumila	AM	80
Festuca rubra	AM + ECM + NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Festuca vivipara	AM	260, 261
Glyceria fluitans	NM	260, 261
Glyceria maxima	NM	260, 261
Glyceria plicata	AM + NM	260, 261
Heteropogon contortus	AM	326, 343
Hierochloe odorata	AM	599, 260, 261
Holcus lanatus	AM	395, 586
	AM + NM	260, 261
Holcus mollis	AM	194, 260, 261
Homolepsis aturensis	AM	142
Hordeum brachyantherum	AM	293
Hordeum comosum	AM	207
Hordeum distichon	AM	260, 261
Hordeum jubatum	AM	302, 626
Hordeum murinum	AM	260, 261
Hordeum vulgare	AM	119
	AM + NM	260, 261
Imperata cylindrica	AM	422
Ischaemum byronis	AM	326
Koeleria glauca	NM	260, 261
Koeleria macrantha	AM	260, 261
Koeleria pyramidata	NM	274
Koeleria vurilochensis	NM	207
Lagurus ovatus	AM	260, 261
Lasiurus sindicus	AM	567
Leersia hexandra	AM	404
Leersia oryzoides	AM	58, 140
	NM	260, 261
Leymus arenarius	AM	240, 241
	NM	260, 261
Lolium perenne	AM	23, 140, 171, 307
Lolium perenne ssp. multiflorum	AM	260, 261
Lolium perenne ssp. perenne	AM	260, 261
Lolium temulentum	AM + NM	260, 261
Lygeum spartum	AM	170
Melica nutans	AM + NM	260, 261
Melica uniflora	NM	260, 261
Microstegium ciliatum	AM	422
Milium effusum	AM + NM	260, 261
Molinia caerulea	AM	586, 260, 261
Mulenbergia porteri	AM	137
Nardus stricta	AM	194, 269, 260, 261
Nassella leucotricha	AM	604
Neyraudia reynaudiana	AM	343
Oryza sativa	AM	536
Oryzopsis hymenoides	AM	11
Palicourea rigida	AM	358
Panicum amarum	AM	43

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Panicum clandestinum	AM	58
Panicum hemitomon	AM	404
Panicum laxum	AM	149
Panicum maximum	AM	20
Panicum micranthum	AM	358
Panicum nephelophilum	AM	326
Panicum purpurascens	AM	143
Panicum virgatum	AM	83, 134
	Weak AM	626
Panicum virginatum	AM	193
Paractaenum novae-hollandiae	NM	438
Parapholis incurva	AM	260, 261
Paspalidium flavidum	AM	343
Paspalum cf. carinatum	AM	358
Paspalum conjugatum	AM	142
Paspalum dilatatum	AM	243
Paspalum notatum	AM	193, 295, 562
Paspalum thunbergii	AM	643
Pennisetum alopecuroides	AM	643
Pennisetum glaucum	AM	51, 567
Pennisetum padicillatum	AM	544
Pennisetum parviflorum	AM	545
Pennisetum setaceum	AM	326
Phalaris arundinacea	AM	58, 140
	NM	62
	AM + NM	260, 261
Phleum alpinum	AM	194, 260, 261
Phleum arenarium	NM	260, 261
Phleum phleoides	AM + NM	260, 261
Phleum pratense	AM	132, 194, 260, 261
Phragmites australis	NM	62
	AM	140, 368
	AM + NM	260, 261
Phragmites communis	AM	620
Piptatherum miliaceum	AM	497
Poa alpina	AM + NM	260, 261
Poa angustifolia	AM	307
Poa annua	AM	560, 643
	NM	342
	AM + NM	260, 261
Poa arctica	NM	594
Poa compressa	NM	307
	AM + NM	260, 261
Poa cookie	NM	560
	AM	342
Poa flexuosa	AM + NM	260, 261
Poa foliosa	NM	342
Poa kerguelensis	AM	560
Poa lanuginosa	AM	207
Poa literosa	NM	342

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Poa nemoralis	AM + NM	260, 261
Poa palustris	AM + NM	260, 261
Poa pratensis	AM	194, 467, 626
	AM + NM	260, 261
Poa trivialis	AM + NM	260, 261
Polypogon monspeliensis	AM	260, 261
Puccinellia distans	AM + NM	260, 261
Puccinellia macquariensis	AM	342
Puccinellia maritima	AM + NM	260, 261
Puccinellia nuttalliana	AM	301
Raddiella esembeckii	AM	358
Rhynchelytrum repens	AM	355
Saccharum officinarum	AM	326, 489
Saccharum spontaneum	Weak AM	439
Schizachyrium scoparium	Facultative AM	29
	AM	117, 140
Schizachyrium stoloniferum	AM	415
Secale cereale	AM	512
	AM + NM	260, 261
Sesleria albicans	AM + NM	260, 261
Setaria glauca	AM	643
Setaria pumila	AM	260, 261
Setaria verticillata	AM	260, 261
Setaria viridis	AM	643
	AM + NM	260, 261
Sorghastrum nutans	AM	264
Sorghum bicolor	AM	171
Sorghum halpense	AM	193
Sorghum sudanense	AM	311
Spartina alterniflora	NM	278
	Weak AM	391
Spartina anglica	NM	260, 261
Spartina cynosuroides	AM	278, 391
Spartina gracilis	AM	302
Spartina patens	AM	97, 278, 324
Spartina pectinata	AM	626
Spartina × townsendii	NM	260, 261
Sphenopholis obtusa	AM	625
Sporobolus heterolepis	AM	168
Sporobolus virginicus	AM	144, 326
Sporobolus wrightii	AM	491
Stipa tenacissima	AM	497
Themeda triandra	AM	23
Thysanolaena maxima	AM	422
Trachypogon gouinii	AM	144
Trachypogon plumosus	AM	149, 353, 358
Triodia basedowii	Weak AM	438
Tripogon filiformis	AM	343
Triraphis mollis	Weak AM	438
Trisetum flavescens	AM	207, 260, 261
Triticum aestivum	AM	15
Triticum durum	AM	10
Uniola paniculata	AM	563

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Vulpia ciliata ssp. ambigua	AM	110
Zea mays	AM	123
Zoysia japonica	AM	326
Commelinaceae		
Amischotolype hispida	AM	655
Commelina communis	AM	294
	NM	643
Commelina aff. erecta	AM	143
Musaceae		
Musa acuminata	AM	163
Heliconiaceae		
Heliconia psittacorum	AM	510
Cannaceae		
Canna coccinea	NM	510
Zingiberaceae		
Alpinia conchigera	AM	655
Amomum villosum	AM	422
Costus speciosus	AM	422
Paramomum petaloideum	AM	655
Renealmia guianensis	AM	510
Costaceae		
Costus scaber	AM	510
Costus spiralis var. spiralis	AM	510
Myristicaceae		
Horsfieldia pandurifolia	AM	655
Horsfieldia tetratepala	AM	422
Myristica yunnanensis	AM	655
Pycnanthus angolensis	AM	445
Staudtia kamerunensis	AM	445
Magnoliaceae		
Liriodendron tulipifera	AM	362, 470
Magnolia henryi	AM	422, 655
Talauma ovata	NM	548
Annonaceae		
Annona cherimola	AM	42
Enantia chlorantha	AM	445
Goniothalamus griffithii	AM	422, 655
Hexalobus crispiflorus	AM	445
Mitrephora calcarea	AM	655
Pseuduvaria indochinensis	NM	655
Lauraceae		
Beilschmiedia pendula	AM	356, 357
Cryptocarya angulata	AM	222
Cryptocarya mackinnoniana	AM	222
Cryptocarya yunnanensis	AM	422
Laurus nobilis	AM	368, 603
Lindera benzoin	AM	140
Litsea dileniifolia	AM	655
Litsea liyuyingi	AM	655
Nectandra rigida	AM	31
Ocotea indecora	AM	651
Ocotea puberula	AM	651
Persea americana	AM	41, 250, 326, 609
Phoebe lanceolata	AM	422
Aristolochiaceae		
Asarum europaeum	AM + NM	260, 261
Piperaceae		
Peperomia hesperomannii	AM	326
Peperomia membranacea	AM	326
Piper longum	AM	422, 655
Piper nigrum	AM	578
Piper sarmentosum	AM	422
Piper sp.	NM	422
Papaveraceae		
Chelidonium majus	NM	260, 261
Macleaya cordata	AM	343
Papaver rhoeas	AM + NM	260, 261
Papaver somniferum	NM	260, 261
Menispermaceae		
Cocculus trilobus	AM	326
Berberidaceae		
Berberis buxifolia	AM	207
Berberis darwinii	NM	207
Berberis vulgaris	AM	260, 261
Mahonia aquifolium	AM	260, 261
Podophyllum peltatum	AM	410, 621
Ranunculaceae		
Aconitum delphinifolium	AM	594
Aconitum napellus	AM + NM	260, 261
Actea spicata	AM + NM	260, 261
Anemone nemorosa	AM + NM	260, 261
Anemone ranunculoides	AM	260, 261
Anemone vulgaris	AM	260, 261
Batrachium circinatum	NM	62
Batrachium peltatum	NM	62
Caltha palustris	NM	62
	AM + NM	260, 261
Clematis stans	AM	636
Clematis vitalba	AM	368
	AM + ECM	260, 261
Consolida ambigua	AM	260, 261
Corydalis lutea	NM	260, 261
Corydalis solida	NM	260, 261
Fumaria officinalis	AM + NM	260, 261
Helleborus foetidus	AM	260, 261
Myosurus minimus	AM	260, 261
Pulsatilla patens	AM	408
Pulsatilla pratensis	AM	408
Pulsatilla vulgaris	AM + NM	260, 261
Ranunculus acris	AM	194, 456, 586, 260, 261
Ranunculus acris ssp. pumilus	AM	503
Ranunculus adoneus	AM	416, 519

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Ranunculus auricomus	AM	586
	AM + NM	260, 261
Ranunculus biternatus	AM	560
Ranunculus bulbosus	AM	456, 260, 261
Ranunculus crassipes	AM	342
Ranunculus ficaria	AM + NM	260, 261
Ranunculus flammula	AM	62
	AM + NM	260, 261
Ranunculus fluitans	NM	260, 261
Ranunculus lingua	AM + NM	260, 261
Ranunculus nemorosus	AM	586
Ranunculus paludosus	AM	260, 261
Ranunculus repens	AM + NM	260, 261
Ranunculus reptans × *flammula*	AM	260, 261
Ranunculus sardous	AM	260, 261
Ranunculus sceleratus	AM + NM	260, 261
Thalictrum minus	AM	260, 261
Trollius europaeus	AM	194, 503, 260, 261
Proteaceae		
Banksia aricifolia	Weak AM	454
Conospermum longifolium	AM	67
Conospermum taxifolium	AM	67
Lomatia hirsute	NM	207
Grevillea robusta	NM	326
Telopea speciosissima	AM	67
Buxaceae		
Buxus sempervirens	AM	260, 261
Gunneraceae		
Gunnera petaloidea	AM	326
Dilleniaceae		
Hibbertia serpyllifolia	AM	67
Droseraceae		
Drosera anglica	NM	326, 260, 261
Drosera intermedia	AM	212
	NM	260, 261
Drosera rotundifolia	AM	140
	AM + NM	260, 261
Frankeniaceae		
Frankenia laevis	NM	260, 261
Frankenia plicata	Weak AM	438
Tamaricaceae		
Tamarix chinensis	AM	620
Tamarix gallica	AM	368
Plumbaginaceae		
Armeria maritime	AM	277
	AM + NM	260, 261
Armeria maritima ssp. halleri	AM	456
Limonium vulgare	AM + NM	260, 261
Polygonaceae		
Bistorta vivipara	AM	194

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Coccoloba uvifera	ECM	326
Coccoloba warmingii	AM	31
Fagopyrum esculentum	NM	260, 261
Fallopia convolvulus	NM	260, 261
Oxyria digyna	NM	260, 261
Polygonum amphibium	Facultative AM	62, 626
	NM	260, 261
Polygonum aviculare	NM	307
	AM + NM	260, 261
Polygonum bistorta	NM	594
	AM	260, 261
Polygonum capitatum	ECM + weak AM	326
Polygonum cespitosum	AM	140
Polygonum cuspidatum	AM	636
	NM	643
Polygonum hydropiper	NM	260, 261
Polygonum lapathifolium	NM	260, 261
Polygonum lapathifolium ssp. pallidum	NM	307
Polygonum longisetum	NM	643
Polygonum maritimum	NM	260, 261
Polygonum mite	NM	260, 261
Polygonum pesicaria	Weak AM	626
	AM + NM	260, 261
Polygonum statice	AM	343
Polygonum viviparum	ECM	594
	AM + ECM	260, 261
Polygonum weyrichii	ECM	587
Polygonum weyrichii var. alpinum	NM	636
Rumex acetosa	AM	194, 294, 456
	AM + NM	260, 261
Rumex acetosella	NM	207, 456
Rumex acetosella agg.	NM	260, 261
Rumex alpinus	AM + NM	260, 261
Rumex altissimus	AM	140
Rumex conglomeratus	NM	260, 261
Rumex crispus	NM	307
	AM + NM	260, 261
Rumex hastatus	AM	343
Rumex hydrolapathum	NM	62
Rumex japonicus	NM	643
Rumex longifolius	Weak AM	194
Rumex obtusifolius	AM + NM	260, 261
Rumex palustris	NM	260, 261
Rumex scutatus	NM	260, 261
Ruprechtia laxiflora	NM	651
Caryophyllaceae		
Agrostemma githago	NM	260, 261
Arenaria serpyllifolia	NM	260, 261
Cerastium alpinum	NM	260, 261
Cerastium arcticum	NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Cerastium arvense	AM	456
	NM	260, 261
Cerastium cerastoides	NM	260, 261
Cerastium fontanum	AM	194
	NM	456
Cerastium fontanum ssp. fontanum	AM	342
Cerastium fontanum ssp. glabrescens	AM + NM	260, 261
Cerastium glomeratum	NM	560
Cerastium holosteoides var. hallaisanense	NM	643
Cerastium semidecandrum	NM	260, 261
Colobanthus apetalus var. alpinus	AM	342
Colobanthus kerguelensis	NM	560
Colobanthus muscoides	NM	342
Dianthus carthusianorum	AM	456
	NM	260, 261
Dianthus caryophyllus	NM	554
Dianthus deltoides	NM	260, 261
Dianthus gratianopolitanus	NM	260, 261
Gypsophila fastigiata	NM	456
Honkenya peploides	NM	260, 261
Lychnis flos-cuculi	AM + NM	260, 261
Lychnis viscaria	NM	260, 261
Minuartia hybrida	AM	260, 261
Minuartia verna	NM	260, 261
Moehringia trinervia	NM	260, 261
Myosoton aquaticum	NM	260, 261
Polycarpaea corymbosa	AM	336
Sagina apetala	NM	260, 261
Sagina procumbens	NM	260, 261
Sagina subulata	NM	260, 261
Saponaria officinalis	NM	260, 261
Scleranthus annuus	NM	260, 261
Silene acaulis	AM	594
	AM + ECM + NM	260, 261
Silene alba	NM	260, 261
Silene colorata ssp. canescens	AM	368
Silene dioica	Weak AM	194
	NM	260, 261
Silene maritima	NM	260, 261
Silene nutans	NM	260, 261
Silene otites	AM	260, 261
Silene vulgaris	NM	456, 260, 261
Schiedea spergulina	AM	326
Spergula arvensis	AM + NM	260, 261
Spergularia marina	AM or NM	260, 261
Spergularia media	AM + NM	260, 261
Stellaria alsine	NM	260, 261
Stellaria graminea	NM	260, 261
Stellaria holostea	AM + NM	260, 261
Stellaria media	AM	294
	AM + NM	260, 261
Stellaria media ssp. media	AM	342
Stellaria nemorum	AM + NM	260, 261
Stellaria pallida	AM + NM	260, 261
Stellaria palustris	NM	260, 261
Stellaria parviflora	NM	342
Amaranthaceae		
Achyranthes aspera	NM	422
	AM	343
Achyranthes fauriei	NM	643
Achyranthes splendens	NM	326
Amaranthus caudatus	AM	33
Amaranthus lividus	AM	294
Amaranthus retroflexus	NM	260, 261
Amaranthus spinosus	NM	422
	AM	343
Amaranthus tricolor	AM	33
Amaranthus viridis	AM	343
Atriplex barclayana	Weak AM	112
Atriplex canescens	AM	57
Atriplex glabriuscula	NM	260, 261
Atriplex halimus	NM	368
Atriplex hortensis	NM	260, 261
Atriplex julacea	AM	543
Atriplex limbata	NM	438
Atriplex littoralis	AM	260, 261
Atriplex patula	AM	260, 261
Atriplex prostrata	NM	260, 261
Atriplex semibaccata	NM	326
Beta vulgaris	AM	260, 261
Celosia cristata	AM	33
Chenopodium album	NM	307
	AM + NM	260, 261
Chenopodium ambrosioides	AM	343
Chenopodium bonus-henricus	NM	260, 261
Chenopodium glaucum	NM	260, 261
Chenopodium murale	NM	326
Chenopodium rubrum	NM	260, 261
Enchylaena tomentosa	NM	438
Gomphrena globosa	AM	33
Halimione portulacoides	AM + NM	260, 261
Nototrichium sandwicense	NM	326
Ptilotus latifolius	NM	438
Ptilotus obovatus var. obovatus	NM	438
Ptilotus sessilifolius	NM	438
Salicornia europaea	AM	277
	AM + NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Salsola kali	NM	19, 300, 260, 261
	AM + NM	438
Sclerolaena diacantha	AM	438
Sclerolaena holtiana	NM	438
Suaeda glauca	AM	620
Suaeda maritima	AM	533
	AM + NM	260, 261
Suaeda vera	AM + NM	260, 261
Aizoaceae		
Cheredospsis purpurea	NM	417
Delosperma herbium	Falcutative AM	417
Sesuvium portulacastrum	NM	326
	AM	143
Tetragonia tetragonioides	AM	326
Phytolaccaceae		
Stegnosperma halimifolia	AM	112
Nyctaginaceae		
Abronia maritima	Falcutative AM	543
Abronia umbellata	AM	543
Boerhavia repens	NM	326
Bougainvillea spectabilis	NM	326, 651
Mirabilis jalapa	NM	326
Neea sp.	ECM	656
Pisonia sp.	ECM	656
Pisonia umbellifera	NM	326
Cactaceae		
Chamacereus sylvestris	NM	417
Cochemia poselgeri	AM	112
Coryphanta radians	Weak AM	103
Escontria chiotilla	Weak AM	103
Ferocactus acanthodes	AM	151
Ferocactus flavovirens	Weak AM	103
Ferocactus latispinus	Weak AM	103
Ferocactus peninsulae	AM	112
Lemaireocereus thurberi	Weak AM	112
Lophocereus schottii	AM	112
Machaerocereus gummosus	Weak AM	112
Mammilaria carnea	Weak AM	103
Mammilaria dioica	Weak AM	112
Mamillaria elongata	NM	417
Myrtillocactus geometrizans	Weak AM	103
Neobuxbaumia tetetzo	Weak AM	103
Nopalea karwinskiana	AM	20
Opuntia cholla	AM	112
Opuntia excelsa	AM	20
Opuntia ficus-indica	AM	151
Opuntia lindsayi	AM	112
Opuntia pilifera	AM	103
Opuntia puberula	AM	20
Opuntia streptacantha	AM	103
Opuntia stricta var. dillenii	AM	143
Opuntia tuna	NM	417
Pachycereus pectin-aboriginum	AM	494
Pachycereus pringlei	Weak AM	112
Selenicereus macdonaldiae	AM	417
Stenocereus queretaroensis	AM	463, 464
Stenocereus stellatus	Weak AM	103
Portulacaceae		
Lyallia kerguelensis	NM	560
Montia fontana ssp. fontana	NM	342
Montia perfoliata	NM	207
Montia sibirica	AM	260, 261
Portulaca intraterranea	NM	438
Portulaca lutea	NM	326
Portulaca oleracea	AM + NM	260, 261
Portulaca sclerocarpa	NM	326
Olacaceae		
Coula edulis	AM	445
Ongokea gore	AM	445
Strombosis grandifolia	AM	445
Loranthaceae		
Viscum album	NM	260, 261
Santalaceae		
Santalum ellipticum	NM	326
Santalum paniculatum	AM	326
Thesium alpinum	NM	456
Thesium humifusum	NM	260, 261
Loasaceae		
Caiophora sylvestris	NM	207
Loasa berghii	NM	207
Cornaceae		
Cornus sanguinea	AM + NM	260, 261
Balsaminaceae		
Impatiens capensis	AM	140
Impatiens glandulifera	AM + NM	260, 261
Impatiens noli-tangere	AM + NM	260, 261
Impatiens parviflora	AM + NM	260, 261
Impatiens walleriana	AM	322
Tetrameristaceae		
Tetramerista glabra	AM	568
Polemoniaceae		
Polemonium caeruleum	AM	260, 261
Fouquieriaceae		
Fouquieria digueti	AM	112
Theaceae		
Pyrenaria cheliensis	AM	422
Ebenaceae		
Diospyros nigrocartex	AM	422, 655
Theophrastaceae		
Jacquinia pungens	AM	20
Primulaceae		
Anagallis arvensis	AM	472, 260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Anagallis tenella	AM	260, 261
Asterolinum stellatum	AM	472
Cyclamen hederifolium	AM	260, 261
Glaux maritima	AM	260, 261
Hottonia palustris	AM + NM	260, 261
Lysimachia japonica	AM	643
Lysimachia nemorum	AM + NM	260, 261
Lysimachia nummularia	AM + NM	260, 261
Lysimachia terrestris	AM	140
	AM + NM	260, 261
Lysimachia thyrsiflora	NM	62
	AM + NM	260, 261
Lysimachia vulgaris	AM	368
	AM + NM	260, 261
Primula elatior	AM	260, 261
Primula farinosa	AM	260, 261
Primula veris	AM + NM	260, 261
Primula vulgaris	AM	260, 261
Samolus valerandi	AM	368, 260, 261
Trientalis europaea	AM	501
	AM + NM	260, 261
Myrsinaceae		
Ardisia crenata	AM	87
Ardisia tenera	AM	422, 655
Measa indica	AM	422
Myrsine alyxifolia	AM	326
Rapanea ferruginea	AM	31
Styracaceae		
Strichinus brasiliensis	AM	651
Diapensiaceae		
Diapensia lapponica	ERM	260, 261
Lecythidaceae		
Barringtonia macrostachya	AM	655
Barringtonia racemosa	AM	655
Cariniana estrellensis	AM	651
Sapotaceae		
Aningeria adolfi-friedericii	AM	637, 638
Aningeria robusta	AM	445
Argania spinosa	AM	434
Autranella congolensis	AM	445
Baillonella toxisperma	AM	445
Gambeya africana	AM	445
Omphalocarpum procerum	AM	445
Palaquium gutta	AM	568
Actinidiaceae		
Actinidia deliciosa	AM	523
Clethraceae		
Clethra barbinervis	AM	335
Ericaceae		
Andromeda polifolia	ERM	260, 261
Arbutus menziesii	ABM	374
	ECM	375

