lying explanation of these phenomena may be the strain field set up by different rock bodies because they have unequal rigidity and are immersed in a regional strain field. This idea is just the geological counterpart of the materials science problem of inclusions in a matrix. If the inclusion conjecture is correct then one can look forward to predicting faulting and seismicity using a mechanical model derived from a geological map. □

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Plant ecology

Distribution of mycorrhiza throughout the British flora

Peter D. Moore

No study of plant ecology, particularly one involving factors affecting distribution, the availability of nutrients from the soil or the competition between individuals and species for limited inorganic resources, can afford to ignore the importance of mycorrhiza. These intimate associations between fungi and plant roots in the soil form a vital part of the physiology and life history of many plant species. They can even provide channels of movement of materials between plant individuals and between species, thus complicating studies of resource allocation and population ecology in the field. That they are widespread in nature has been appreciated for some time, but their abundance and ecological importance has been fully recognized only during the past 20 years. Information about the occurrence and type of mycorrhiza in different plant species is diffuse throughout the literature, but Harley and Harley have now collated[1] an exhaustive list of references to these associations in the British flora. This list both provides an opportunity to analyse the relative abundance of mycorrhiza and reveals some taxonomic and ecological peculiarities.

The list covers only the flora of the British Isles, but includes pteridophytes, gymnosperms and angiosperms. Harley and Harley have examined a significant proportion of the flora within each of these groups for the presence of mycorrhiza. In the pteridophytes, for example, they examined 82 % of the 74 British species, 72 % of which have mycorrhiza. Of the 13 gymnosperms native or well-naturalized in Britain, all have mycorrhiza. Among the angiosperms, the proportion examined is somewhat lower, but the general preponderance of fungal associations is still evident. In the dicots 53 % of the flora of 1,404 species were surveyed and 80 % of them have mycorrhiza, whereas in monocots 56 % of the 508 species are 76 % mycorrhizal. Thus, 54 % of British angiosperm species have been inspected and 79 % of those are infected with mycorrhiza. The survey reveals that it is the non-mycorrhizal elements in the British flora that are exceptional, rather than the other way round.

Occurrence of mycorrhiza in some major flowering plant families in the British Isles (data from ref.1).

	Total species	Species examined (%)	Mycorrhizal species (% of those examined)
Dicots			
Ranunculaceae	45	56	96
Cruciferae	98	40	46
Caryophyllaceae	83	49	30
Chenopodiaceae	34	44	53
Geraniaceae	20	50	90
Leguminosae	87	47	90
Rosaceae	87	54	96
Onagraceae	21	71	100
Umbelliferae	70	47	79
Euphorbiaceae	18	56	100
Polygonaceae	41	51	38
Salicaceae	34	79	100
Ericaceae	25	84	100
Primulaceae	20	75	100
Gentianaceae	16	50	100
Boraginaceae	34	47	75
Labiatae	63	49	90
Plantaginaceae	8	88	100
Campanulaceae	14	64	78
Rubiaceae	24	50	92
Compositae	160	61	96
Monocots			
Liliaceae	41	71	100
Juncaceae	39	49	63
Iridaceae	15	33	100
Orchidaceae	53	92	100
Cyperaceae	107	54	31
Gramineae	173	60	87

Of the various types of mycorrhiza that have been described, it is the vesicular–arbuscular forms that are most frequent within the British flora. These forms are caused by a relatively small number of genera within the fungal family Endogonaceae, but are represented by many species. These aseptate fungi may form a hyphal coil within a cell, or produce a brush-like, branched haustorium (an arbuscule) as well as fat-containing, multinucleate vesicles with thick walls. The vesicular–arbuscular form of mycorrhiza receives its name from these two types of structure.

Read[2,3] has emphasized the relationship between mycorrhizal type and habitat. In low-latitude and low-altitude grassland and deciduous forest, where nitrogen is usually available in the form of nitrates, the vesicular–arbuscular endomycorrhiza predominates. At high latitudes and altitudes, in acid peaty habitats and in coniferous forests, nitrogen may be available only in a reduced, ammonium-ion form and in these environments, ectomycorrhizas and ericoid endomycorrhizas are the most frequent forms. These tendencies are apparent in Harley and Harley's taxonomic lists when examined from an ecological point of view. Families such as Ericaceae, Monotropaceae and Empetraceae almost all contain distinctive ericoid endomycorrhizas and ectendomycorrhizas. The lack of mycorrhizas in aquatic plants is also evident. Nymphaceae and Menyanthaceae have no mycorrhizal representatives, and Cyperaceae has only 31 % mycorrhizal species among the members investigated.

The close dependence of some families on mycorrhiza has long been known[1], for example, the Orchidaceae and Gentianaceae, but other families are also surprisingly uniform in their fungal associations. Ranunculaceae, Geraniaceae, Leguminosae, Onagraceae, Labiatae and Rosaceae are all more than 90 % mycorrhizal in the species examined (see table). Yet other families have a surprisingly low proportion of mycorrhizal species: Caryophyllaceae, Crassulaceae and Polygonaceae have fewer than 40 %.

There is still much to be learned about the ecological advantages or disadvantages of being mycorrhizal. Such knowledge has already been of considerable economic value for forestry management in temperate and boreal regions. It is now becoming an important area of research in the tropical savanna grasslands, where increasing numbers of grasses are turning out to be mycorrhizal[4]. The productivity of grasses in these important pastoral areas could well be linked to the rapid development of an efficient mycorrhizal system early in the wet season. The current interest in the ecology of temperate mycorrhizal associations could provide an important springboard for the development of mycorrhizal research in tropical agronomy. □

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