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SHORT NOTE

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DEEMY – the concept of a characterization and determination system for ectomycorrhizae

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Abstract A considerable amount of data has been published on morphological and anatomical characteristics of ectomycorrhizae but these are dispersed in several, sometimes not easily available, journals. The few keys that exist are mostly based upon host tree genera. No comprehensive determination tools for non-experts are available. An information system for specific characters of ectomycorrhizae and an interactive key are now provided by DEEMY on CD-ROM.

Key words Characterisation · CD-ROM · DEEMY · DELTA · Ectomycorrhizae · Expert system · Interactive determination

Introduction

The number of published descriptions of ectomycorrhizae has increased enormously in the last two decades, but the data provided are often rather incomplete. Presently, about 250 taxa of ectomycorrhizae (unidentified ectomycorrhizae named binominally, and those identified described on different host tree genera) are known (Agerer 1987–1996).

Progress in computer techniques and software development during recent years has supplied taxonomists with easier access to information, either in the form of data bases or expert/advisory computer systems, for the determination of taxa (Atkinson and Gammerman 1987; Edwards and Morse 1985). In mycology, for example, a DELTA-based expert system for the identification of lichenized and lichenicolous Ascomycetes is available (Rambold 1997). The concept of an identification system for arbuscular mycorrhizal fungi has been established (Dodd and Rosendahl 1996). DEEMY ('System for characterization and DEtermination of EctoMYcorrhizae'), developed by Agerer and Rambold (1996) is the first attempt to produce a user-friendly determination system for ectomycorrhizae.

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Description of the system

DEEMY is a hypertext environment on CD-ROM which includes DELTA-based interactive keys and is offered as an integrated system accompanied by comprehensive explanations of ectomycorrhizal features.

The front page with information on copyright, usage, and masthead leads to a second screen page 'Forum' (Fig. 1) with links to screen pages containing details on the use of the implemented interactive key program INTKEY, and general information on DELTA, the correct citation of the CD-ROM, and persons who contributed to the pictures ('Thanks'). All the information necessary to describe and determine ectomycorrhizae can be obtained by clicking on six buttons. A link 'General' leads to information on making drawings, citation of literature, the cleaning procedure, and naming of ectomycorrhizae, etc.

'Character explanations' provides a list of the 337 key characters used, from 'Morphological features' to information regarding 'Trees'. All important characteristics are included, such as 'Anatomy in plan view of outer mantle layers', 'Rhizomorphs', 'Emanating hyphae', 'Cystidia', 'Longitudinal sections', and reference is also made to 'Ultrastructure' and 'Ecology'. The list includes explanations of all diagnostic characters (Fig. 2). Written explanations are given for most characters, often accompanied by drawings and photographs (Figs. 5, 6). These illustrations, which can be selected using the appropriate buttons at the top of the screen page, are either schematic drawings, and/or colour or black-and-white light micrographs, and/or colour photographs of the intact ectomycorrhizae.

The taxonomic data of DEEMY are stored in DELTA format (Description Language for Taxonomy) (Dallwitz 1980), a coding language for establishing de-