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Arbutus unedo	ABM	200, 238, 421, 368, 472, 260, 261
Arctostaphylos alpinus	ABM	594
	ERM	260, 261
Arctostaphylos uva-ursi	ABM	259, 507
	M(endo) + ERM + ABM + ECM + EEM	260, 261
Calluna vulgaris	ERM	72, 238, 299, 260, 261
Cassiope tetragona	ERM	594
Cavendishia capitulata	ERM	474
Cavendishia melastomoides	ERM	474
Daboecia cantabrica	ERM	260, 261
Disterigma humboldtii	ERM	474
Empetrum nigrum	ERM	594, 260, 261
Erica arborea	ERM	368
Erica cinerea	ERM	99, 260, 261
Erica erigena	ERM	260, 261
Erica mackaiana	ERM	260, 261
Erica multiflora	ERM	472
Erica tetralix	ERM	260, 261
Erica vagans	ERM	260, 261
Gaultheria erecta	ERM	474
Gaultheria procumbens	ERM	238
Gaultheria shallon	ERM	22, 639
Gonocalyx costaricense	ERM	474
Kalmia latifolia	ERM	238
Ledum palustre	ERM	260, 261
Ledum palustre ssp. decumbens	ERM	594
Ledum palustre ssp. groenlandicum	ERM	594
Leucopogon parviflorus	ERM	401
Leucothoe fontanesiana	ERM	238
Loiseleuria procumbens	ERM	594, 260, 261
Oxydendrum arboreum	ERM	238
Pernettya mucronata	ERM	207
Phyllodoce caerulea	ERM	260, 261
Pieris floribunda	ERM	238, 555
Rhododendron brachycarpum	ERM	154
Rhododendron calendulaceum	ERM	238
Rhododendron carolinianum	ERM	238
Rhododendron catawbiense	ERM	238
Rhododendron maximum	ERM	238
Rhododendron mucronulatum	ERM	238
Rhododendron obtusum	ERM	601

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Rhododendron ponticum	ERM	260, 261
Sphyospermum buxifolium	ERM	474
Sphyospermum cordifolium	ERM	474
Vaccinium angustifolium	ERM	157
Vaccinium calycinum	ERM + AM	325, 326
Vaccinium corymbosum	ERM	238, 645
Vaccinium dentatum	ERM + AM	325, 326
Vaccinium macrocarpon	ERM	99, 238, 260, 261
Vaccinium myrtillus	ERM	72, 260, 261
Vaccinium oxycoccos	ERM	260, 261
Vaccinium reticulatum	ERM + weak AM	326
	ERM + AM	325
Vaccinium uliginosum	ERM	594, 260, 261
Vaccinium vitis-idaea	ERM	594, 260, 261
Woollsia pungens	ERM	401
Ericaceae "Pyrolaceae"		
Moneses uniflora	EEM + M(endo)	260, 261
Orthilia secunda	EEM + M(endo)	260, 261
Pyrola media	M(endo)	260, 261
Pyrola minor	EEM + M(endo)	260, 261
Pyrola rotundifolia	EEM + M(endo)	260, 261
Ericaceae (Monotropoideae)		
Monotropa hypopitys	MTM	260, 261
Monotropa uniflora	MTM	647
Monotropastrum humile	MTM	384
Sarcodes sanguinea	ERM + MTM	332
Ericaceae (Epacridoideae)		
Astroloma conostephioides	ERM	393
Astroloma humifusum	ERM	393
Astroloma pinifolium	ERM	393, 394
Brachyloma daphnoides	AM	67
	ERM	393
Epacris impressa	ERM	393, 394
Epacris impressa var. grandiflora	ERM	393
Epacris microphylla	AM	67
	ERM	128
Leucopogon ericoides	ERM	393
Leucopogon juniperinus	AM	67
Leucopogon parviflorus	ERM	393, 556
Lysinema ciliatum	ERM	36
Styphelia adscendens	ERM	393
Styphelia tameiameiae	ERM + AM	325, 326
Woollsia pungens	ERM	127, 312
Icacinaceae		
Pittosporopsis kerrii	AM	422
Boraginaceae		
Arnebia hispidisima	AM	567
Borago officinalis	NM	260, 261
Bourreria sonorae	AM	112
Cerastium arvense	NM	207
Cordia alliodora	AM	20

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Cordia curassavica	Weak AM	103
Cordia ecalyculata	AM	651
Cordia trichotoma	AM	651
Cynoglossum creticum	AM	207
Cynoglossum lanceolatum	AM	343
Echium vulgare	AM	260, 261
Heliotropium anomalum	AM	326
Heliotropium curassavicum	AM	326
Heliotropium sp.	AM	567
Lithospermum arvense	NM	260, 261
Lithospermum officinale	NM	260, 261
Lithospermum purpurocaeruleum	AM	260, 261
Myosotis alpestris	AM + NM	260, 261
Myosotis arvensis	NM	260, 261
Myosotis decumbens	Facultative AM	194
Myosotis discolor	AM	260, 261
Myosotis laxa ssp. caespitosa	AM	260, 261
Myosotis palustris	Facultative AM	62
Myosotis ramosissima	AM + NM	260, 261
Myosotis scorpioides	AM + NM	260, 261
Myosotis sylvatica	AM + NM	260, 261
Omphalalappula concava	NM	438
Plagiobothrys figuratus	AM	293
Pulmonaria officinalis	AM + NM	260, 261
Silene andicola	NM	207
Stellaria graminea	AM	194
Stellaria media	AM	207
Symphytum officinale	AM	260, 261
Symphytum tuberosum	AM + NM	260, 261
Tournefortia argentea	AM	326
Trichodesma zeylanicum	AM	438
Rubiaceae		
Asperula cynanchica	AM	260, 261
Borreria articularis	AM	336
Borreria pusilla	AM	336
Canthium parvifoliam	AM	422
Cephalanthus occidentalis	AM	140
Chesalia curviflora	AM	422, 655
Coffea arabica cv. guatemala	AM	602
Coprosma ernodeoides	AM	326
Coprosma kauensis	AM	326
Coprosma perpusilla ssp. subantarctica	NM	342
Declieuxia fruticosa	AM	149
Duperrea pavettaefolia	AM	655
Galium album	AM	194, 260, 261
Galium antarcticum	AM	560
Galium aparine	NM	207
	AM + NM	260, 261
Galium boreale	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Galium cruciata	AM	260, 261
Galium mollugo	AM	456
	AM + NM	260, 261
Galium odoratum	AM + NM	260, 261
Galium palustre	AM + NM	260, 261
Galium saxatile	AM + NM	260, 261
Galium sp.	AM	140
Galium uliginosum	NM	260, 261
Galium verum	AM	260, 261
Geophila herbacea	AM	422, 655
Hedyotis costata	AM	422
Hedyotis elatior	AM	326
Hedyotis foggiana	AM	326
Hedyotis terminalis	AM	326
Lasianthus hookeri	AM	422
Lasianthus sikkimensis	AM	655
Lasianthus verticillatus	AM	655
Metadina trichotoma	AM	655
Mitragina ciliata	AM	445
Morinda lucida	AM	422
Mycetia hirta	AM	655
Nauclea diederrichii	AM	445
Neonauclea tsaiana	AM	655
Nertera granadensis	AM	326
Oldenlandia aspera	AM	336
Ophiorrhiza austro-yunnanensis	AM	422
Paederia scandens	AM	643
Pausynistalia johimbe	AM	445
Prismatomeria tetrandra	AM	422
Psychotria calocarpa	AM	655
Psychotria henryi	AM	422
Psychotria siamica	NM	655
Psychotria sp.	AM	326
Randia ruglosa	AM	315
Relbuneum hypocarpium	AM	207
Relbuneum richardianum	AM	207
Rubia peregrina	AM	368
	AM + ECM	472
	ECM	260, 261
Sherardia arvensis	AM	472
Vangueria infausta	AM	84, 85
Vangueria infausta ssp. infausta	AM	221
Gentianaceae		
Blackstonia perfoliata	AM	368, 472
	AM + NM	260, 261
Centaurium erythraea	AM	472, 260, 261
Gentiana algida	NM	594
Gentiana nivalis	AM + NM	260, 261
Gentiana pneumonanthe	AM + NM	260, 261
Gentiana verna	AM	561, 260, 261
Gentianella amarella	AM	260, 261
Gentianella campestris	AM	194, 260, 261
Gentianella germanica	AM	456, 260, 261
Voyria aurantiaca	Mycoheterotrophy (via AM)	79
Voyria caerulea	Mycoheterotrophy (via AM)	79
Voyria corymbosa	Mycoheterotrophy (via AM)	79
Voyria obconica	Mycoheterotrophy (via AM)	292
Voyria rosea	Mycoheterotrophy (via AM)	79
Voyria tenuiflora	Mycoheterotrophy (via AM)	79
Voyriella parviflora	Mycoheterotrophy (via AM)	79
Loganiaceae		
Anthocleista schweinfurthii	AM	445
Buddleia asiatica	AM	326
Apocynaceae		
Adenium obesum	AM	623
Adenium somalense	AM	623
Allamanda cathartica var. schotti	AM	623
Allamanda violacea	AM	623
Alstonia boonei	AM	445
Alyxia oliviaeformis	AM	326
Amsonia tabernaemontana	AM	623
Apocynum cannabinum	AM	623
Apocynum medium	AM	623
Aspidosperma parvifolium	NM	548
Aspidosperma polyneuron	NM	651
Catharanthus roseus	AM	623
Dyera costulata	NM	568
Landolphia heudelottii	NM	47
Mandevilla sanderei	AM	623
Nerium oleander	AM	623
Pachypodium lamerei	AM	623
Picralima nitida	AM	445
Plumeria obtuse	AM	623
Plumeria rubra	AM	623
Rauwolfia serpentina	AM	623
Rauwolfia verticillata	AM	623
Saba senegalensis	NM	47
Stemmadenia donnell-smithii	AM	244
Strophanthus capensis	AM	623
Tabernaemontana australis	AM	651
Thevetia peruviana	AM	623

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Trachelospermum jasminoides	AM	623
Vinca major	AM	260, 261
Vinca minor	AM	623, 260, 261
Apocynaceae (Asclepiadoideae)		
Asclepias incarnata	AM	58, 140
Calotropis gigantea	AM	343
Cynanchum nummularifolium	AM	207
Periploca graeca	NM	368
Stapelia glabricaulis	AM	417
Oleaceae		
Fraxinus excelsior	AM	465, 622
	AM + ECM	260, 261
Fraxinus ornus	AM	368
Fraxinus oxycarpa	AM	368
Fraxinus pennsylvanica	AM	28
Jasminum laurifolium	AM	655
Jasminum wangii	AM	422
Ligustrum vulgare	AM	368, 260, 261
Olea europaea	AM	17, 101
Olea europaea ssp. cuspidate	AM	637, 638
Olea europaea ssp. sylvestris	AM	108, 368
Olea europaea var. oleaster	AM	472
Phillyrea angustifolia	AM	368, 472
Phillyrea latifolia	AM	368
Gesneriaceae		
Corallodiscus flabellatus	AM	343
Cytrandra longifolia	AM	326
Pedaliaceae		
Sesamum indicum	AM	612
Plantaginaceae		
Callitriche hamulata	AM	260, 261
Littorella uniflora	AM	62, 432, 260, 261
Plantago coronopus	AM	260, 261
Plantago drummondii	AM	438
Plantago lanceolata	AM	194, 307, 446, 456, 260, 261
Plantago major	AM	49, 368, 260, 261
Plantago major ssp. intermedia	AM	260, 261
Plantago maritima	AM	260, 261
Plantago media	AM	48, 194, 260, 261
Plantago princeps	AM	326
Bignoniaceae		
Incarvillea arguta	AM	343
Jacaranda mimosaefolia	AM	548, 651

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Jacaranda puberula	AM	651
Oroxylum indicum	AM	655
Stenolobium stans	AM	548
Tabebuia chrysotricha	AM	651
Tabebuia roseo-alba	AM	651
Tecoma stans	Weak AM	103
	AM	112
Zeyheria tuberculosa	NM	651
Verbenaceae		
Aegiphila sellowiana	AM	651
Citharexylum myrianthum	AM	651
Clerodendron japonicum	AM	422
Lantana camara	AM	326
Lippia graveolens	Weak AM	103
Lippia nodiflora	AM	143
Tectona grandis	AM	476
Teucrium flavum	AM	368
Verbena hastata	AM	140
Verbena officinalis	AM	260, 261
Vitex agnus-castus	AM	368
Vitex montevidensis	AM	651
Vitex negundo	AM	343
Vitex rotundifolia	AM	326
Vitex vestita	AM	655
Lamiaceae		
Ajuga genevensis	AM	260, 261
Ajuga pyramidalis	AM	194
Ajuga reptans	AM	260, 261
Ballota nigra	NM	260, 261
Betonica officinalis	AM	212
Clinopodium gracile	AM	643
Clinopodium vulgare	AM + NM	260, 261
Colebrookea oppositifolia	AM	655
Coleus parviflorus	AM	469
Coleus × hybridus	AM	322
Collinsonia canadensis	AM	140
Elsholtzia blanda	AM	422
Elsholtzia cypriani	AM	343
Galeopsis segetum	NM	260, 261
Galeopsis tetrahit	NM	260, 261
Glechoma hederacea	AM + NM	260, 261
Gomphostemma microdon	AM	655
Hyptis lantiflora	AM	112
Lamiastrum galeobdolon	AM + NM	260, 261
Lamium album	AM	260, 261
Lamium amplexicaule	AM	294, 260, 261
Lamium purpureum	AM	260, 261
Lavandula augustifolia	AM	348
Lavandula officinalis	AM	104
Lavandula pedunculata	AM	339
Lavandula spica	AM	39
Leucas aspera	AM	336
Lycopus europaeus	AM + NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Melittis melissophyllum	AM + NM	260, 261
Mentha aquatica	AM	368
	AM + NM	260, 261
Mentha arvensis	AM	248
	AM + NM	260, 261
Mentha arvensis ssp. haplocalyx	AM	1
Mentha cardiaca	AM	1
Mentha citrata	AM	1
Mentha piperita	AM	1
	AM + NM	260, 261
Mentha pulegium	AM	260, 261
Mentha spicata	AM	1
Mentha viridis	AM	1
Nepeta cataria	AM	260, 261
Ocimum basilicum	AM	105, 171, 343
Origanum vulgare	AM	260, 261
Paraphlomis javanica	AM	655
Prunella vulgaris	AM	194, 586
	AM + NM	260, 261
Pycnanthemum tenuifolium	AM	140, 599
Pycnanthemum virginianum	AM	140
Rosmarinus officinalis	AM	472
Salvia azurea	AM	633
Salvia officinalis	AM	105
Salvia pratensis	AM	260, 261
Salvia splendens	AM	322
Salvia verbenaca	AM	260, 261
Scutellaria galericulata	AM + NM	260, 261
Stachys × ambigua	AM	260, 261
Stachys maritima	AM	368
Stachys officinalis	AM	260, 261
Stachys palustris	AM	260, 261
Stachys recta var. psammophila	NM	368
Stachys sylvatica	AM + NM	260, 261
Stenogyne purpurea	AM	326
Teucrium chamaedrys	AM	260, 261
Teucrium fruticans	AM	348, 472
Teucrium scordium	AM	260, 261
Teucrium scordonia	AM	260, 261
Thymus mastichina	AM	339
Thymus polytrichus ssp. britannicus	AM	630
Thymus pulegioides	AM	456
Thymus serpyllum	AM	456, 260, 261
Thymus vulgaris	AM	105, 583
Thymus zygis	AM	339
Acanthaceae		
Barleria cristata	AM	343
Carlowrightia californica	AM	112

