

SHORT NOTE

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The BEG Expert System – a multimedia identification system for arbuscular mycorrhizal fungi

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Abstract Knowledge of the biodiversity of arbuscular mycorrhizal fungi is limited and keys for their identification are not in a user-friendly format for the non-expert. An Expert System, linked to the BEG (La Banque Européenne des Glomales), has been developed on a CD-ROM to produce a multimedia identification system for these fungi.

Key words Arbuscular mycorrhiza · Glomales · BEG · Expert System · CD-ROM

Introduction

The BEG (Banque Européenne des Glomales – European Bank of Glomales; WWW site <http://www.ukc.ac.uk/biolab/beg/index.html>) is a pan-European entity that resulted from an initiative in the European COST collaborative network 8.10/8.21 on arbuscular mycorrhizal fungi (AMF) to help focus research on these fungi within Europe and worldwide (Gianinazzi 1995). Most research on these fungi has been carried out over the past 30 or more years, during which their important role within agricultural, horticultural and forestry systems has been increasingly recognised. However, knowledge of the biodiversity of these fungi is limited by the difficulty in culturing them away from the host, and there is an urgent need for a system for identifying or at least helping to identify them. Species of AMF are currently placed within the Zygomycetes in the order Glomales and various attempts have been made to devise dichotomous or synoptic keys (Trappe

1982). The limited use and success of such keys is the result of our limited knowledge of taxonomic characters and material used for the descriptions. The attempt by Schenck and Perez (1990) to collate the available species descriptions demonstrated the poor quality of many of these descriptions and that some species names were synonymous. Scientists around the world trying to work with these fungi (particularly ecologists keen to monitor biodiversity) are reluctant to both isolate AMF in pure culture and subsequently to try to identify the culture – even to the genus. Morton (1988), Morton and Benny (1990) and Walker (1982, 1992) have worked on the development of systems to aid taxonomic classification but there has been no real attempt to collate information in a user-friendly format for the non-expert. With this in mind, we have developed the BEG Expert System as the first attempt to produce a multimedia identification system for this group of biotechnologically important fungi.














The BEG Expert System – description and use

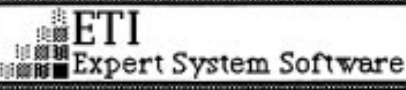
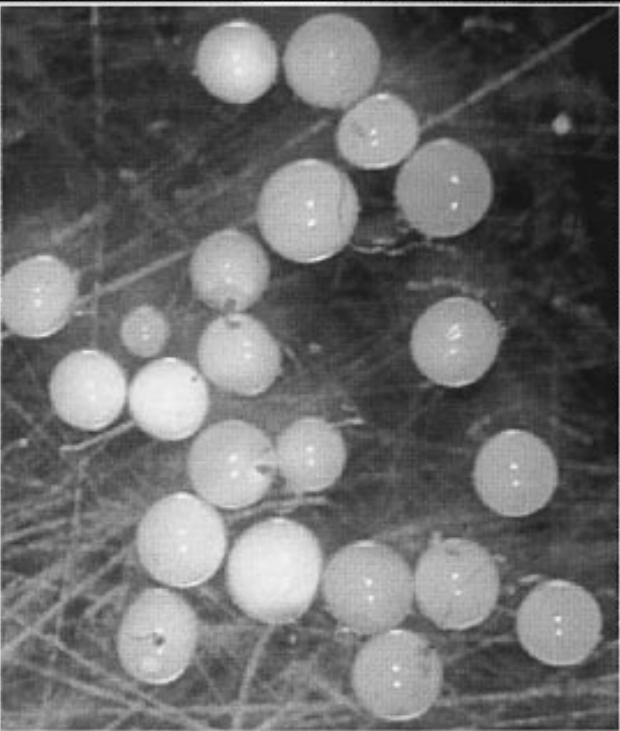







An Expert System has been defined by D.A. Waterman (cited by Edwards and Morse 1995) as a sophisticated computer programme that manipulates knowledge to solve problems efficiently and effectively in a narrow problem area. The BEG Expert System was created to show the potential of such a system with a limited number of well-defined AMF species. The system was put together using Linnaeus II software (Expert Centre for Taxonomic Identification-ETI, University of Amsterdam) for biodiversity documentation and species identification. It includes much unpublished data and photographic images on a CD-ROM suitable for computers with Windows or Macintosh platforms.

The CD-ROM can be run on a Macintosh/Power-Mac platform running System 7.0 or higher with a minimum of 4 Mb RAM. The Windows version requires system 3.1 and 4 Mb RAM. The CD-ROM contains approximately 120 images, the quality of which when

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	Glomales: Navigator
<div style="text-align: center;">  Species Cards </div> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> <div style="text-align: center;">  IdentifyIt™ </div> <div style="text-align: center;">  Introduction </div> <div style="text-align: center;">  Higher Taxa </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> <div style="text-align: center;">  Glossary </div> <div style="text-align: center;">  SpeciesList </div> <div style="text-align: center;">  References </div> </div>	<h2 style="margin-top: 0;">Welcome to the BEG-Expert System</h2> <p style="margin-top: 20px;">This BEG-Expert System was made with the ETI's Linnaeus II™ software, a multimedia package developed by ETI specifically for biodiversity documentation and species identification. The CD-ROM version of the BEG-Expert System is the result of a contract study between the Botanical Institute at the University of Copenhagen and the EU Commission, DG-XII. The initiative was taken within the COST Action 8.10 - the European network on arbuscular mycorrhizal fungi.</p> <p style="margin-top: 20px;">The BEG-Expert System is a demonstration version. Only 14 species are included, and the system is made in order to study the feasibility of an expert system.</p>
<div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">  Help </div> <div style="text-align: center;">  Run Demo </div> <div style="text-align: center;">  Contributors </div> </div>	<div style="text-align: right;">   </div>