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Justicia procumbens var. leucantha	AM	643
Phlogacanthus curviflorus	AM	655
Pseudoranthemum palatiferum	AM	422, 655
Ruellia peninsularis	AM	112
Scrophulariaceae		
Antirrhinum majus	AM	74
Bartsia alpina	AM + NM	260, 261
Buddleja davidii	NM	260, 261
Calceolaria crenatiflora	AM	207
Calceolaria polyrrhiza	AM	207
Castilleja arvensis	NM	326
Chaenorhinum minus	NM	260, 261
Cymbalaria muralis	AM	260, 261
Digitalis purpurea	AM + NM	260, 261
Eremophila longifolia	Weak AM	438
Eremophila macdonnellii	Weak AM	438
Euphrasia minima	NM	260, 261
Euphrasia officinalis s. l.	NM	260, 261
Euphrasia stricta	NM	456
Kickxia spuria	AM	260, 261
Lamourouxia rhinanthifolia	NM	103
Linaria repens	AM + NM	260, 261
Linaria supina	AM + NM	260, 261
Linaria vulgaris	AM + NM	260, 261
Melampyrum arvense	NM	260, 261
Melampyrum cristatum	NM	260, 261
Melampyrum pretense	NM	194
	AM + NM	260, 261
Melampyrum sylvaticum	NM	194, 260, 261
Mimulus guttatus	NM	62
	AM	95
Mimulus ringens	AM	140
Odontites lutea	AM	368
Odontites verna	NM	260, 261
Pedicularis capitata	NM	594
Pedicularis kanei	NM	594
Pedicularis langsdorffii	NM	594
Pedicularis palustris	NM	260, 261
Pedicularis sylvatica	NM	260, 261
Pedicularis verticillata	NM	594
Penstemon cardwellii	Facultative AM	585
Penstemon frutescens	Facultative AM	587
Plantago asiatica	AM	643
Rhinanthus angustifolius	AM	456
	NM	260, 261
Rhinanthus minor	Weak AM	194
Scrophularia auriculata	AM	260, 261
Scrophularia nodosa	AM + NM	260, 261
Scrophularia umbrosa	NM	260, 261
Scrophularia vernalis	NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Verbascum lychnitis	AM	260, 261
Verbascum nigrum	AM	260, 261
Verbascum thapsus	AM	207, 260, 261
Veronica agrestis	AM + NM	260, 261
Veronica alpina	AM	260, 261
Veronica anagallis-aquatica	Facultative AM	62
	AM	260, 261
Veronica arvensis	AM	643, 260, 261
Veronica beccabunga	NM	62, 260, 261
Veronica chamaedrys	AM	194, 456
	AM + NM	260, 261
Veronica filiformis	AM	260, 261
Veronica fruticans	AM	260, 261
Veronica officinalis	AM	194
	AM + NM	260, 261
Veronica peregrina	AM	260, 261
Veronica persica	AM	643, 260, 261
Veronica serpyllifolia	AM	194, 260, 261
Veronica spicata	AM	260, 261
Lentibulariaceae		
Pinguicula alpine	NM	260, 261
Pinguicula vulgaris	NM	260, 261
Convolvulaceae		
Calystegia sepium	AM	260, 261
Calystegia soldanella	NM	368
Convolvulus arvensis	AM	260, 261
Convolvulus elegantissimus	AM	472
Convolvulus eyreanus	AM	438
Ipomoea arborescens	Weak AM	103
Ipomoea batatas	AM	455
Ipomoea imperati	AM	326
Ipomoea pes-caprae	AM	64, 65, 144, 326, 336
Ipomoea stolonifera	Weak AM	143
Jacquemontia ovalifolia	AM	326
Jacquemontia reclinata	AM	202
Solanaceae		
Atropa belladonna	AM	260, 261
Capsicum annuum	AM	50
Cestrum intermedium	AM	651
Datura metal	AM	216
Datura stramonium	AM	343
Lycium barbarum	AM	260, 261
Lycium fremontii	AM	112
Lycium sandwicense	AM	326
Lycopersicon esculentum	AM	407
Nicotiana velutina	AM	438
Petunia × hybrida	AM	322
Solanum argenteum	AM	651
Solanum dulcamara	NM	62
	AM	260, 261
Solanum elipticum	AM	438
Solanum khasianum	AM	343

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Solanum hindsianum	AM	112
Solanum nigrum	AM + NM	260, 261
Solanum surattense	AM	567
Solanum torvum	NM	422
Solanum tuberosum	AM	386
Aquifoliaceae		
Ilex aquifolium	AM + ECM	260, 261
Ilex paraguariensis	AM	31
Ilex verticallata	AM	140
Araliaceae		
Didymopanax angustissimum	AM	31
Hedera helix	AM	368, 472, 260, 261
Macropanax dispermus	AM	655
Panax ginseng	AM	178
Panax quinquefolius	AM	390
Pseudopanax laetevirens	AM	207
Stilbocarpa polaris	NM	342
Trevesia palmata	NM	422
Trevesia palmata var. costata	NM	655
Pittosporaceae		
Pittosporum gayanum	AM	326
Apiaceae		
Actinotis helianthi	AM	67
Aegopodium podograria	AM + NM	260, 261
Aethusa cynapium	AM	260, 261
Angelica archangelica	AM	260, 261
Angelica sylvestris	AM	260, 261
Anthriscus sylvestris	NM	260, 261
Apium graveolens	AM	490, 260, 261
Apium nodiflorum	NM	260, 261
Astrantia major	AM + NM	260, 261
Azorella macquariensis	AM	342
Berula erecta	Facultative AM	62
	NM	260, 261
Bupleurum baldense	AM	472
Bupleurum falcatum	AM	260, 261
Carum carvi	AM	194, 260, 261
Chaerophyllum temulentum	AM + NM	260, 261
Conium maculatum	AM	260, 261
Conopodium majus	AM	260, 261
Coriandrum sativum	AM	220
Daucus carota	AM	171
	AM + NM	260, 261
Echinophora spinosa	AM	368
Eryngium campestre	AM	260, 261
Eryngium maritimum	AM	368
	AM + NM	260, 261
Eryngium paniculatum	AM	207
Foeniculum vulgare	AM	305
Heracleum sphondylium	AM + NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Hydrocotyle bonariensis	AM	143
Hydrocotyle novae-zeelandiae	AM	342
Hydrocotyle vulgaris	AM	368
	AM + NM	260, 261
Myrrhis odorata	AM	260, 261
Oenanthe aquatica	NM	260, 261
Oenanthe crocata	NM	260, 261
Osmorhiza chilensis	AM	207
Pastinaca sativa	AM	307, 260, 261
Petroselium crispum	AM	171
	NM	260, 261
Peucedanum ostruthium	AM	260, 261
Peucedanum palustre	AM	260, 261
Pimpinella major	AM + NM	260, 261
Pimpinella saxifraga	AM	194, 456
	AM + NM	260, 261
Platysace linearifolia	ECM	67
Sanicula europaea	AM	260, 261
Scandix pecten-veneris	AM	260, 261
Seseli libanotis	AM	260, 261
Seseli tortuosum	AM	368
Silaum silaus	AM	260, 261
Sium latifolium	NM	260, 261
Trachymene glaucifolia	AM	438
Campanulaceae		
Brighamia insignis	AM	326
Campanula glomerata	AM	260, 261
Campanula lasiocarpa	AM	587
Campanula patula	AM	260, 261
Campanula persicifolia	AM	194
	AM + NM	260, 261
Campanula punctata ssp.hondoensis	AM	636
Campanula rapunculoides	AM	260, 261
Campanula rotundifolia	AM	194, 437, 456, 260, 261
Campanula trachelium	NM	260, 261
Clermontia fauriei	AM	326
Cyanea leptostegia	AM	326
Downingia elegans	AM	293
Jasione montana	AM + NM	260, 261
Lobelia cardinalis	AM	140
Lobelia dortmanna	AM	62, 432, 260, 261
Lobelia sp.	AM + ECM	656
Lobelia yuccoides	AM	326
Phyteuma orbiculare	AM	260, 261
Phyteuma spicatum	AM + NM	260, 261
Pratia nummularia	AM	422
Trematolobelia kauaiensis	AM	326
Menyanthaceae		
Menyanthes trifoliata	NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Nymphoides peltata	NM	260, 261
Goodeniaceae		
Calogyne sp.	AM + ECM	656
Dampiera stricta	AM + ECM	67
Goodenia cycloptera	AM	438
Goodenia lunata	AM	438
Goodenia sp.	AM + ECM	656
Scaevola chamissoniana	AM	326
Scaevola gaudichaudii	AM	326
Scaevola parvibarbata	AM	438
Scaevola procera	AM	326
Scaevola sericea	AM	326
Asteraceae		
Achillea millefolium	AM	194
	AM + NM	260, 261
Achillea ptarmica	AM	194
	NM	260, 261
Ageratina espinosarum	Weak AM	103
Ageratum conyzoides	AM	336, 422
Ambrosia artemisifolia	AM	143
Anaphalis margaritacea	Facultative AM	585
	AM	260, 261
Angianthus sp.	AM + ECM	656
Antennaria dioica	AM	194, 260, 261
Anthemis arvensis	AM	260, 261
Anthemis tinctoria	AM	260, 261
Arctium lappa	AM + NM	260, 261
Arctium minus s. l.	AM	260, 261
Arnica angustifolia	AM	443
Arnica montana	AM	194, 269
Artemisia absinthium	NM	260, 261
Artemisia californica	AM	646
Artemisia campestris	AM	260, 261
Artemisia codonocephala	AM	343
Artemisia dracunculus	AM	105
Artemisia ludoviciana	AM	633
Artemisia maritima	AM + NM	260, 261
Artemisia princeps	AM	643
Artemisia tridentata	AM	183
Artemisia tridentata ssp. wyomingensis	AM	552
Artemisia vulgaris	AM	307, 260, 261
Aster novi belgii	AM	260, 261
Aster sericeus	AM	633
Aster subulatus	AM	326
Aster tripolium	AM	113, 518, 260, 261
Baccharis racemosa	AM	207
Balduina angustifolia	AM	30
Bebbia juncea	AM	112
Bellis perennis	AM + NM	260, 261
Berkheya coddii	AM	597

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Bidens asymmetrica × *sandvicensis*	AM	227
Bidens bipinnata	AM	422
Bidens cosmoides	AM	326
Bidens frondosa	AM	140, 368
Bidens pilosa	AM	143, 343, 422
Bidens sandwicensis	AM	227, 326
Bidens tripartita	AM	140
	AM + NM	260, 261
Blainvillea acmella	AM	343
Calendula officinalis	AM	260, 261
Callistephus chinensis	AM	428
Carduus acanthoides	AM	307, 260, 261
Carlina vulgaris	AM	456, 260, 261
Carthamus tinctorius	AM	94
Centaurea cyanus	AM	260, 261
Centaurea jacea	AM	194, 260, 261
Centaurea maculosa	AM	109, 371
Centaurea nigra	AM	260, 261
Centaurea pratensis	AM	260, 261
Centaurea scabiosa	AM	260, 261
Centaurea subciliata	AM	368
Chrysanthemum morifolium	AM	551
Chrysanthemum segetum	AM	260, 261
Cicerbita alpina	AM + NM	260, 261
Cichorium intybus	AM	260, 261
Cirsium acaule	AM	260, 261
Cirsium arvense	AM	307, 260, 261
Cirsium helenioides	AM	260, 261
Cirsium oleraceum	AM	260, 261
Cirsium palustre	AM + NM	260, 261
Cirsium purpuratum	AM	636
Cirsium setosum	AM	620
Cirsium vulgare	AM	626
	AM + NM	260, 261
Conyza blinii	AM	343
Conyza canadensis	AM	326, 343
Cotula plumose	NM	342, 560
Crassocephalum crepidioides	AM	422
Crepis biennis	AM	260, 261
Crepis capillaris	AM	260, 261
Crepis paludosa	AM + NM	260, 261
Crepis praemorsa	AM	194
Crepis setosa	AM	207
Cynara cardunculus	AM	369
Dittrichia viscosa	AM	497
Dubautia ciliolata	AM	326
Dubautia knudseni	AM	326
Dubautia plantaginea	AM	326
Dubautia scabra	AM	326
Eclipta alba	AM	577

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Emilia sonchifolia	AM	326, 336
Erechtites hieracifolia	AM	326
Ericameria diffusa	AM	112
Erigeron acer	NM	260, 261
Erigeron annuus	AM	643
Erigeron bonariensis	AM	643
Erigeron borealis	AM	260, 261
Erigeron canadensis	AM	294
	AM + NM	260, 261
Eriophyllum lanatum	AM	293
Eupatorium cannabinum	AM	260, 261
Eupatorium coelesticum	AM	422
Eupatorium maculatum	AM	140
Eupatorium odoratum	AM	422
Eupatorium perfoliatum	AM	140
Eupatorium serotinum	AM	599
Filaginella uliginosa	AM	194
Florestina tripteris	AM	143
Flourensia cernua	AM	137
Galinsoga ciliata	AM	260, 261
Galinsoga parviflora	AM	260, 261
Galinsoga supinum	AM	260, 261
Galinsoga sylvaticum	AM	260, 261
Galinsoga uliginosum	AM	260, 261
Gnaphalium norvegicum	AM	502, 503, 260, 261
Gnephosis eriocarpa	Weak AM	438
Gutierrezia sarothrae	AM	492, 493
Gymnosperma glutinosum	Weak AM	103
Haplopappus venetus	AM	543
Helianthus annuus	AM	121, 260, 261
Helianthus niveus	AM	543
Helichrysum italicum	AM	368
Helichrysum sp.	AM + ECM	656
Helichrysum stoechas	AM	368
Helipterum sp.	AM + ECM	656
Hieracium albiflorum	Facultative AM	585
Hieracium alpinum	AM	260, 261
Hieracium bifidum	AM	260, 261
Hieracium lachenalii	AM	260, 261
Hieracium lactucella	AM	194
Hieracium laevegatum	AM + NM	260, 261
Hieracium murorum	AM + NM	260, 261
Hieracium pilosella	AM	270, 456, 260, 261
Hieracium sagittatum	AM	260, 261
Hieracium subaundum	AM	260, 261
Hieracium umbellatum	AM	194, 260, 261
Hieracium vulgatum	AM + NM	260, 261
Homogyne alpina	AM + ECM	260, 261
Hypochaeris radicata	Facultative AM	584, 585, 260, 261
Hypochoeris achyrophorus	AM	472

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Inula conyza	AM	260, 261
Inula salicina	AM	260, 261
Ixeris denticulate	AM	129
Jaumea carnosa	AM	90
Lactuca hirsuta	AM	140
Lactuca sativa	AM	40, 171, 500
Laggera pterodonta	AM	343
Lapsana communis	AM	260, 261
Launaea sarmentosa	AM	336
Leontodon autumnalis	AM	194, 260, 261
Leontodon hispidus	AM	260, 261
Leontodon hispidus ssp. danubialis	AM	456
Leontodon hispidus ssp. hispidus	AM	456
Leucanthemum vulgare	AM	194, 260, 261
Leuceria achillaeifolia	NM	207
Liatris tenuifolia var. laevigata	Weak AM	30
Lipochaeta connata	AM	326
Matricaria maritime ssp. inodora	AM	307
Matricaria matricarioides	AM	260, 261
Matricaria recutita	AM + NM	260, 261
Microseris laciniata	AM	293
Mutisia decurrens	AM	207
Mutisia spinosa	AM	207
Mycelis muralis	AM + ECM + NM	260, 261
Omalotheca norvegica	AM	194
Onopordum acanthium	AM + NM	260, 261
Otanthus maritimus	AM	368
Othonna gregorii	AM + NM	438
Palafoxia lindenii	AM	144
Parthenium argentatum	AM	461
Parthenium hysterophorus	AM	343
Pectis saturejoides	AM	143
Petasites albus	AM + NM	260, 261
Petasites frigidus	NM	594
Petasites hybridus	AM + NM	260, 261
Phagnalon rupestre	AM	472
Picris echioides	AM	260, 261
Picris hieracioides	AM	260, 261
Piptocarpha axillaris	AM	651
Pityopsis graminifolia	Weak AM	30
Pleurophyllum hookeri	AM	342
Podolepis sp.	AM + ECM	656
Polycalymma stuartii	AM	438
Porophyllum numularium	AM	143
Pulicaria angustifolia	AM	567
Pulicaria dysenterica	AM	260, 261
Remya kauaiensis	AM	326
Rhodanthe floribunda	AM	438
Rhodanthe moschata	AM	438

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Sagittaria latifolia	AM	58, 626
Sanvitalia procumbens	AM	260, 261
Saussurea alpina	AM	260, 261
Scorzonera humilis	AM	194
Senecio articulatus	AM	417
Senecio bicolor	AM	368, 260, 261
Senecio bracteolatus	AM	207
Senecio erucifolius	AM	260, 261
Senecio jacobaea	AM + NM	260, 261
Senecio pendulus	AM	417
Senecio praecox	AM	208
	NM	103
Senecio squalidus	AM	260, 261
Senecio sylvaticus	AM + NM	260, 261
Senecio viscosus	AM	307, 260, 261
Senecio vulgaris	AM	625
	AM + NM	260, 261
Serratula tinctoria	AM	212, 260, 261
Siegesbeckia orientalis	AM	343
Solidago altissima	AM	643
Solidago canadensis	AM	298, 626
Solidago chilenesis	AM	207
Solidago gigantea	AM	140
Solidago graminifolia	AM	140
Solidago litoralis	AM	368
Solidago sp.	AM	58
Solidago virgaurea	AM	194, 260, 261
Sonchus arvensis	AM	302
	AM + NM	260, 261
Sonchus asper	AM + NM	260, 261
Sonchus oleraceus	AM	343, 643, 260, 261
Spilanthes callimorpha	AM	422
Synedrella nudiflora	AM	422
Tagetes erecta	AM	2, 102, 350
Tagetes patula	AM	322, 350, 554
Tagetes tenuifolia	AM	350
Tanacetum parthenium	NM	260, 261
Tanacetum vulgare	AM + NM	260, 261
Taraxacum japonicum	AM	643
Taraxacum officinale	AM	307
Tithonia diversifolia	AM	422, 539
Tragopogon pratensis	AM	260, 261
Tridax procumbens	AM	336
Tripleurospermum inodorum	AM	260, 261
Tripleurospermum maritimum	AM	260, 261
Tussilago farfara	AM	307
	AM + NM	260, 261
Verbesina encelioides	AM	326
Vernonia noveboracensis	AM	140
Viguiera eriophora	AM	103

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Waitzia sp.	AM + ECM	656
Wedelia trilobata	AM	326
Wilkesia gymnoxiphium	AM	326
Xanthium sibiricum	AM	343
Xanthocephalum microcephala	AM	137
Zinnia acerosa	AM	137
Zinnia elegans	AM	2, 343
Adoxaceae		
Adoxa moschatellina	NM	260, 261
Caprifoliaceae		
Carlemannia tetragona	AM	655
Linnaea borealis	AM	260, 261
Lonicera caprifolium	AM	260, 261
Lonicera implexa	AM	368
Lonicera pericylmenum	AM	260, 261
Lonicera xylosteum	AM + NM	260, 261
Sambucus nigra	AM + NM	260, 261
Sambucus racemosa	AM + ECM+NM	260, 261
Symphoricarpos rivularis	AM + NM	260, 261
Viburnum lantana	AM	260, 261
Viburnum lentago	AM	140
Viburnum opulus	AM	260, 261
Viburnum tinus	AM	368
Dipsacaceae		
Dipsacus fullonum	AM + NM	260, 261
Knautia arvensis	AM	194, 260, 261
Pycnocomon rutifolium	AM	368
Scabiosa columbaria	AM	260, 261
Scabiosa ochroleuca	AM	456
Succisa pratensis	AM	194, 260, 261
Valerianaceae		
Centranthus ruber	NM	260, 261
Valeriana dioica	NM	260, 261
Valeriana laxiflorac	AM	207
Valeriana officinalis	AM + NM	260, 261
Hamamelidaceae		
Liquidambar styraciflua	AM	139
Crassulaceae		
Aeonium decorum	AM	417
Crassula aquatica	NM	260, 261
Crassula moschata	NM	342, 560
Crassula phyturus	AM	417
Crassula rupestris	AM	417
Echeveria sedoides	NM	417
Kalanchoe daigremontana	AM	417
Sedum acre	AM + NM	260, 261
Sedum adolfii	AM	417
Sedum album	NM	260, 261
Sedum dasyphyllum	NM	260, 261
Sedum forsteranum	NM	260, 261
Sedum reflexum	NM	260, 261
Sedum rosea	AM + NM	260, 261
Sedum telephium	NM	260, 261
Sempervivum tectorum	M(endo) + NM	260, 261
Haloragaceae		
Myriophyllum alterniflorum	NM	260, 261
Proserpinaca palustris	AM	140
Grossulariaceae		
Ribes alpinum	AM + ECM + NM	260, 261
Ribes magellanicum	AM	207
Ribes nigrum	AM	260, 261
Ribes rubrum	AM	260, 261
Ribes uva-crispa	AM	260, 261
Saxifragaceae		
Chrysosplenium alternifolium	AM + NM	260, 261
Chrysosplenium oppositifolium	NM	260, 261
Saxifraga aizoides	AM + NM	260, 261
Saxifraga granulate	AM	194
	AM + NM	260, 261
Saxifraga hieracifolia	NM	594
Saxifraga hirculus	NM	594
Saxifraga oppositifolia	AM + NM	260, 261
Saxifraga stellaris	NM	260, 261
Vitaceae		
Cayratia japonica	AM	643
Leea compactiflora	AM	655
Leea indica	AM	655
Leea marcophylla	AM	655
Vitis vinifera	AM	306, 517
Geraniaceae		
Erodium cicutarium	AM + NM	260, 261
Erodium crinitum	AM	438
Geranium carolinianum	AM	643
Geranium dissectum	AM	260, 261
Geranium lucidum	AM + NM	260, 261
Geranium molle	AM + NM	260, 261
Geranium nodosum	AM	260, 261
Geranium pratense	AM	260, 261
Geranium robertianum	AM	262, 472
	AM + NM	260, 261
Geranium sanguineum	NM	260, 261
Geranium sessiliflorum	AM	207
Geranium sylvaticum	AM	194, 260, 261
Pelargonium hortorum	AM	435
Combretaceae		
Terminalia catappa	AM	326
Terminalia superba	AM	445
Onagraceae		
Camissonia californica	AM	543
Chamerion angustifolium	AM + NM	260, 261
Circaea alpina	AM	260, 261
Circaea lutetiana	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Epilobium alsinifolium	AM + NM	260, 261
Epilobium anagallidifolium	AM	260, 261
Epilobium angustifolium	Facultative AM	585
Epilobium brunnescens ssp. brunnescens	NM	342
Epilobium ciliatum	AM	260, 261
Epilobium coloratum	AM	140
Epilobium hirsutum	Facultative AM	62
	AM	260, 261
Epilobium lanceolatum	AM	260, 261
Epilobium montanum	AM + NM	260, 261
Epilobium obscurum	AM	260, 261
Epilobium palustre	AM	260, 261
Epilobium parviflorum	AM	260, 261
Epilobium pendunculare	AM	342
Epilobium roseum	AM	260, 261
Epilobium tetragonum	AM	260, 261
Ludwigia palustris	AM	140
Ludwigia prostrata	AM	422
Oenothera biennis	AM	260, 261
Oenothera erythrosepala	AM	260, 261
Lythraceae		
Cuphea carthagenensis	AM	326
Lafoensia pacari	AM	651
Lythrum alatum	AM	599
Lythrum hyssopifolia	NM	260, 261
Lythrum maritimum	AM	326
Lythrum salicaria	AM	140, 462, 558, 629
	AM + NM	260, 261
Myrtaceae		
Acca sellowiana	AM	31
Acmena resa	AM	222
Angophora hispida	ECM	67
Baeckea ramosissima	ECM	67
Campomanesia xanthocarpa	AM	651
Eucalyptus bosistoana	AM	5
Eucalyptus camaldulensis	AM + ECM	179
Eucalyptus citriodora	AM	343
	AM + ECM	179
Eucalyptus cloeziana	AM + ECM	179
Eucalyptus delegatensis	AM	5
Eucalyptus dives	AM	5
Eucalyptus dumosa	Weak AM	5
Eucalyptus dunnii	AM + ECM	442
Eucalyptus globoidea	ECM	133
Eucalyptus globulus	AM	5
	ECM	359
Eucalyptus globulus ssp. bicostata	ECM	12
Eucalyptus gomphocephala	AM	5

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Eucalyptus grandis	AM + ECM	179
	ECM	96
Eucalyptus haemostoma	ECM	67
Eucalyptus largiflorens	AM	5
Eucalyptus macarthurii	AM	5
Eucalyptus marginata	ECM	365
Eucalyptus microcorys	ECM	120
Eucalyptus racemosa	ECM	67
Eucalyptus regnans	ECM	341
Eucalyptus sieberi	ECM	133
Eucalyptus stricta	ECM	67
Eucalyptus torelliana	ECM	120
Eucalyptus urophylla	AM	5
	AM + ECM	179
Eucalyptus viminalis	AM	5
	AM + ECM	66
Eucalyptus viridis	AM	5
Eugenia uniflora	AM	651
Gomidesia spectabilis	AM	31
Kunzea capitata	ECM	67
Leptospermum flavescens	ECM	67
Leptospermum lanigerum	ECM	67
Luma apiculata	AM	207
Melaleuca quinquenervia	AM + ECM	316
Metrosideros polymorpha	AM	326
Myrtus communis	AM	368, 382, 472
Plinia rivularis	Weak AM	651
Psidium cattleianum	AM	326
Psidium guajava	AM	31, 198, 337
Rhodomyrtus tomentosa	AM	326
Syzygium firmum	AM	215
Syzygium guineense	AM	637, 638
Syzygium jambolanum	AM	548
Syzygium latilimbum	AM	422
Syzygium makul	AM	215
Syzygium operculatum	AM	215
Syzygium rubicundum	AM	215
Tristaniopsis whiteana	NM	568
Melastomataceae		
Clidemia hirta	AM	326
Graffenrieda emarginata	AM + ECM	266
Leandra dasytricha	AM	31
Melastoma affine	NM	422
Melastoma melabathricum	AM	568
Krameriaceae		
Krameria paucifolia	AM	112
Zygophyllaceae		
Balanites aegyptiaca	AM	47
Fagonia cretica	AM	567
Larrea tridentata	AM	112, 137
Morkillia mexicana	Weak AM	103
Tribulus cistoides	NM	326
Tribulus terrester	AM	343

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Viscainoa geniculata	AM	112
Zygophyllum dumosum	AM	268
Zygophyllum howittii	NM	438
Parnassiaceae		
Parnassia palustris	AM + NM	260, 261
Celastraceae		
Euonymus europaeus	AM	260, 261
Maytenus boaria	AM	207
Maytenus chubutensis	AM	207
Maytenus magellanica	AM	207
Maytenus phyllantoides	AM	112
Humiriaceae		
Sacoglottis gabonensis	AM	445
Pandaceae		
Panda oleosa	AM	445
Rhizophoraceae		
Combretocapus rotundatus	NM	568
Poga oleosa	AM	445
Linaceae		
Linum bienne	AM	472
Linum catharticum	AM	456
	AM + NM	260, 261
Linum perenne ssp. anglicum	NM	260, 261
Linum strictum	AM	472
Linum trigynum	AM	472
Linum usitatissimum	AM	171, 180
	AM + NM	260, 261
Erythroxylaceae		
Erythroxylon compactum	NM	103
Euphorbiaceae		
Acalypha acmophylla	AM	343
Actinostemon concolor	AM	651
Adelia virgata	AM	112
Alchornea cordifolia	AM	445
Alchornea tiliaefolia	AM	422, 655
Aleurites moluccana	AM	326
Amperea xiphoclada	ECM	67
Baccaurea ramiflora	AM	422, 655
Breynia fruticosa	AM	422
Celaenodendron mexicanum	AM	20
Chamaesyce atrococca	AM	326
Chamaesyce celastroides	AM	326
Chamaesyce degeneri	AM	326
Chamaesyce hypericifolia	AM	326
Cleidion bracteosum	AM	422
Cleidion brevipetiolatum	AM	655
Cleistanthus sumatranus	AM	422
	NM	655
Croton ciliato-glanduliferus	Weak AM	103
Croton floribundus	AM	651
Croton kongensis	AM	422
Croton machrostachyus	AM	637, 638
Croton punctatus	AM	143
Croton urucurana	AM	651
Ditaxis lanceolata	AM	112
Drypetes gossweileri	AM	445
Drypetes hoaensis	NM	655
Epiprinus silhetianus	NM	655
Euphorbia amygdaloides	AM	260, 261
Euphorbia cyparissias	AM	260, 261
Euphorbia dulcis	AM	260, 261
Euphorbia esula	AM	260, 261
Euphorbia gatbergensis	AM	417
Euphorbia helioscopia	AM + NM	260, 261
Euphorbia heterophylla	AM	343
Euphorbia hirta	AM	216, 343
	Facultative AM	422
Euphorbia lathyrus	AM	260, 261
Euphorbia paralias	AM	260, 261
Euphorbia parliramulosa	AM	417
Euphorbia peplis	AM	368
Euphorbia peplus	AM	472
	AM + NM	260, 261
Euphorbia royleana	AM	343
Euphorbia tannensis	AM	438
Euphorbia thymifolia	AM	343
Glochidion assamicum	NM	655
Hevea brasiliensis	AM	288, 526, 527
Hieronyma alchorneoides	AM	31
Jatropha cinerea	AM	112
Jatropha cuneata	AM	112
Macaranga denticulata	AM	422, 648
Macaranga indica	AM	655
Macaranga peltata	AM	315
Manihot esculanta	AM	252
Mercurialis annua	AM	260, 261
Mercurialis perennis	AM + NM	260, 261
Pedilanthus cymbiferus	NM	103
	AM	112
Pedilanthus macrocarpus	AM	112
Phyllanthus asteranthus	AM	422
Phyllanthus lacunarius	AM	438
Phyllanthus niruri	AM	577
Phyllanthus urinaria	AM	343
Ricinodendron heudelotii	AM	445
Ricinus communis	AM	318
Sauropus androgynus	AM	253
Sebastiania commersoniana	AM	651
Uapaca acuminata	AM + ECM	445
Uapaca guineense	ECM	52, 445
Uapaca heudelotti	AM	52

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Uapaca staudtii	ECM+AM	413
	ECM	445
Uapaca vanhouttei	ECM	445
Violaceae		
Viola arvensis	AM + NM	260, 261
Viola calaminaria	AM	588
Viola canina	AM	269
	AM + NM	260, 261
Viola hirta	AM	260, 261
Viola kitaibeliana	AM + NM	260, 261
Viola lutea	AM	260, 261
Viola maculata	AM	207
Viola odorata	AM	260, 261
Viola palustris	AM + NM	260, 261
Viola reichenbachiana	AM + NM	260, 261
Viola riviniana	AM	260, 261
Viola rupestris	AM	260, 261
Viola tricolor	AM	194, 456
	AM + NM	260, 261
Viola wailenalenae	AM	326
Viola × wittrockiana	AM	322
Salicaceae		
Casearia sylvestris	AM	31, 651
Populus alba	ECM+AM	368
	ECM+NM	260, 261
Populus balsamifera	ECM	470
Populus balsamifera ssp. trichocarpa	ECM	271
Populus × canadensis	AM + ECM	260, 261
Populus canescens	ECM	260, 261
Populus deltoides	AM	140
Populus euroamericana	AM + ECM	317
Populus nigra	AM + ECM	260, 261
Populus nigra 'Italica'	AM + ECM	260, 261
Populus serotina	AM + ECM	260, 261
Populus tremula	AM + ECM	260, 261
Populus tremula × tremuloides	ECM	59
Populus tremuloides	ECM	145, 338
	ECM+AM	430
Populus trichocarpa	ECM	59, 260, 261
Salix alba	ECM	260, 261
Salix alba vitellina	ECM	260, 261
Salix arbuscula	ECM	260, 261
Salix arctica	ECM	594
Salix aurita	ECM+NM	260, 261
Salix babylonica	AM + ECM	316, 260, 261
Salix caprea	AM + ECM	260, 261
Salix cinerea	AM + ECM	260, 261
Salix daphnoides	ECM	260, 261
Salix fragilis	ECM	260, 261
Salix gracilistyla	AM	511
Salix herbacea	ECM+EEM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Salix lapponum	ECM	260, 261
Salix myrsinites	ECM	260, 261
Salix nigra	AM	140
Salix nigricans	ECM+NM	260, 261
Salix phylicifolia	ECM	260, 261
Salix polaris	ECM	594
Salix purpurea	AM + ECM	260, 261
Salix reinii	ECM	587
Salix repens	AM	605
	AM + ECM	260, 261
Salix reticulata	ECM	594, 260, 261
Salix triandra	ECM	260, 261
Salix viminalis	AM	60
	AM + ECM	260, 261
Xylosma ciliatifolium	AM	651
Xylosma pseudosalzmannii	AM	651
Turneraceae		
Turnera ulmifolia	AM	143
Clusiaceae		
Calophyllum sclerophyllum	AM	568
Calophyllum soulattri	AM	568
Clusia minor	AM	474
Clusia rotundata	AM	474
Cratoxylum arborescens	AM	568
Garcinia cowa	NM	655
Garcinia kola	AM	445
Garcinia lucida	AM	445
Garcinia xanthochymus	Facultative AM	422
Hypericaceae		
Hypericum calycinum	NM	260, 261
Hypericum hirsutum	NM	260, 261
Hypericum humifusum	NM	260, 261
Hypericum maculatum	AM	194, 260, 261
Hypericum montanum	NM	260, 261
Hypericum perforatum	AM	409, 260, 261
Hypericum pulchrum	AM	260, 261
Hypericum tetrapterum	AM + NM	260, 261
Elatinaceae		
Elatine hexandra	AM	62
Ochnaceae		
Lophira alata	AM	445
Chrysobalanaceae		
Licania platypus	AM	321
Oxalidaceae		
Oxalis acetosella	AM	598
	AM + NM	260, 261
Oxalis corniculata	AM	294, 643, 260, 261
Oxalis corymbosa	AM	643
Oxalis exilis	AM	260, 261
Oxalis europaea	AM	260, 261
Oxalis stricta	AM	260, 261
Oxalis valdiviensis	AM	207

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Cunoniaceae		
Ceratopetalum apetalum	AM	387
	ECM	389
Elaeocarpaceae		
Aristotelia chilensis	AM	207
Elaeocarpus austro-yunnanensis	AM	422
Sloanea guianensis	AM	31
Polygalaceae		
Polygala nicaeensis	AM	368
Polygala amarella	AM + NM	260, 261
Polygala calcarea	AM	260, 261
Polygala serpyllifolia	AM	260, 261
Polygala vulgaris	AM	194
	AM + ECM	260, 261
Salomonia sp.	Mycoheterotrophy via AM	658
Fabaceae		
Acacia albida	AM	174
Acacia ampliceps	AM	477
Acacia arabica	AM	317
Acacia auriculiformis	AM	52, 229
Acacia bonariensis	AM + ECM	211
Acacia caven	AM	211
Acacia cochliacantha	Weak AM	103
Acacia constricta	Weak AM	103
Acacia eriopoda	AM	477
Acacia farnesiana	AM	343, 600
	Weak AM	103
Acacia holosericea	ECM	186
Acacia koa	AM	326, 406
Acacia leptocarpa	AM	52
Acacia linifolia	AM	68
	ECM+AM	67
Acacia mangium	ECM	186, 187
	AM	52, 257, 520
Acacia nilotica	AM	473, 538
Acacia obtusifolia	ECM+AM	67
Acacia pennatula	AM	18
Acacia polyphylla	AM	651
Acacia suaveolens	ECM+AM	67
Acacia tortilis	AM	567
Acacia ulicifolia	ECM+AM	67
Adenanthera pavonina	AM	52
Aeschynomene indica	AM	546
Afzelia africana	NM	47
	ECM	45, 52
Afzelia bipidensis	ECM+AM	413, 445
Afzelia pachyloba	AM + ECM	445
Afzelia quanzensis	ECM	418
Albizia corniculata	AM	655
Albizia falcataria	AM	14
Albizia ferruginea	AM	52, 256

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Albizia gummifera	AM	637, 638
Albizia hassleri	AM	651
Albizia kalkora	AM	343
Albizia lebbeck	AM	52, 216, 477, 538, 548
Albizia schimperiana	AM	637, 638
Alysicarpus regosus	AM	336
Alysicarpus vaginalis	AM	343
Amorpha crenulata	AM	202
Amphimas ferrugineus	AM	445
Amphimas pterocarpoides	AM	52, 445
Anadenanthera colubrina	AM	452, 651
Anadenanthera falcata	AM	548
Anadenanthera macrocarpa	AM	651
Anadenanthera peregrina	AM	528, 593
Anthonotha fragrans	ECM	52
	ECM+AM	413, 445
Anthonotha macrophylla	ECM	52, 413, 445
Anthyllis cytisoides	AM	170, 234, 583
Anthyllis tetraphylla	AM	472
Anthyllis vulneraria	AM	456
	AM + NM	260, 261
Aphanocalyx cynometroides	ECM	413
Arachis hypogaea	AM	111
Astragalus alpinus	NM	594
Astragalus applegatei	AM	55
Astragalus glycyphyllos	NM	260, 261
Atylosia scarabaeoides	AM	343
Baphia nitida	AM	52
Bauhinia forficata	AM	211, 651
Berlinia bracteosa	ECM	445
Berlinia confusa	ECM	52, 445
Bossiaea obcordata	AM	67
Brachystegia cynometroides	ECM	445
Brachystegia eurycoma	ECM	445
Brachystegia leonensis	ECM	52
Brachystegia zenkeri	ECM	445
Bussea occidentalis	AM	52
Caesalpinia eriostachys	AM	20
Caesalpinia ferrea	AM	548
Caesalpinia gilliesii	AM	211
Caesalpinia pannosa	AM	112
Caesalpinia peltophoroides	AM	548
Cajanus cajan	AM	172, 624
Calliandra eriophylla	Weak AM	103
Calliandra parvifolia	Weak AM + ECM	211
Calliandra selloi	AM	211
Calliandra tweedii	AM + ECM	211
Calopogonium caeruleum	AM	289
Calopogonium mucunoides	AM	439