	Glomales: <i>Gigaspora margarita</i>
<p>Description:</p> <p><i>Gigaspora margarita</i> Becker & Hall</p> <p>Spore formation: Spores formed singly in the soil (See adjacent picture).</p> <p>Hyphal attachment: Also known as the sporogenous cell in the Gigasporaceae. Terminally attached and bulbous.</p> <p>Spore shape: Globose.</p> <p>Spore size range: 260-480µm</p>	
<div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">  Detail </div> <div style="text-align: center;">  First </div> <div style="text-align: center;">  Previous </div> <div style="text-align: center;">  Next </div> <div style="text-align: center;">  Go Back </div> </div>	<div style="text-align: right;">   </div>

◀ **Fig. 1** The 'Navigator' icon of the BEG Expert System

viewed will depend on the monitor used. The software uses Hypertext, which is a method of displaying text without the constraint of following a linear sequence through a document. The document can be browsed using the mouse to select icons, keywords or images to display other related parts of the document.





The 'Navigator' (Fig. 1) is the centre of the programme from which all other parts of the document are accessed. An 'Introduction' briefly outlines the importance and role of AMF in different ecosystems, each description being illustrated by an accompanying image. The 'Species Card' is the main section of the programme where 14 species of AMF covering five genera (*Acaulospora*, *Entrophospora*, *Gigaspora*, *Glomus* and *Scutellospora*) are found. The first page of the 'Species Card' of *Gigaspora margarita* Becker and Hall (BEG 34) is given as an example in Fig. 2. Each 'Species Card' contains various database fields which can be accessed by clicking on the appropriate button. These fields include a description of the species, its taxonomy, possible synonyms, literature references and media

clips. The media clips are photos showing important morphological features.

Our initial philosophy was to make the descriptions of species consistent in their presentation on the CD-ROM and so we have made several alterations to the published taxonomic descriptions. A consistent taxonomy is necessary for creating the identification system, which is based on the ETI 'IdentifyIt' multiple-entry taxonomic key. This software is based on a character and state matrix and we have included the characters considered most important for identification of AMF across the five genera used on the CD-ROM. There is a different 'card' for each character, which allows the selection of states to include or exclude in the search pattern (Fig. 3). Images and clarification of terminology accompany these cards to aid the user. However, this still requires the user to view spores under a stereomicroscope to obtain certain information and examine slide mounts on a compound microscope to select the correct character states! Using the identified character states applicable to the specimen/isolate (as many as possible), 'IdentifyIt' performs a search on the selected states for the closest resembling AMF species, with results indicated as successful hit percentages next to the

◀ **Fig. 2** Page 1 of the 'Species Card' presenting *Gigaspora margarita*

Fig. 3 Identification search using IdentifyIt and showing results for *Glomus mosseae*

ETI Expert System Software		BEG Glomales Identify: Object Search	
Objects - Search Results:		Select Character for Searching:	
94 <i>Glomus mosseae</i>	↑	! Spore size range	↑
83 <i>Glomus geosporum</i>		! Spore shape	
72 <i>Glomus caledonium</i>		# Spore germination	
66 <i>Glomus intraradices</i>		! Root colonization	
55 <i>Gigaspora margarita</i>		! Inner memb wall in Melzer's	
50 <i>Glomus claroideum</i>		! Ornamentation in inner wall	
50 <i>Gigaspora rosea</i>		# Spore occlusion	↓
44 <i>Glomus fasciculatum</i>			
44 <i>Acaulospora spinosa</i>			
44 <i>Acaulospora delicata</i>			
44 <i>Entrophospora colombiana</i>			
33 <i>Scutellospora heterogama</i>			
33 <i>Scutellospora weresubiae</i>			
22 <i>Scutellospora nigra</i>	↓		
		Selected States - Search Pattern:	
		Hyphal attachment, Funnel shaped	↑
		Spore colour, Yellow	
		Outer wall layer, Not visible	
		Auxiliary cells, Absent	
		Spore walls, Spore wall alone	
		Ornamentation of spore wall, Smooth	
		Spore formation, singly	
		Spore formation, in sporocarps	
		Spore wall in Melzer's, Unknown	↓
 Find	 Compare	 Examine	 Go Back

species names. Fig. 3 illustrates this in the identification of an isolate of *Glomus mosseae* (Nicol and Gerd) Gerd and Trappe (BEG 12). There are other additions to the programme, such as a 'Glossary of Terms' whereby the user can click on a word to find the definition, some of which are illustrated with media clips. Words in the Glossary are highlighted in the Windows version but not in the current Macintosh version. Finally, there is a 'Run Demo' icon which provides a self-running demonstration of all the species in the programme.

The aim of this venture has been to stimulate renewed interest in the accurate collection of ecological information on the global diversity of AMF by simplifying the identification procedure. It is an attempt to move the taxonomy forward and is open to suggestions from any user. This version of the BEG Expert System is free, it only includes 14 species and should be viewed as a Demonstration Version. The potential for video clips and other information has not been fully explored in this Demonstration Version, given the short time available for its preparation, but the next version will look at this aspect more closely. Colleagues in COST Action 8.21 have also shown considerable interest in its potential use in teaching. Copies of the CD-ROM are still available for people wishing to test it and requests should be sent to either author by post or via e-mail (Soerenr@bot.ku.dk or J.C.Dodd@ukc.ac.uk).

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