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Canavalia rosea	AM	144, 336
Cassia grandis	AM	548
Cassia siamea	AM	52, 230, 251
Cassia spectabilis	AM	258
Castanospermum australe	AM	4
Cathormion polyanthum	AM	211
Centrolobium tomentosum	AM	372, 651
Ceratonia siliqua	AM	147
Cercidium praecox	AM	112
Chamaecrista chamaecristoides	AM	143
Cicer arietinum	AM	124, 125
Colophospermum mopane	AM	477
Copaifera langsdorffii	AM	548, 651
Cordyla pinnata	AM	47
Coronilla emerus ssp. emeroides	AM	368
Coronilla scorpioides	AM	472
Coronilla varia	AM	159
	NM	260, 261
Crotalaria burhia	AM	567
Crotalaria incana	AM	143
Crotalaria medicaginea	AM	343, 567
Cullen discolor	AM	438
Cullen pallida	AM	438
Cylicodiscus gabunensis	AM	445
Cynometra alexandri	AM	591
Cynometra leonensis	AM	52
Cynometra sanagaensis	AM	445
Cytisus scoparius	AM	260, 261
Dalbergia obtusifolia	AM	655
Dalbergia sissoo	AM	317, 473
Daniella ogea	AM	445
Daviesia corymbosa	AM	67
Desmanthus illinoensis	AM	541
Desmodium heterophyllum	AM	355
Desmodium microphyllum	AM	343
Desmodium oxyphyllum	AM	643
Desmodium paniculatum	AM	541
Detarium macrocarpum	AM	445
Dialium guineense	AM	47, 52
Dicorynia guianensis	AM	71, 161
Didelotia africana	ECM + Weak AM	413
	ECM	445
Didelotia letouzeyi	ECM	413, 445
Dillwyinia parvifolia var. tricopoda	ECM+AM	67
Dillwynia retorta	ECM	67
	AM	589
Diphysa robinoides	AM	143
Dipteryx panamensis	AM	321

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Distemonanthus benthamianus	AM	445
Dorycnium hirsutum	NM	368
Enterolobium contortisiliquum	AM	211, 651
Enterolobium cyclocarpum	AM	143, 256
Eperua falcata	AM	161
Erythrina berteroana	AM	142
Erythrina crista-galli	AM	211
Erythrina poeppigiana	AM	148
Erythrophleum ivorense	AM	52, 445
Eysenhardtia polystachya	Weak AM	103
Faidherbia albida	AM	46
Genista hirsute	AM	339
Genista tinctoria	AM	260, 261
Geoffroea decorticians	AM	211
Gilbertiodendron brachystegioides	ECM	445
Gilbertiodendron dewevrei	ECM+AM	591
	ECM	445
Gilbertiodendron preussi	ECM	52
Gleditsia amorphoides	Weak AM + ECM	211
Gliricidia sepium	AM	52, 199, 258
Glyceria maxima	NM	62
Glycine max	AM	37
Gompholobium grandiflorum	AM	67
Gossweilerodendron balsamiferum	AM	445
Guibourtia tessmannii	AM	445
Havardia albicans	AM	18
Hedysarum confertum	AM	496
Hedysarum coronarium	AM	351
Hedysarum spinosissimum	AM	496
Hippocrepis comosa	AM	260, 261
Hippocrepis unisiliquosa	AM	472
Holocalyx balansae	Weak AM	651
Hymenaea courbaril	NM	548
Indigofera brevidens	Weak AM	438
Indigofera cordifolia	AM	567
Indigofera linifolia	AM	567
Inga leiocalycina	AM	627
Inga marginata	AM	31
Inga sessilis	AM	651
Inga striata	AM	651
Inga urguuensis	AM	211
Intsia palembanica	AM + ECM	14
Julbernardia seretii	ECM+AM	591
	ECM	445
Koompassia malacensis	NM	568
Kummerowia striata	AM	213
Lablab purpureusus	AM	640
Laburnum anagyroides	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Lathyrus montanus	AM	260, 261
Lathyrus japonicus	AM	260, 261
Lathyrus niger	AM + NM	260, 261
Lathyus odoratus	AM	260, 261
Lathyrus pratensis	AM	194
	AM + NM	260, 261
Lens culinaris	AM	319
Leucaena leucocephala	AM	18, 52, 254, 326
Lonchocarpus campestris	AM	651
Lonchocarpus muehlbergianus	Weak AM	651
Lonchocarpus nitidus	AM + ECM	211
Lotus corniculatus	AM	140, 159, 194, 307, 456
	AM + NM	260, 261
Lotus glaber	AM	508
Lotus tenuis	AM	396
Lotus uliginosus	AM	260, 261
Lupinus arcticus	NM	594
Lysiloma candida	AM	112
Machaerium minutiflorum	AM	651
Machaerium stipitatum	Weak AM	651
Macrotyloma uniflorum	AM	453
Medicago littoralis	AM	368
Medicago lupulina	AM	260, 261
Medicago marina	AM	368
Medicago polymorpha	AM	294, 260, 261
Medicago sativa	AM	38, 159, 351, 260, 261
Melilotus alba	AM	260, 261
Melilotus officinalis	AM	159, 260, 261
Microberlinia bisulcata	ECM	413
Mimosa adenantheroides	Weak AM	103
Mimosa bimucronata	AM	452
Mimosa biuncifera	Weak AM	103
	AM	82
Mimosa calcicola	Weak AM	103
Mimosa lacerata	Weak AM	103
Mimosa luisana	AM	103
Mimosa polyantha	Weak AM	103
Mimosa pudic	AM	326
Mimosa purpusii	Weak AM	103
Mimosa scabrella	AM	31, 651
Mimosa texana	Weak AM	103
Monopetalanthus le-testui	ECM	445
Monopetalanthus microphyllus	ECM	445
Mora excelsa	AM	592
Olneya tesota	AM	112
Onobrychis viciifolia	AM	260, 261
Onobrychis sativa	AM	260, 261
Ononis repens	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Ononis spinosa	AM	260, 261
Ormosia arborea	NM	548
	AM	651
Oxystigma buchholzii	AM	445
Oxystigma mannii	AM	445
Oxytropis scammaniana	AM	594
Pachyelasma tessmannii	AM	445
Paraberlinia bifoliolata	ECM	445
Parapiptadenia rigida	AM	211, 452, 651
Parkia bicolor	AM	52
Parkia biglobosa	AM	47, 247
Parkia speciosa	AM	14
Parkinsonia aculeata	AM	211
Peltophorum dubium	AM	211
	NM	548, 651
Pentaclethra macrophyll	AM	52, 445
Phaseolus lunatus	AM	20
Phaseolus mungo	AM	478
Phaseolus radiatus	AM	478
Phaseolus vulgaris	AM	37
Piptadeniastrum africanum	AM	52, 445
Plagiosiphon longitubus	AM	445
Plagiosiphon multijugus	AM	445
Platycyamus regnellii	AM	548
Poecilanthe parviflora	AM	211, 651
Prioria copaifera	AM	592
Prosopis articulata	AM	112
Prosopis cineraria	AM	379
Prosopis glandulose	AM	137
Prosopis juliflora	AM	76, 175, 567
Prosopis laevigata	AM	495
Psoralea bituminosa	AM	472
Pterocarpus angolensis	AM	419
Pterocarpus mildbraedii	AM	445
Pterocarpus soyauxii	AM	445
Pterogyne nitens	Weak AM	651
Pueraria phaseoloides	AM	150
Pultenaea elliptica	ECM + AM	67
Retama sphaerocarpa	AM	16, 17, 497
Robinia pseudoacacia	ECM	330
	AM + ECM	582, 260, 261
	ECM + EEM	86
Samanea saman	AM	52
Schizolobium parahyba	AM	548
Schrankia quadrivalvis	AM	143
Scorodophloeus zenkeri	AM	445
Scorpiurus muricatus	AM	472
Senna corymbosa	AM	211
Senna macranthera	AM	548, 651
Senna multijuga	AM	548
Senna siamea	AM	441
Senna spectabilis	AM	548
Sesbania aegyptiaca	AM	231

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Sesbania grandiflora	AM	231
Sesbania punicea	AM	211
Sesbania tomentosa	AM	326, 227
Sophora chrysophylla	AM	326, 406
Spartium junceum	AM	368
Strophostyles helvola	AM	596
Strophostyles umbellata	AM	532
Stryphnodendron microstachyum	AM	36
Stylosanthes guvanensis	AM	545
Stylosanthes scarbaeoidesand	AM	545
Swainsona phacoides	AM	438
Tamarindus indica	AM	47, 247, 343
Tephrosia purpurea	AM	216, 343
Tephrosia sphaerospora	AM	438
Tetraberlinia bifoliolata	ECM + Weak AM	413
	ECM	445
Tetraberlinia moreliana	ECM	413
Tipuana tipu	AM	548
Toubaouate brevipaniculata	ECM	445
Trifolium arvense	AM	307
Trifolium aureum	AM	194
Trifolium dubium	AM	643, 260, 261
Trifolium fragiferum	NM	260, 261
Trifolium glomeratum	AM	260, 261
Trifolium hybridum	AM	307
	AM + NM	260, 261
Trifolium medium	AM	260, 261
Trifolium pratense	AM	140, 159, 194, 204, 456
	AM + NM	260, 261
Trifolium repens	AM	140, 194, 283, 643, 260, 261
Trifolium spadiceum	AM	194
Trifolium subterraneum	AM	171
	AM + NM	260, 261
Trigonella foenumgraecum	AM	220
Ulex europaeus	AM	368, 260, 261
Ulex gallii	NM	260, 261
Ulex parviflorus	AM	497
Vicia angustifolia var. segetalis	AM	643
Vicia cracca	AM	194, 294, 260, 261
Vicia faba	AM	191
Vicia nigricans	AM	207
Vicia hirsute	AM	643, 260, 261
Vicia sativa	AM	260, 261
Vicia sepium	AM	194, 260, 261
Vicia sylvatica	AM + ECM	260, 261
Vicia tetrasperma	AM	307, 260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Vicia villosa	AM	140
Vigna aconitifolius	AM	343
Vigna luteola	AM	273
Vigna marina	AM	326, 547
Vigna mungo	AM	319
Vigna parkeri	AM	440
Vigna radiate	AM	377
Vigna unguiculata	AM	37, 287
Xylia xylocarpa	AM	315
Zornia sp.	Weak AM	103
Rosaceae		
Acaena magellanica	AM	342
Acaena minor	NM	560
	AM	342
Acaena novae-zelandiae	AM	260, 261
Acaena ovalifolia	AM	207
Acaena pinnatifida	AM	207
Adenostoma fasciculatum	AM + ECM	21
Agrimonia eupatoria	AM	260, 261
Alchemilla alpina	AM	80, 194, 260, 261
Alchemilla glabra	AM	260, 261
Alchemilla glaucescens	AM	194
Alchemilla glomerulans	AM	503
Alchemilla vulagris agg.	AM + NM	260, 261
Alchemilla xanthochlora	AM	260, 261
Aphanes arvensis	AM	260, 261
Cotoneaster integerrimus	AM	260, 261
Crataegus laevigata	AM + ECM	260, 261
Crataegus monogyna	ECM	368
	AM + ECM	260, 261
Dryas octopetala	ECM	80, 594
	AM + ECM	260, 261
Duchesnea chrysantha	AM	643
Filipendula ulmaria	AM + NM	260, 261
Fragaria chiloensis	AM	207
Fragaria vesca	AM + NM	260, 261
Fragaria xananassa	AM	537
Geum rivale	AM	194
	AM + NM	260, 261
Geum urbanum	AM	260, 261
Geum virginianum	AM	140
Hagenia abyssinica	AM	637, 638
Malus communis	AM	260, 261
Malus domestica	AM	368
Malus micromalus	AM	26
Malus pumila var. domestica	AM	233
Malus sylvestris	AM + ECM	260, 261
Osteomeles anthyllidifolia	AM	326
Ovidia andina	AM	207
Potentilla anglica	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Potentilla anserine	AM	307, 626, 260, 261
Potentilla argentea	AM	260, 261
Potentilla cinerea	AM	456
Potentilla crantzii	AM	194, 260, 261
Potentilla erecta	AM	194, 586
	AM + NM	260, 261
Potentilla fruticosa	AM	260, 261
Potentilla hookeriana	AM	443
Potentilla palustris	AM + NM	260, 261
Potentilla pulchella	AM	443
Potentilla reptans	AM	260, 261
Potentilla sterilis	AM	260, 261
Potentilla tabernaemontani	AM	260, 261
Prunus africana	AM	637, 638
Prunus avium	AM	465
	AM + ECM	260, 261
Prunus cerasifera	AM	73
Prunus cerasus	ECM	260, 261
Prunus domestica	AM + NM	260, 261
Prunus maritima	AM	324
Prunus padus	AM + ECM	260, 261
Prunus sellowii	Weak AM	651
Prunus spinosa	AM + NM	260, 261
Pyrus communis	AM	219
Pyrus pyraster	AM + ECM	260, 261
Rosa arvensis	AM	260, 261
Rosa canina	AM	81, 260, 261
Rosa hybrida	AM	160
Rosa rubiginosa	AM	207
Rosa rugosa	AM	324
Rosa sempervirens	AM	368
Rubus caesius	AM	260, 261
Rubus chamaemorus	NM	260, 261
Rubus fruticosus s. l.	AM	260, 261
Rubus idaeus	AM	573, 574
	AM + NM	260, 261
Rubus nessensis	AM + ECM	260, 261
Rubus rufus	AM	422
Rubus saxatilis	AM	260, 261
Rubus ulmifolius	AM	368
Sanguisorba minor	AM	260, 261
Sanguisorba officinalis	AM	260, 261
Sibbaldia procumbens	AM	594
	NM	260, 261
Sorbus aria	AM + ECM	260, 261
Sorbus aucuparia	AM + ECM + NM	260, 261
Sorbus torminalis	ECM	260, 261
Spiraea latifolia	AM	140
Spiraea tomentosa	AM	140
Rhamnaceae		
Colletia hystrix	AM	207
Colubrina glabra	AM	112

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Colubrina glandulosa	AM	651
Colubrina oppositifolia	AM	227
Condalia globosa	AM	112
Discaria articulata	AM	207
Discaria chacaye	AM	207
Frangula alnus	AM + ECM + NM	260, 261
Hovenia dulcis	AM	548
Phylica ericoides	AM	24
Rhamnus catharticus	AM + NM	260, 261
Rhamnus lycioides	AM	17, 108
Ventilago calyculata	AM	655
Zizyphus mauritiana	AM	47, 343, 378, 381, 655
Zizyphus nummularia	AM	567
Zizyphus obtusifolia	AM	112
Ziziphus xylopyrus	AM	380
Elaeagnaceae		
Elaeagnus commutata	AM	613
Hippophae rhamnoides	AM	405, 260, 261
Hippophae tibetana	AM	581
Shepherdia canadensis	AM	581
Ulmaceae		
Celtis wightii	AM	422
Gironniera subaequalis	NM	422
Trema micrantha	AM	548, 651
Trema orientalis	AM	445
Ulmus glabra	AM	260, 261
Ulmus procera	AM + ECM	260, 261
Cannabaceae		
Humulus lupulus	AM + NM	260, 261
Moraceae		
Artocarpus altilis	AM	136
Brosimum alicastrum	AM	18
Brosimum lactescens	AM	31
Broussonetia papyrifera	AM	343
Ficus cyrtophylla	NM	655
Ficus guaranitica	AM	651
Ficus hirta	AM	422
Ficus hispida	AM	655
Ficus langkokensis	AM	655
Milicia excelsa	AM	445
Milicia regia	AM	279
Morus alba	AM	475, 535
Musanga cecropioides	AM	445
Sorocea bonplandii	Weak AM	651
Urticaceae		
Boehmeria zollingeriana	AM	422
Cecropia glaziovii	AM	651
Cecropia pachystachya	AM	651
Elatostema parvum	AM	422
Parietaria judaica	AM + NM	260, 261
Pipturus albidus	AM	326

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Touchardia latifolia	NM	326
Urera glabra	AM	326
Urtica dioica	NM	611
	AM + NM	260, 261
Urtica urens	NM	260, 261
Cucurbitaceae		
Bryonia dioica	AM	260, 261
Citrullus lanatus	AM	310, 438
Ctenolepis cerasiformis	AM	567
Cucumis callosus	AM	567
Cucumis sativus	AM	499
Cucurbita foetidissima	AM	396
Cucurbita pepo	AM	340
Mukia maderaspatana	AM	216
Begoniaceae		
Begonia angustinei	AM	422
Begonia cathayana	AM	422
Hillebrandia sandwicensis	AM	326
Tetramelaceae		
Tetrameles nudiflora	AM	422
Fagaceae		
Castanea sativa	ECM	260, 261
Castanopsis borneensis	ECM	267
Castanopsis indica	NM	422
	AM	655
Fagus sylvatica	ECM	529, 260, 261
Lithocarpus densiflora	ECM	375
Lithocarpus leucostachyus	NM	422
Nothofagus dombeyi	ECM	207
Quercus alba	ECM	444, 470
Quercus cerris	ECM	260, 261
Quercus ilex	ECM	368, 472, 260, 261
Quercus petraea	ECM	53, 260, 261
Quercus pubescens	ECM	138
Quercus robur	ECM	53, 368, 260, 261
Quercus rubra	ECM	214
Myricaceae		
Comptonia peregrina	Facultative AM	284
Myrica cerifera	AM	468
Myrica faya	AM	326
Myrica gale	Facultative AM	146
	AM + NM	260, 261
Myrica pensylvanica	NM	324
	Facultative AM	284
Juglandaceae		
Engelhardtia roxburghiana	ECM	267
Juglans nigra	AM	465
Juglans regia	AM	177
	AM + ECM + NM	260, 261
Betulaceae		

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Alnus acuminata	ECM	61
Alnus cordata	AM	361
Alnus glutinosa	AM	210
	ECM + AM	368
	ECM	471
	AM + ECM + EEM + NM	260, 261
Alnus incana	AM	34
	AM + ECM	260, 261
Alnus sinuate	ECM	271
Alnus tenuifolia	ECM	641
Betula alleghaniensis	ECM	162, 516
Betula lenta	ECM	619
Betula nana	ECM	594, 260, 261
Betula papyrifera	ECM	303
Betula pendula	ECM	92, 155
	ECM+EEM	260, 261
Betula pubescens	ECM	370
	ECM+EEM	260, 261
Betula verrucosa	ECM	217
Carpinus betulus	ECM	529, 260, 261
Corylus avellana	ECM	367, 529, 260, 261
Casuarinaceae		
Allocasuarina littoralis	ECM	579
Casuarina cunninghamiana	Weak AM	485
	AM	316
	Weak ECM	579
Casuarina equisetifolia	AM	447, 326, 542, 606
Casuarina equisetifolia ssp. equisetifolia	ECM	579
Tropaeolaceae		
Tropaeolum majus	AM	360, 610
Moringaceae		
Moringa concanensis	AM	450
Caricaceae		
Carica papaya	AM	360, 595
Bataceae		
Batis maritime	NM	326
Resedaceae		
Reseda lutea	AM + NM	260, 261
Reseda luteola	AM + NM	260, 261
Capparidaceae		
Atamisquea emarginata	AM	112
Capparis sandwichiana	NM	326
Brassicaceae		
Alliaria petiolata	NM	260, 261
Alyssum montanum	NM	456
Arabidopsis thaliana	Weak AM + NM	260, 261
Arabis alpina	NM	260, 261
Arabis hirsuta	NM	472, 260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Armoracia rusticana	AM + NM	260, 261
Barbarea vulgaris	NM	260, 261
Biscutella laevigata	NM	456
	AM	446, 260, 261
Blennodia pterosperma	NM	438
Brassica napus	AM + NM	260, 261
Brassica nigra	NM	83, 260, 261
Brassica oleracea	AM + NM	260, 261
Brassica rapa	NM	260, 261
Cakile maritima	NM	368
	AM + NM	260, 261
Capsella bursa-pastoris	Facultative AM	167
	AM	164
	AM + NM	260, 261
Cardamine amara	NM	260, 261
Cardamine bulbifera	AM + NM	260, 261
Cardamine concatenata	NM	165
Cardamine corymbosa	NM	342
Cardamine flexuosa	AM + NM	260, 261
Cardamine hirsuta	AM + NM	260, 261
Cardamine impatiens	NM	260, 261
Cardamine pratensis	NM	260, 261
Cardamine trifolia	NM	260, 261
Cardaminopsis arenosa	AM	456
Cochlearia anglica	AM + NM	260, 261
Cochlearia danica	AM	260, 261
Cochlearia officinalis	AM + NM	260, 261
Diplotaxis erucoides	AM + NM	260, 261
Diplotaxis muralis	AM + NM	260, 261
Erophila verna	NM	260, 261
Erysimum cheiranthoides	NM	260, 261
Hesperis matronalis	Facultative AM	167
Iberis amara	AM	260, 261
Isatis tinctoria	NM	260, 261
Lepidium bidentatum	AM	326
Lepidium phlebopetalum	NM	438
Lepidium ruderale	NM	260, 261
Lepidium serra	NM	326
Matthiola incana	Facultative AM	167
Nasturtium officinale	NM	260, 261
Pringlea antiscorbutica	NM	560
Raphanus raphanistrum	NM	260, 261
Raphanus sativus	AM + NM	260, 261
Rorippa amphibia	NM	62
Rorippa islandica	AM	140
Rorippa palustris	NM	260, 261
Sinapis alba	NM	260, 261
Sisymbrium loeselii	NM	260, 261
Sisymbrium officinale	AM + NM	260, 261
Sisymbrium orientale	NM	260, 261
Thlaspi arvense	NM	260, 261
Thlaspi caerulescens	AM	488
Thlaspi montanum	AM	488
Thlaspi praecox	AM	488, 614
Thymelaeaceae		
Daphne laureola	AM	260, 261
Daphne gnidium	AM	368
Daphne mezereum	AM + NM	260, 261
Gonystylus bancanus	AM	568
Pimelea linifolia	AM	67
Wikstroemia furcata	AM	326
Bixaceae		
Cochlospermum vitifolium	AM	20
Cistaceae		
Cistus creticus	ECM	368
Cistus ladanifer	ECM	339
Cistus incanus	ECM	368
Cistus monspeliensis	ECM	368
	ECM + AM	472
Fumana thymifolia	AM	472
Helianthemum almeriense	EEM + ECM	249
Helianthemum apenninum	AM + ECM + EEM	260, 261
Helianthemum canum	AM + ECM + EEM	260, 261
Helianthemum guttatum	ECM + EEM	209
Helianthemum nummularium	ECM	80
	AM + ECM + EEM	260, 261
Helianthemum ovatum	ECM	330
Tuberaria guttata	ECM	260, 261
Dipterocarpaceae		
Hopea mengarawan	NM	568
Shorea balangeran	AM	568
Shorea leprosula	ECM	14
Shorea teysmanniana	AM	568
Shorea uliginosa	AM	568
Malvaceae		
Abelmoschus esculentus	AM	69
Abutilon californicum	AM	112
Abutilon indicum	AM	343
Abutilon otocarpum	AM	438
Abutilon theophrasti	AM	553
Althaea officinalis	AM	260, 261
Bastardiopsis densiflora	AM	651
Gossypium hirsutum	AM	7, 649
Gossypium tomentosum	AM	326
Kokia kauaiensis	AM	326
Malva sylvestris	AM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Thespesia populnea	AM	326
Sida ammophila	NM + Weak AM	438
Sida cordifolia	AM	567
Sida fallax	AM	326
Sida szechuensis	AM	343
Malvaceae (Bombacoideae)		
Adansonia digitata	AM	47
Bombax malabaricum	AM	343
Ceiba pentandra	AM	18
Ceiba speciosa	AM	548
Chorisia speciosa	AM	651
Ochroma pyramidale	AM	321
Pseudobombax grandiflorum	AM	651
Malvaceae (Tilioideae)		
Corchorus tridens	AM	567
Grewia biloba	AM	343
Heliocarpus americanus	AM	651
Heliocarpus appendiculatus	AM	244, 245
Heliocarpus pallidus	AM	20
Luehea candicans	AM	651
Luehea divaricata	AM	651
Luehea grandiflora	AM	548
Luehea seemannii	AM	321
Tilia cordata	ECM	529
	AM + ECM + NM	260, 261
Tilia platyphyllos	ECM	549, 260, 261
Tilia × *vulgaris*	ECM	260, 261
Malvaceae (Sterculioideae)		
Eriboma oblonga	AM	445
Guazuma ulmifolia	AM	18, 32, 651
Pterigota macrocarpa	AM	445
Pterospermum menglunense	AM	422
Pterospermum yunnanensis	AM	655
Theobroma cacao	AM	131, 321
Waltheria indica	AM	143, 326
Rutaceae		
Acronychia pedunculata	AM	655
Agathosma ovata	AM	24
Boronia thujona	AM	67
Citrus aurantifolia	AM	400
Citrus aurantium	AM	429
Citrus jambhiri	AM	176
Eriostemon australasius	AM	67
Fagara heitzii	AM	445
Flindersia brayleana	AM	222
Melicope barbigera	AM	326
Paramignya retispina	AM	655
Zanthoxylum rhetsa	AM	315
Meliaceae		
Azadirachta excelsa	AM	282

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Azadirachta indica	AM	255, 427, 477
Cabralea canjerana	AM	31
Cedrella fissilis	AM	548, 593, 651
Chisocheton siamensis	Facultative AM	422
Ekebergia capensis	AM	637, 638
Entandrophragma angolense	AM	445
Entandrophragma candollei	AM	445
Entandrophragma cylindricum	AM	445
Entandrophragma utile	AM	445
Guarea cedrata	AM	445
Guarea kunthiana	Weak AM	651
Khaya ivorensis	AM	445
Lansium domesticum	AM	422
Lovoa trichilioides	AM	445
Melia azedarach	AM	422
Melia toosanden	NM	422
Swietenia macrophylla	AM	433
Trichilia casaretti	Weak AM	651
Trichilia claussenii	Weak AM	651
Trichilia elegans	Weak AM	651
Simaroubaceae		
Castella peninsularis	AM	112
Irvingia gabonensis	AM	445
Anacardiaceae		
Anacardium excelsum	AM	321
Anacardium occidentale	AM	27, 47
Antrocaryon klaineanum	AM	445
Astronium graveolens	AM	651
Campnosperma auriculatum	AM	568
Cyrtocarpa edulis	AM	112
Mangifera sp.	AM	486
Pistacia atlantica	AM	197
Pistacia lentiscus	AM	368, 472
Pistacia palestina	AM	197
Pistacia terebinthus	AM	104
Pistacia vera	AM	197
Schinus patagonicus	AM	207
Schinus terebinthifolius	AM	548, 651
Sclerocarya birrea	AM	47
Trychoscypha acuminata	AM	445
Burseraceae		
Bursera fagaroides	NM	103
	AM	112
Bursera hindsiana	Weak AM	112
Bursera microphylla	Weak AM	112
Canarium schweinfurthii	AM	445
Sapindaceae		
Acer campestre	AM + ECM + NM	260, 261

Table 1 (continued)

Examined species[a]	Mycorrhizal status[b,c]	References
Acer platanoides	AM	607
	AM + ECM + NM	260, 261
Acer pseudoplatanus	AM	465, 622
	AM + ECM + NM	260, 261
Acer rubrum	AM	140
Acer saccharum	AM	141, 162, 470
Aesculus hippocastanum	AM	260, 261
Allophylus schweinfurthii	AM	445
Aphania senegalensis	AM	47
Blighia welwitschii	AM	445
Cardiospermum corindum	AM	112
Deinbollia pycnophylla	AM	445
Dodonaea viscosa	AM	326, 343, 479
Eriocoelum macrocarpum	AM	445
Harpullia cupanioides	AM	655
Lepisanthes senegalensis	Facultative AM	422
Litchi chinensis	AM	326
Matayba guianensis	AM	31
Pometia tomentosa	AM	422
	NM	655
Sapindus saponaria	AM	548
Some unplaced taxa		
Bruniaceae		
Staavia radiata	AM	24
Escalloniaceae		
Escallonia rubra	AM	207

[a]The families in column 1 are divided into four groups: bryophytes, pteridophytes, gymnosperms and angiosperms. For each group, the order of families is consistent with the phylogeny used in Fig. 1

[b]The mycorrhizal types shown in column 2 are consistent to the current widely used system of Smith and Read (1997): *AM* arbuscular mycorrhiza, *ECM* ectomycorrhiza, *EEM* ectendomycorrhiza, *ORM* orchid mycorrhiza, *ERM* ericoid mycorrhiza, *MTM* monotropoid mycorrhiza, *ABM* arbutoid mycorrhiza, as well as *NM* nonmycorrhiza, and mycoheterotrophy

[c]For the bryophytes, fungal associations were used instead of mycorrhiza; *A*, *B*, and *G* indicate ascomycetous, basidiomycetous, and glomeromycetous fungal associations, respectively

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mosses (Fig. 1; but see Boullard 1988 for mycorrhizoids in *Takakia*), tends to suggest that these plant–fungus interactions began when land plants originated. At present, there is no doubt that bryophytes preceded vascular plants during early evolution of land plants (Kenrick and Crane 1997).

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Furthermore, liverworts are clearly favored as the earliest divergent lineage of extant land plants according to emerging molecular evidence (Qiu et al. 1998; Dombrovska and Qiu 2004; Groth-Malonek et al. 2005; Qiu et al. unpublished), despite some lingering controversy on relationships among three bryophyte lineages: liverworts, mosses, and hornworts (see Qiu and Lee 2000; Renzaglia et al. 2000). Hence, the widespread occurrence of fungal association in liverworts deserves some attention here.

Mycorrhizas, or more precisely mycorrhizoids and mycothalli, are found in many of the liverworts that have been investigated (Pocock and Duckett 1985; Boullard 1988; Duckett et al. 1991). Several aspects of these symbioses revealed by recent studies may help clarify their evolutionary relationship to mycorrhizas in vascular plants. First, in cases where detailed ultrastructural analysis has been done, structures similar to those in the endomycorrhizas of vascular plants, i.e. arbuscules, have been observed in some liverworts (Read et al. 2000; Carafa et al. 2003; Russell and Bulman 2005). Second, cross-inoculation experiments have convincingly demonstrated that the same fungi can infect both liverworts and angiosperms and produce similar structures for either glomeromycetous or ascomycetous mycorrhizas (Read et al. 2000). Third, although isotopic tracing of nutrient, water, and carbon exchange has not been done for most liverwort–fungus symbioses, the carbon flow from *Betula* through the ectomycorrhizal fungus *Tulasnella* to the mycoheterotrophic liverwort *Cryptothallus* has been confirmed by a ^{14}C feeding experiment (Bidartondo et al. 2003). Finally, the evolutionary pattern of plant–fungus symbiosis observed in angiosperms by Trappe (1987) and in vascular plants (this study), i.e., glomeromycetous mycorrhizas being the common type and occurring in early-diverging plant lineages and ascomycetous and basidiomycetous mycorrhizas being the rare type and found in late-evolving plant lineages, is also seen in liverworts (Fig. 1). These four lines of evidence indicate that even though the plant structures involved in symbiosis are probably structurally and functionally analogous between liverworts and vascular plants, the nature of the biological interaction is almost certain to be evolutionarily homologous. Besides further investigations of the functional aspects of mycorrhizas in liverworts and other bryophytes as suggested by Read et al. (2000), one line of evidence that will provide conclusive support for evolutionary homology between the mycorrhizal symbioses in bryophytes and vascular plants could come from studies of plant genes that are involved in the processes, some of

Table 2 Mycorrhizal investigation of four major groups of land plants at both family and species levels

Group	Total number of families/species surveyed	No. (%) of mycorrhizal families (obligate and facultative)	No. (%) of obligately mycorrhizal species	No. (%) of facultatively mycorrhizal species	No. (%) of nonmycorrhizal families	No. (%) of nonmycorrhizal species
Bryophytes	28/143	20 (71%)	60 (42%)	6 (4%)	8 (29%)	77 (54%)
Pteriophytes	28/426	26 (93%)	185 (43%)	39 (9%)	2 (7%)	202 (47%)
Gymnosperms	12/84	12 (100%)	83 (99%)	1 (1%)	0 (0%)	0 (0%)
Angiosperms	195/2,964	184 (94%)	2,141 (72%)	396 (13%)	11 (6%)	427 (14%)
Sum	263/3,617	242 (92%)	2,469 (68%)	442 (12%)	21 (8%)	706 (20%)

which have been identified in recent studies (Stracke et al. 2002; Liu et al. 2003; Ane et al. 2004; Demchenko et al. 2004; Levy et al. 2004). If the same genes are found to control development of mycorrhizas in all groups regardless of their expression in the gametophytes of bryophytes or the sporophytes of vascular plants, and if the gene phylogenies are congruent to the plant phylogeny, the final doubt about homology of the two types of symbioses will be dispelled.

If the mycorrhizal symbiosis in liverworts, other bryophytes, such as the moss *Takakia* (see Boullard 1988), and hornworts proves to be homologous to that in vascular plants, it becomes obvious that mycorrhiza was indeed an important means of water and nutrient uptake adopted by the earliest land plants (Pirozynski and Malloch 1975). Fossil evidence is in agreement with such a scenario. Both glomeromycetous fungi (Redecker et al. 2000) and liverworts (Wellman et al. 2003) evolved by the Ordovician, when plants colonized the land (Kenrick and Crane 1997). Fossil mycorrhizas formed between nonseptate fungi and the protracheophyte *Aglaophyton major* have been uncovered from the Rhynie chert, confirming that this type of plant–fungus interaction existed at least 400 million years ago (Remy et al. 1994; Kerp et al. 2004; Taylor et al. 2005). It is possible that evolution of mycorrhiza might even have predated the origin of land plants, if fungal association in the extinct charophyte *Palaeonitella* (Taylor et al. 1992) is mycorrhizal. We conclude that although more work is needed to solidify the relationship between mycorrhizal symbioses in bryophytes and vascular plants, including morphological, physiological, and molecular characterization of the plant–fungus interactions in both bryophytes and early vascular plants (see Read et al. 2000), all available evidence seems to point to an origin of mycorrhizas at the beginning of land plant evolution.

Arbuscular mycorrhiza is the ancestral type of mycorrhiza

When the different types of mycorrhizas are mapped onto the land plant phylogeny, it becomes clear that arbuscular mycorrhiza (AM), the endomycorrhiza formed by glomeromycetous fungi and plants, is the ancestral type, as it occurs in a vast majority of plants and in all early-diverging lineages of major clades of land plants (Fig. 1). Even in bryophytes where the plant structures involved in symbiosis are rhizoids and thalli of the gametophyte, glomeromycetous fungi-mediated symbiosis results in formation of AM-like structures and is found in most early-diverging lineages of liverworts and in hornworts (Ligrone and Lopes 1989; Read et al. 2000; Russell and Bulman 2005). These two aspects of AM symbiosis suggest that the genetic mechanism underlying interaction between the plants and glomeromycetous fungi might have been established in the common ancestor of all land plants. Future molecular studies should be able to test this hypothesis to determine if the same genes are involved in plants–glomeromycetous fungi symbioses throughout land plants.

Trappe (1987) reported that AM is the ancestral type of mycorrhiza in angiosperms. Our survey, which broadens the scope to include all land plants, extends this conclusion to all land plants. This result is not likely to change even if relationships among three bryophyte lineages and vascular plants are altered (see Qiu and Lee 2000) because all of their early-diverging lineages possess AM when they are mycorrhizal. Furthermore, fossil evidence clearly indicates that AM is the most ancient type of mycorrhiza. The Devonian protracheophyte *Aglaophyton major* provides the best fossil record for existence of AM-like symbiosis as early as 400 million years ago; the arbuscules are visible in the protosteles of this early Devonian plant (Remy et al. 1994; Taylor et al. 2005). Fossil roots of younger age from the Triassic show that this type of symbiosis has been present continuously in early land plant evolution (Stubblefield et al. 1987). On the other hand, the oldest ectomycorrhizal fossils have so far been found only in the middle Eocene (50 million years ago) (LePage et al. 1997). The fossil record of glomeromycetous fungi, found in the Ordovician (Redecker et al. 2000), also clearly predates that of ascomycetous fungi unearthed from the Lower Devonian (Taylor et al. 1999). Given all these lines of evidence, it seems safe to conclude that AM represents the ancestral type of mycorrhiza in land plants.

Many independent conversions of arbuscular mycorrhiza to other types of mycorrhizas

If the ancestral state of AM in land plants is accepted, and further, if it can be agreed upon that the glomeromycetous fungi–plant interaction is underpinned by a genetic mech-

anism that has been stably inherited since its establishment in the common ancestor of all land plants, the phylogenetic distribution of AM and other types of mycorrhiza shown in Fig. 1 leads to the conclusion that there have been many independent conversions of AM to these other types of mycorrhizas. Brundrett (2002) previously proposed these evolutionary changes. In this review, we find overwhelming evidence in support of this hypothesis. Many plant lineages, ranging from pteridophytes through gymnosperms to angiosperms, contain some species that can form both AM and other types of mycorrhizas, e.g., Dryopteridaceae, Pinaceae, Gnetaceae, Araucariaceae, Cupressaceae, Orchidaceae, Cyperaceae, Poaceae, Ranunculaceae, Polygonaceae, Caryophyllaceae, Ericaceae, Rubiaceae, Oleaceae, Aquifoliaceae, Campanulaceae, Goodeniaceae, Asteraceae, Caprifoliaceae, Grossulariaceae, Myrtaceae, Melastomataceae, Euphorbiaceae, Salicaceae, Polygalaceae, Fabaceae, Rosaceae, Rhamnaceae, Juglandaceae, Betulaceae, Casuarinaceae, Cistaceae, Malvaceae, and Sapindaceae (Table 1; Fig. 1). These species might be in a transitional state from AM to other types of mycorrhizas. These other types of mycorrhizas have probably evolved as a consequence of emergence of new lineages in fungi on one side (e.g., certain groups of Ascomycetes and Basidiomycetes) and in plants on the other side (e.g., Pinaceae, Orchidaceae, Ericaceae, Fagales, and Malvales), and the associations formed by these new lineages that were able to colonize habitats that were previously not very successfully occupied by AM plants (Malloch et al. 1980). Because these other types of mycorrhizas have been classified using both morphological and plant partner criteria (Smith and Read 1997), we follow this classification in our discussion below.

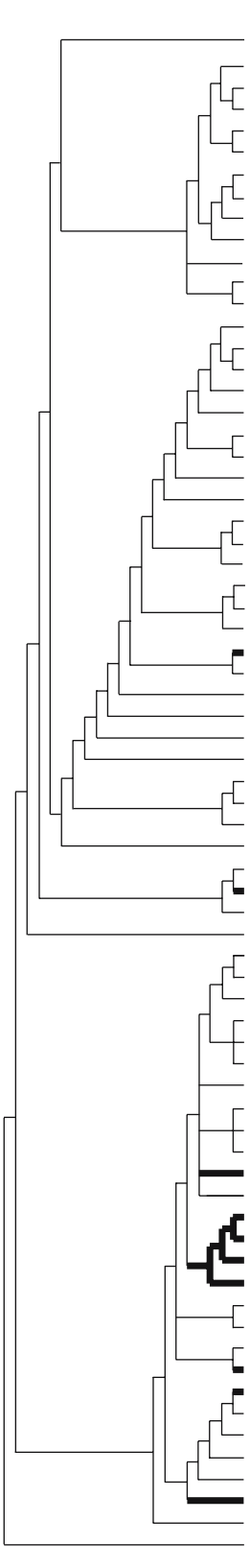
Ectomycorrhiza

Ectomycorrhiza (ECM) is a partnership between mostly basidiomycetous fungi and various groups of land plants. It primarily occurs in Pinaceae, Araucariaceae, Cupressaceae, Gnetaceae, Polygonaceae, Nyctaginaceae, Myrtaceae, Salicaceae, Fabaceae, Fagales, and Malvales. In addition, many other families of vascular plants contain a small percentage of species that form this type of mycorrhiza. Most leafy liverworts also have ascomycetous and basidiomycetous fungal associations (Table 1; Fig. 1). Although ECM is much rarer than AM in land plants, among all types of mycorrhizas formed by ascomycetous and basidiomycetous fungi, it is the most common one. When viewed in a plant phylogenetic perspective, the distribution of ECM clearly suggests many independent origins of this type of mycorrhiza because its occurrence is sporadic throughout land plants and it is mostly found in derived lineages in major plant clades. Previously, Bruns and Shefferson (2004) estimated at least 12 independent origins of ECM within angiosperms by mapping ectomycorrhizal information provided in Smith and Read (1997) onto an angiosperm phylogeny (Soltis et al. 2000). Fitter and Moyersoen (1996) conducted a similar survey and reached a similar conclusion. Our study revealed many more events of evolution of this type of mycorrhiza in land plants (Fig. 1).

Examination of the evolutionary histories of both plants and fungi may provide some ideas to understand how this type of mycorrhiza evolved repeatedly. The plants that form ECM typically grow in nutrient-poor environments, e.g., temperate and timberline forests of both Southern and Northern Hemispheres (Malloch et al. 1980), the spruce–hemlock–redwood forest of the coastal fog belt in the Pacific Northwestern USA, the wet eucalyptus forest in Australia, and the wet dipterocarp forest of Australasia (J. Trappe, personal communication). Phylogenetically, these plants represent derived lineages of some major land plant clades that once lived in a less nutrient-deficient environment, e.g., Pinaceae and Cupressaceae, as opposed to other conifers such as Cephalotaxaceae, Taxaceae, and Taxodiaceae, and Fagales and some Malvales vs other rosids. Meanwhile, the fungal species that participate in ECM symbiosis evolved repeatedly from saprotrophic homobasidiomycetes and also reverted to free-living condition many times independently (Hibbett et al. 2000), and they also represent derived lineages of fungi as a whole (Lutzoni et al. 2004). Thus, evolution of ECM could be viewed as an adaptation by those major plant clades to the change of environment when the climate on earth became more seasonal and arid (Hickey and Doyle 1977; Malloch et al. 1980), which immobilized nutrients, or simply as an adaptation to the environments that were limited in nutrient availability. From these considerations, it may be argued that the plasticity exhibited by ECM evolution reflects the opportunistic nature of a collective response by both plant and fungal partners to environmental challenges. This seems to be a short-term evolutionary strategy in comparison to AM, which clearly represents a major evolutionary innovation to solve a permanent water-and-nutrients deficiency problem faced by plants when they first made the virtually irreversible invasion onto the land in the Ordovician.

Fig. 1 A phylogenetic tree of 263 land plant families mapped with ▶ mycorrhizal information. **a** Non-angiosperms (including bryophytes, pteridophytes, and gymnosperms), **b** angiosperms except core eudicots, **c** core eudicots except rosids, and **d** rosids. For each family, the number in the column *Total* shows the total number of examined species; the *M%* column shows the percentage of obligately mycorrhizal species. The *FM%* column shows the percentage of facultatively mycorrhizal species, and the *NM%* column shows the percentage of nonmycorrhizal species. *Thicker terminal branches* were used to indicate 21 nonmycorrhizal families. For each of the 242 mycorrhizal families, the percentages of different types of mycorrhizae among all mycorrhizal species are shown in the *M type* column. The mycorrhizal types are consistent to the current widely used system of Smith and Read (1997): *AM* arbuscular mycorrhiza, *ECM* ectomycorrhiza, *EEM* ectendomycorrhiza, *ORM* orchid mycorrhiza, *ERM* ericoid mycorrhiza, *MTM* monotropoid mycorrhiza, *ABM* arbutoid mycorrhiza, as well as mycoheterotrophy. For the bryophytes, fungal associations were used instead of mycorrhiza: *A*, *B*, and *G* indicate ascomycetous, basidiomycetous, and glomeromycetous fungal associations, respectively. ①Families in which ectomycorrhizal species have been reported. ②Families in which mycoheterotrophic species have been reported

a



		Total	M%	FM%	NM%	M type
angiosperms						
Taxaceae	gymnosperms	2	100	0	0	AM only
Cupressaceae①		11	100	0	0	82% AM,18% AM+ECM
Taxodiaceae		3	100	0	0	AM only
Podocarpaceae②		6	100	0	0	83% AM, 17% mycoheterotrophy?
Araucariaceae①		5	100	0	0	60% AM, 20% ECM, 20% AM+EEM
Gnetaceae①		3	100	0	0	67% ECM, 33% AM+ECM
Welwitschiaceae		1	100	0	0	AM only
Ephedraceae		2	100	0	0	AM only
Pinaceae①		43	98	2	0	86% ECM, 7% AM+ECM, 5% ECM+EEM, 2% AM+ECM+EEM
Ginkgoaceae		1	100	0	0	AM only
Zamiaceae		5	100	0	0	AM only
Cycadaceae		2	100	0	0	AM only
Davalliaceae	pteridophytes	4	75	0	25	AM only
Grammitidaceae		8	38	0	63	AM only
Polypodiaceae		37	8	3	89	AM only
Nephrolepidaceae		3	33	0	67	AM only
Dryopteridaceae①		40	53	8	40	96 %AM, 4% AM+ECM
Blechnaceae		11	64	9	27	AM only
Thelypteridaceae		33	36	6	58	AM only
Aspleniaceae		99	32	12	56	AM only
Dennstaedtiaceae		20	60	5	35	AM only
Adiantaceae		25	48	12	40	AM only
Vittariaceae		3	33	0	67	AM only
Pteridaceae		22	45	9	45	AM only
Dicksoniaceae		4	75	0	25	AM only
Cyatheaceae		6	33	0	67	AM only
Plagiogyriaceae		1	100	0	0	AM only
Azollaceae		1	0	0	100	
Marsileaceae		1	0	100	0	AM only
Schizaeaceae		4	75	25	0	AM only
Gleicheniaceae		10	40	0	60	AM only
Hymenophyllaceae		11	36	0	64	50% AM, 50% endo-M (also AM?)
Osmundaceae		3	67	33	0	AM only
Ophioglossaceae		11	91	9	0	AM only
Psilotaceae		3	67	0	33	AM only
Marattiaceae		17	88	0	12	AM only
Equisetaceae		12	25	42	33	AM only
Selaginellaceae		17	76	6	18	AM only
Isoetaceae		3	0	0	100	
Lycopodiaceae		17	35	24	41	AM only
Anthocerotaceae	bryophytes	2	100	0	0	fungal association (G), AM-like
Gymnomitriaceae		7	0	14	86	fungal association
Jungermanniaceae		21	48	0	52	fungal association (A, B)
Calypogeiaceae		8	100	0	0	fungal association (A, B)
Cephaloziaceae		14	71	14	14	fungal association (A)
Cephaloziellaceae		6	67	0	33	fungal association (A)
Scapaniaceae		8	13	13	75	fungal association
Lepidoziaceae		9	67	0	33	fungal association (A)
Geocalycaceae		10	30	10	60	fungal association
Arnelliaceae		1	100	0	0	fungal association (B)
Plagiochilaceae		5	20	0	80	fungal association
Herbertaceae		1	0	0	100	
Pseudolepicoleaceae		1	0	100	0	fungal association
Lejeuneaceae		11	0	0	100	
Jubulaceae		6	0	0	100	
Porellaceae		5	0	0	100	
Radulaceae		3	0	0	100	
Codoniaceae		2	100	0	0	fungal association (G)
Pelliaceae		3	100	0	0	fungal association (G), AM-like
Aneuraceae②		5	40	0	60	ORM-like (mycoheterotrophy via ECM)
Metzgeriaceae		6	0	0	100	
Ricciaceae		1	0	0	100	
Conocephalaceae		1	100	0	0	fungal association (G), AM-like
Aytoniaceae		1	100	0	0	fungal association (G), AM-like
Marchantiaceae		2	100	0	0	fungal association (G), AM-like
Lunulariaceae		1	100	0	0	fungal association (G)
Blasiaceae		1	0	0	100	
Haplomitriaceae		2	100	0	0	fungal association (G), AM-like
Characeae						

Fig. 1 (continued)

b

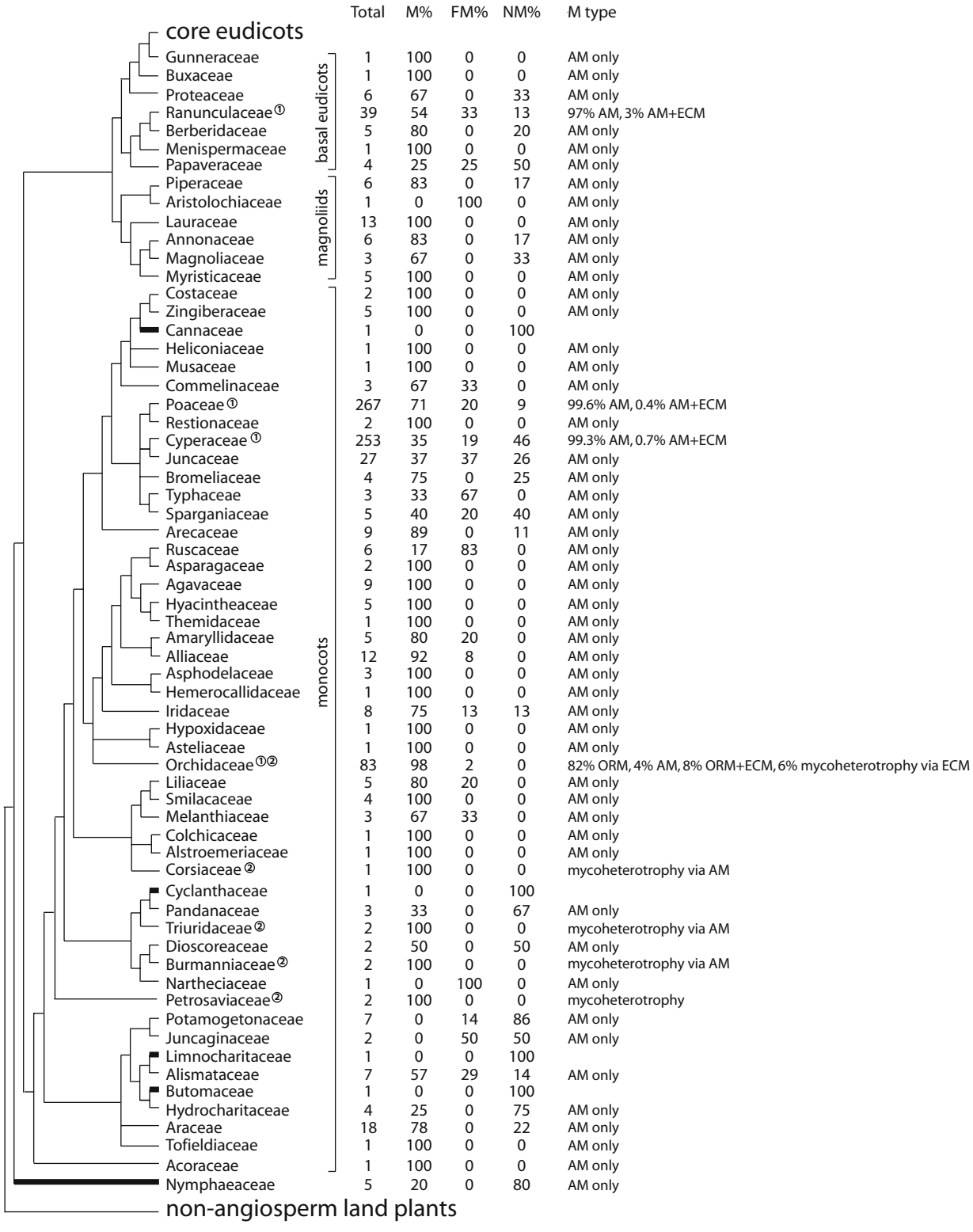
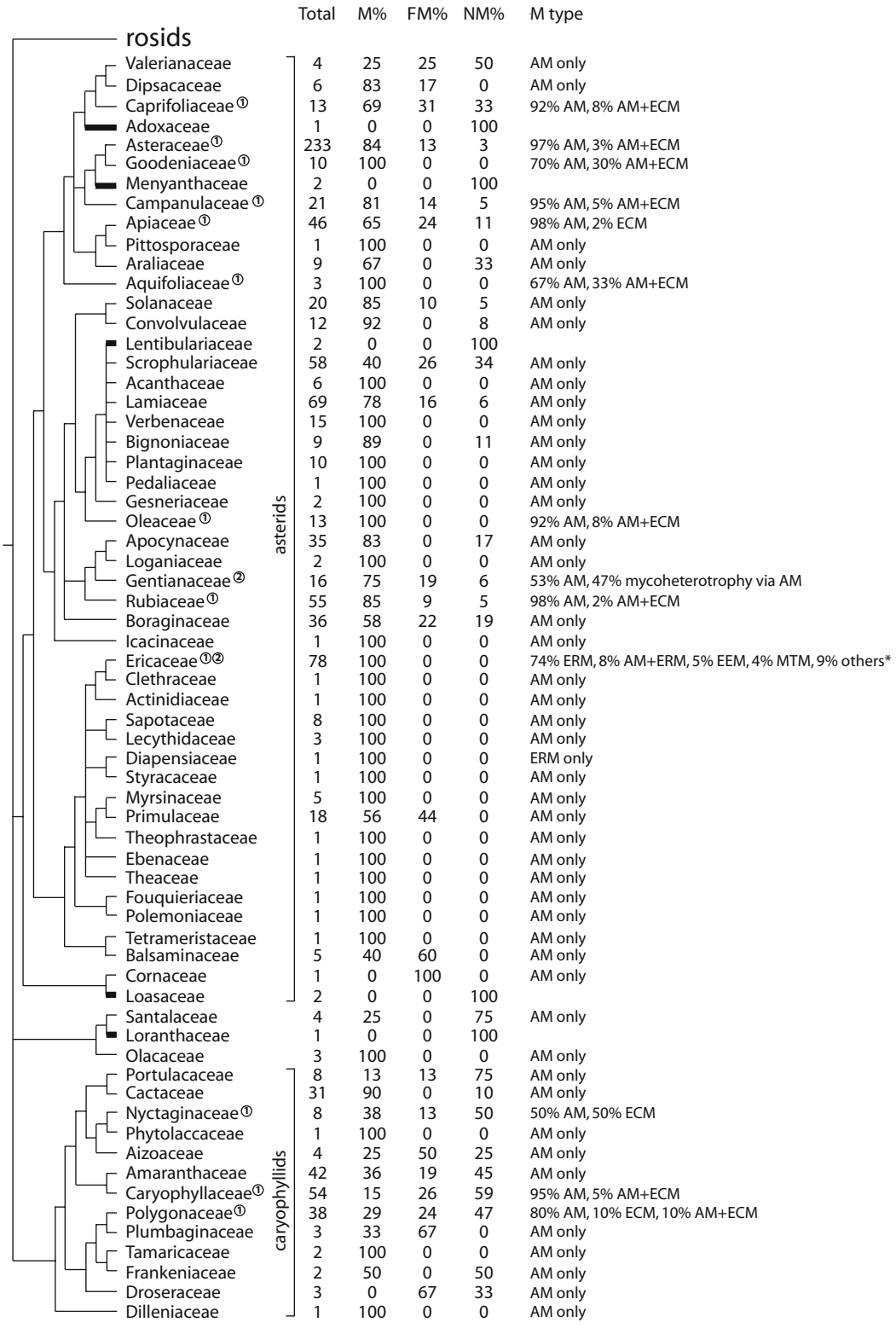


Fig. 1 (continued)

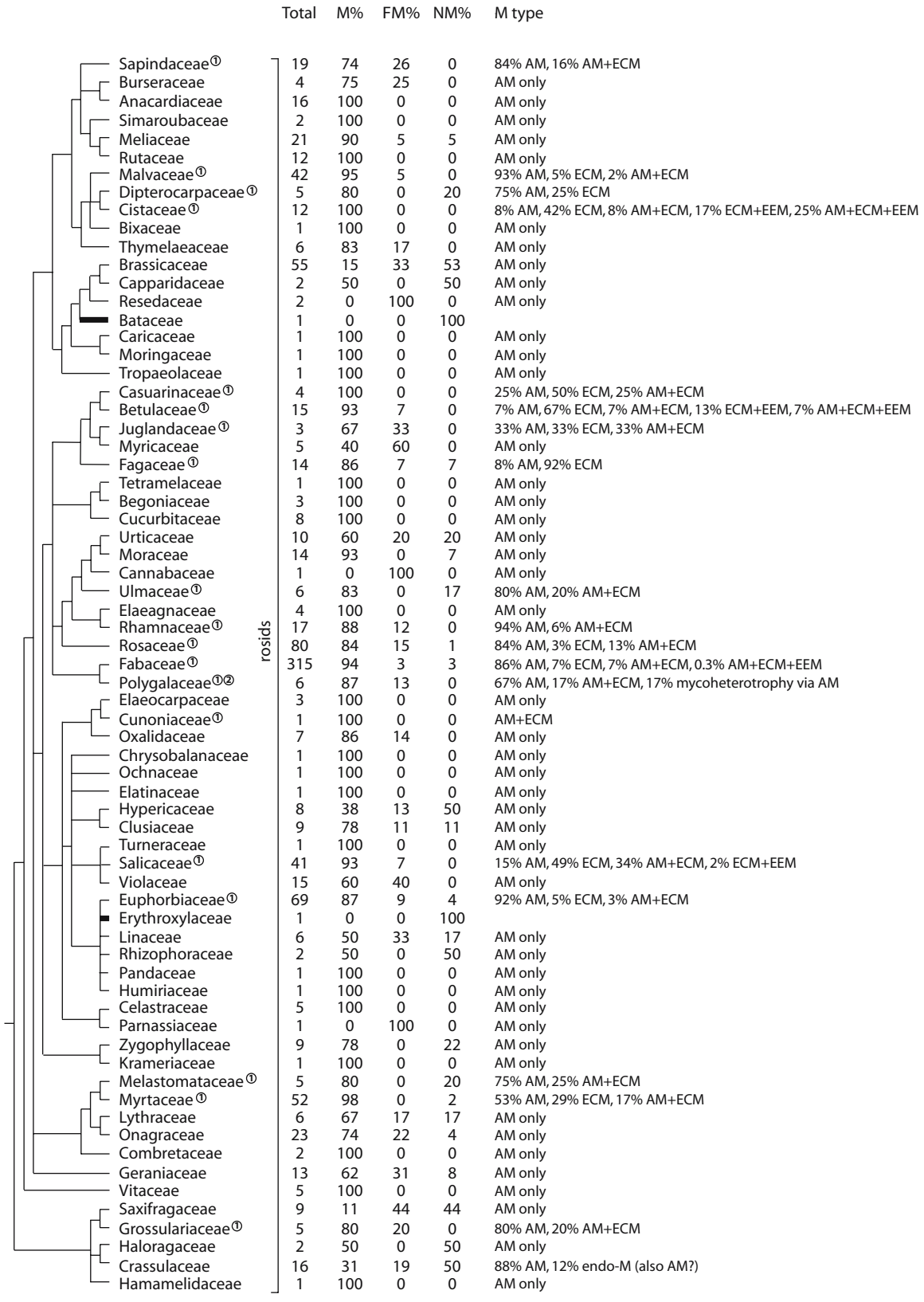
c



* Ericaceae: MTM is mycoheterotrophic. 9% others include 1.3% AM, 1.3% endoM, 1.3% ABM, 1.3% ABM+ECM, 1.3% ABM+ERM, 1.3% Mono M+ERM, 1.3% ERM+ABM+ECM+EEM

Fig. 1 (continued)

d



The very different evolutionary pattern of ECM from that of AM might suggest a different underlying genetic mechanism. Also, the structure is quite different between the two types of mycorrhizas. In ECM, the fungal hyphae do not penetrate the cell wall, and instead form a Hartig net (an intercellular meshwork in the root epidermis and cortex) and a sheath around the root derived from this net. On the other hand, the fungal hyphae in AM penetrate the cell wall and often form arbuscules. At present, little is known about the molecular genetic basis of ECM development. All plant genes involved in mycorrhizal symbiosis identified so far control AM development (Stracke et al. 2002; Liu et al. 2003; Ane et al. 2004; Demchenko et al. 2004; Levy et al. 2004). One of these genes has a homolog in the moss *Physcomitrella patens* and several other early land plants (Wang and Qiu, unpublished data). Hence, it can be inferred that there might be a general genetic program in plants that mediates plant–fungus interaction, a small portion of which might even be involved in plant–fungal pathogen interaction as well (Harrison 1999). This program was most likely established at the beginning of land plant evolution, if not earlier, and mostly targets glomeromycetous fungi. It has been inherited in land plants since its inception and is responsible for the prevalence of AM seen today. When ECM evolved in a particular plant lineage, the homobasidiomycetous fungi might have adopted much of this general genetic program, but also modified some aspects of it to suit a slightly different plant–fungus partnership. One intriguing question is how different plant lineages, particularly those as diverse as ferns, gymnosperms, and angiosperms, adapted the general genetic program for ECM development, as the structures of mycorrhizas are apparently very similar between these diverse lineages. Perhaps different genes are involved in each case, thus, the host specificity developed with different fungal symbionts in each case of ECM (as opposed to AM). Indeed, difference in gene expression was observed to be related to host specificity (Le Quere et al. 2004). Future work will likely reveal more details to help us understand how many independent conversions of ECM from AM had occurred.

The ericaceous mycorrhizas and their close relationship to ectomycorrhiza

There are six types of mycorrhizas in Ericaceae. With the exception of AM, five of them are partnerships between ascomycetous or basidiomycetous fungi and plants: ECM, ectendomycorrhiza (EEM), arbutoid mycorrhiza (ABM), monotropoid mycorrhiza (MTM), and ericoid mycorrhiza (ERM). Among these five types, ECM occurs in many plant lineages outside of Ericaceae (see above), and EEM is found in Pinaceae, Araucariaceae, Ericaceae, Salicaceae, Fabaceae, Betulaceae, and Cistaceae (Fig. 1). ABM, MTM, and ERM can be deemed to be genuinely ericaceous mycorrhizas, as they occur almost exclusively in this family. The only exception is ERM, which has also been found in Diapensiaceae, a close relative of Ericaceae. The ericaceous mycorrhizas share many characteristics with ECM, but exhibit a high degree of intracellular penetration (Smith and Read 1997). Brundrett (2002) suggested that ABM, MTM, and ERM were derived from ECM. Our mapping of ECM and these other types of mycorrhizas onto the land plant phylogeny and examination of their distribution within Ericaceae supports this interpretation. Further, we add that EEM probably represents a transitional stage between ECM and the three types of ericaceous mycorrhizas, ABM, MTM, and ERM, as ECM and EEM are found only in the basal lineages of Ericaceae, Monotropoideae, and Arbutoideae (Kron et al. 2002).

Previous studies have identified the fungal symbionts of the ericaceous mycorrhizas. One interesting phenomenon is that the fungal strains isolated from these three types of mycorrhizas can also form ECM with other plant species (reviewed by Smith and Read 1997). This observation strongly suggests a close relationship between ECM and the ericaceous mycorrhizas. An interesting question that arises is why the same fungi cannot penetrate into root cells of ectomycorrhizal hosts yet are able to do so with ericaceous plants. One answer could be that host plants play an important role in controlling development of different types of mycorrhizas.

Orchid mycorrhiza

Orchid mycorrhiza (ORM) is generally thought to be restricted to the Orchidaceae, which involve mostly basidiomycetous fungi (Leake 1994). Occurrence of this type of mycorrhiza in other plants such as the subterranean nonphotosynthetic liverwort *Cryptothallus mirabilis* (Ligrone et al. 1993; Bidartondo et al. 2003) and the monocot *Thismia* sp. (Brundrett 2002 see http://www.ffp.csiro.au/research/mycorrhiza/) probably represents functional and structural convergence, as the fungal partners are of different types than those of the true ORM in Orchidaceae (Leake 1994). In this perspective, ORM, like the ericaceous mycorrhizas discussed above, can be considered to occur exclusively in one plant family, Orchidaceae, and probably represents a highly specialized type of ectomycorrhiza. One fact supporting this idea is that some species of lower Epidendroideae, an early-diverging lineage within Orchidaceae (Cameron et al. 1999), still have ECM (Bidartondo et al. 2004; Selosse et al. 2004).

Did evolution of ectomycorrhiza and its derived types of mycorrhizas spur diversification of plant lineages that harbor these symbiotic systems?

If AM was instrumental in the origin and subsequent diversification of land plants in a newly exploited niche, did evolution of ECM and its derived types of mycorrhizas, which involve Ascomycetes and Basidiomycetes, contribute to diversification of plant lineages that forged these new partnerships? Our review provides a rather positive

answer to this question. In plant families where ECM and its derivatives are the main types of mycorrhizas or account for a significant percentage (>20%), e.g., Pinaceae, Orchidaceae, Nyctaginaceae, Polygonaceae, Ericaceae, Aquifoliaceae, Salicaceae, Fagaceae, Betulaceae, Cistaceae, Dipterocarpaceae, Myrtaceae, and Melastomataceae (Mabberley 1987), the species number is often high to very high in comparison to their close relatives that have AM (Fig. 1). In the case of woody plants, the members of these families are often dominant species in their communities (Malloch et al. 1980). Although there are many factors that may affect speciation rate, we believe that the correlation between high occurrence rate of ECM and its derived types of mycorrhizas and the species richness of plant clades that harbor these symbiotic systems are not coincidental. This observation becomes particularly striking when compared to mycoheterotrophy, another type of plant–fungus symbiosis, which will be discussed below. Because ascomycetous and basidiomycetous mycorrhizal fungi have a much higher host specificity than glomeromycetous fungi (Horton and Bruns 1998; Newton and Haigh 1998; Bidartondo and Bruns 2002), diversification of the plant hosts had likely in turn driven the speciation rate of the fungal symbionts. This coevolutionary arms race probably explains the large number of Basidiomycetes that are ectomycorrhizal today (Molina et al. 1992). In comparison, AM has obviously contributed very little to the diversification of glomeromycetous fungi, and the relatively low host specificity of these fungi may be to blame.

Mycoheterotrophy

Mycoheterotrophy represents a shift of balanced mutualistic symbiosis between plants and fungi toward an exploitative use of mycorrhizal fungi by plants that are no longer fully photosynthetic (Leake 1994). It is clearly a derived condition in mycorrhizal evolution. In our survey, we found that mycoheterotrophy had evolved many times independently in land plants, in the following families: Aneuraceae, Podocarpaceae, Petrosaviaceae, Burmanniaceae, Triuridiaceae, Corsiaceae, Orchidaceae, Ericaceae (Monotropoideae), Gentianaceae, and Polygalaceae (Fig. 1). The mycoheterotrophy in the moss genus *Buxbaumia* needs more thorough investigation (Leake 1994). In addition, gametophytes of *Lycopodium, Psilotum,* and *Botrychium* are also mycoheterotrophic (reviewed by Brundrett 2002). However, it has been suggested that mycoheterotrophy in these latter cases and most species of Orchidaceae may be different from that in other plant groups mentioned above (Bidartondo 2005) because these plants only engage in mycoheterotrophy for a part of their life cycles during establishment, and they are photosynthetic for the rest of their life cycles and enter mutualistic symbiosis with mycorrhizal fungi.

The independent evolution of mycoheterotrophy in many unrelated lineages of land plants is further underscored by the fact that it evolved repeatedly from AM and ECM and ECM-derived types of mycorrhizas (Fig. 1). Hence, evolution of mycoheterotrophy reinforces the evolutionary parallelism commonly seen in mycorrhizal evolution, which has dominated evolution of ECM as discussed above and loss of mycorrhiza to be discussed below. Although one may think that an exploitative relationship such as mycoheterotrophy can be evolutionarily unstable, which seems to be supported by the general paucity of species in most clades of mycoheterotrophic plants (Leake 1994), this unique type of interaction among more than two species of very different modes of nutrition uptake (autotrophy and heterotrophy) might have played a special role to facilitate some major transitions during land plant evolution. In the case of lycophytes and ferns, mycoheterotrophy probably helped to ease the transition from a gametophyte generation-dominant life cycle in bryophytes to a sporophyte generation-dominant life cycle in vascular plants. For most Orchidaceae, mycoheterotrophy has perhaps alleviated the problem of extremely small size of the seeds, which can be advantageous for dispersal but at the same time, limits nutrition packaging for the next generation, and thus has probably contributed significantly to the success of the family. These two examples once again highlight the important roles played by fungi not only in the origin, but also in many subsequent radiations of land plant evolution.

Many independent losses of mycorrhiza in land plants

Many families of land plants have not been found to form mycorrhizas with fungi in their natural habitats. In liverworts, no fungal association has been observed in Blasiaceae, Ricciaceae, Metzgeriaceae, Radulaceae, Porellaceae, Jubuliaceae, Lejeuneaceae, or Herbertaceae. In pteridophytes, species in Isoetaceae and Azollaceae are nonmycorrhizal. Similarly in angiosperms, species in Nymphaeaceae, Butomaceae, Limnocharitaceae, Cyclanthaceae, Cannaceae, Loranthaceae, Loasaceae, Lentibulariaceae, Menyanthaceae, Adoxaceae, Eryothroxylaceae, and Bataceae are nonmycorrhizal. In addition, nonmycorrhizal species occur together with mycorrhizal species in many families, and approximately half of the ten or more species examined in the following families are nonmycorrhizal: Geocalycaceae, Jungermanniaceae, Lycopodiaceae, Hymenophyllaceae, Gleicheniaceae, Pteridaceae, Adiantaceae, Aspleniaceae, Thelypteridaceae, Dryopteridaceae, Polypodiaceae, Cyperaceae, Polygonaceae, Amaranthaceae, Caryophyllaceae, Crassulaceae, and Brassicaceae (Table 1, Fig. 1). The fact that these families are deeply embedded among mycorrhizal families and are not closely related to each other provides convincing evidence that these plants lost their ability to form mycorrhiza independently.

There are two interesting features for phylogenetic distribution of nonmycorrhizal plants. One is that leafy liverworts and pteridophytes in general tend to have a high concentration of nonmycorrhizal species. Of course, mosses, as an entire clade, lack mycorrhiza as well (Read et al. 2000) except *Takakia* (Boullard 1988). Gymnosperms, on the other hand, are all mycorrhizal and almost

all obligately mycorrhizal. Angiosperms generally are also mycorrhizal, and have only a few groups that have a high percentage of nonmycorrhizal species, alismatids (including Araceae according to Stevens' (2004) new classification system, see Fig. 1b), Cyperaceae, caryophyllids, and Brassicaceae. This feature may be related to the fact that early land plants had not fully adapted to the symbiotic system with the fungi. Indeed, these plants generally have the *Paris*-type AM, which lacks well-developed systems of intercellular hyphae and do not always form arbuscules (Read et al. 2000). It will be interesting to see if future studies can demonstrate that a simpler genetic system is behind this rather unstable symbiotic relationship in basal land plants. The other feature is that almost all nonmycorrhizal plants are derived from ancestors that engaged in AM symbiosis. In the several families where ECM and ECM-derived mycorrhizas dominate or account for a large percentage, e.g., Pinaceae, Orchidaceae, Ericaceae, Myrtaceae, Salicaceae, Fagales, and Cistaceae, very few species are nonmycorrhizal. This feature is perhaps related to the highly specialized nature of the ECM symbiosis.

As to the mechanisms responsible for mycorrhizal loss, Trappe (1987) noticed several characters that tend to be shared by nonmycorrhizal species, and his observations still hold true here. First, many nonmycorrhizal vascular plants grow in aquatic or wetland habitat. In these environments, both nutrients and water supplies are not as limited as in the typical terrestrial environment. Hence, the plants can develop independence from the fungal symbionts and reduce the carbon cost that would normally be provided to the fungal partners in exchange for nutrients and water. The loss of mycorrhiza in alismatids and other aquatic plants likely occurred through this mechanism. Second, species that grow in nutrient-rich environments tend to be nonmycorrhizal. The ruderals in caryophyllids, Brassicaceae, and Crassulaceae, and the spring ephemerals in Ranunculaceae, Papaveraceae, and Saxifragaceae belong to this category. Third, the plants that have a long, fine, and highly branched root system with well-developed root hairs also have a high tendency to become nonmycorrhizal. Cyperaceae and the ruderals perhaps developed independence from fungal symbionts through this route. It has been suggested that root hairs and mycorrhizal fungi were two alternative mechanisms for plant nutrient uptake (Baylis 1970; Koide 1991). If a plant can absorb sufficient nutrients through its own root hairs, any genetic changes preventing the formation of mycorrhiza with fungi would be favorably selected. Besides these three observations made by Trappe (1987), we also noticed that many liverworts that lack fungal association are leaf and bark epiphytes, e.g., Radulaceae, Jubulaceae, Porellaceae, and Lejeuneaceae. A possible explanation could be that fungal development is thwarted by defense mechanisms of the plant on which these epiphytes live.

Areas of further study

This study and those by Trappe (1987) and Harley and Harley (1987) represent the three most extensive surveys of mycorrhizal occurrence in land plants, but the total number of species included in the three studies is only slightly over 10,000 (assuming that there is little overlap among the three surveys), which is about 3% of all listed land plant species that live on our planet. As can be seen from Table 1 and Fig. 1, for most plant families we have knowledge of the mycorrhizal status for only one or a few species. Hence, the first area that deserves more attention in the future is the investigation of mycorrhizal status of more species. From this study and those by Trappe (1987) and Harley and Harley (1987), as well as several reviews published earlier on this topic (Pirozynski and Malloch 1975; Malloch et al. 1980; Selosse and Le Tacon 1998; Read et al. 2000; Brundrett 2002), it is clear that mycorrhizas were instrumental in the origin and subsequent diversification of land plants and are continuing to play a vital role in maintaining floristic diversity and ecosystem function on earth. Thus, mycorrhizal symbiosis should be viewed as an integral part of any floristic, ecological, or evolutionary studies in the future.

Besides the general increase of mycorrhizal research, a few specific areas should be pursued. First, more basal land plants should be investigated, as they occupy an especially important position in our understanding of the origin of mycorrhizal symbiosis in land plants. Despite several studies on basal land plants (Pocock and Duckett 1985; Duckett et al. 1991; Read et al. 2000), our knowledge on phylogenetically critically positioned taxa such as Treubiaceae, many simple thalloid liverworts, mosses, and some hornworts, remains fragmentary. In this regard, mosses deserve special attention, as they represent the only major clade of land plants that is nonmycorrhizal (Read et al. 2000), a situation which by itself is very puzzling. Several basal moss lineages such as Andreaeaceae, Tetraphidaceae, Polytrichaceae, Buxbaumiaceae, and Diphysciaceae all grow on nutrient-poor, sandy soil or rocks. It will be interesting to know how they manage to grow on these poor substrates if they are truly nonmycorrhizal. *Takakia*, a sister group to all other mosses, is reported to be mycorrhizal (Boullard 1988) and grows on thin soil and rocks (Gao 2000). Second, several early-diverging lineages of angiosperms, Amborella, Austrobaileyales, Chloranthaceae, and magnoliids should be investigated; the information on their mycorrhizal status is currently lacking. Even when Trappe's (1987) survey is included, our knowledge of these plants is still quite poor. A focused study on these plants will fill an important gap in our understanding of mycorrhizal evolution in early angiosperms. Finally, as we learn more from studies of model organisms such as legumes (Stracke et al. 2002; Liu et al. 2003; Ane et al. 2004; Demchenko et al. 2004; Levy et al. 2004), characterization of molecular aspects of mycorrhizas in nonmodel organisms will significantly expand the dimension and depth of our knowledge of this important symbiotic system. In summary, the mycorrhizal research

conducted over the last several decades has brought this long neglected field into mainstream biology, and future research will undoubtedly further enhance our understanding of this important biological interaction and its impact on the evolution of both plants and fungi, as well as the establishment and functioning of the terrestrial ecosystem.

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