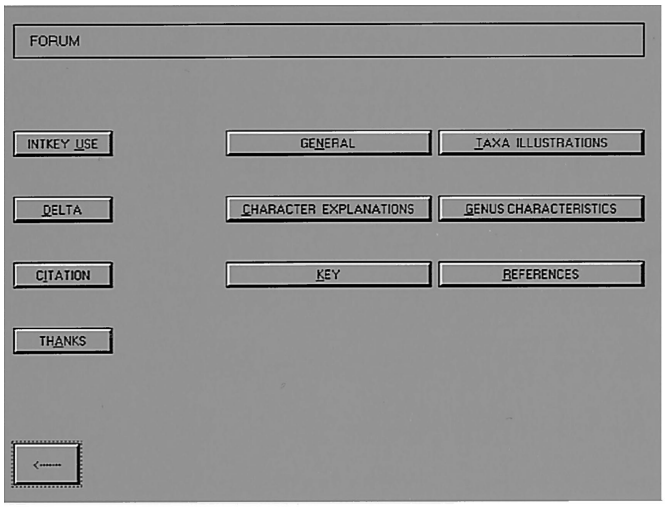

Fig. 1

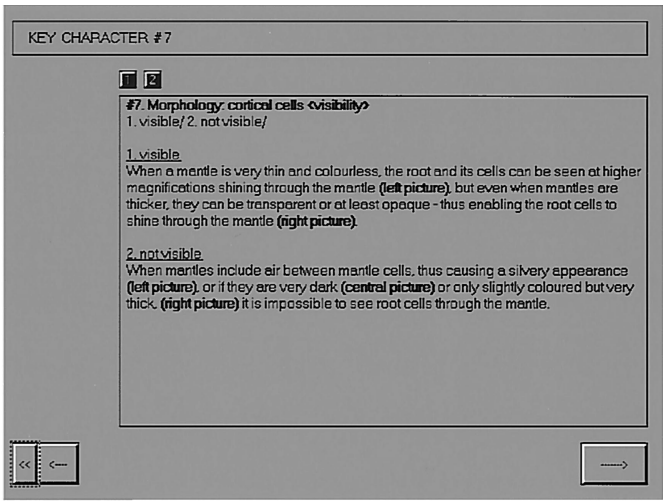

Fig. 2

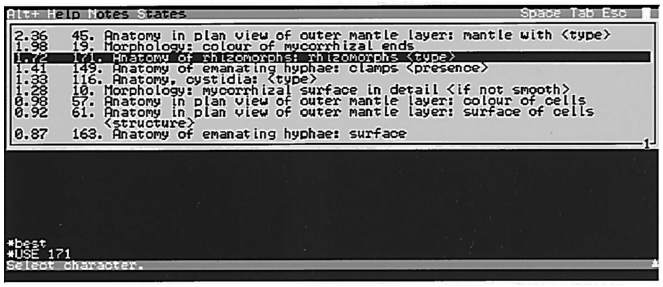

Fig. 3

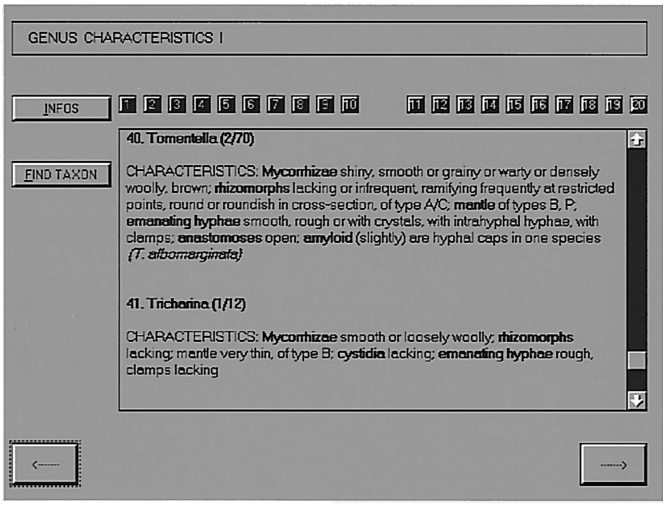

Fig. 4

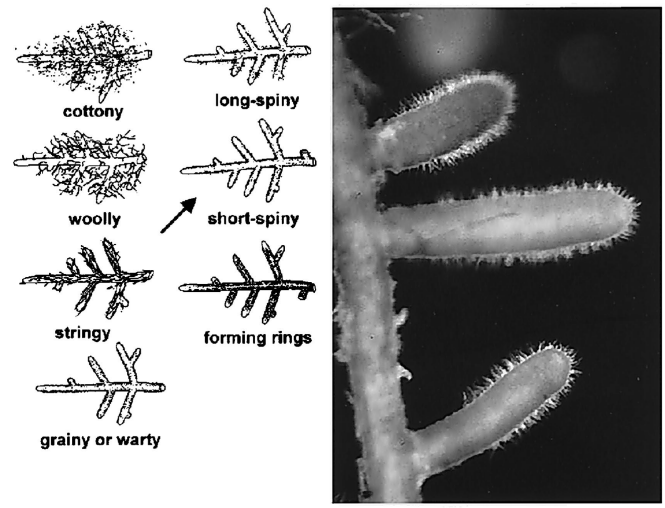

Fig. 5

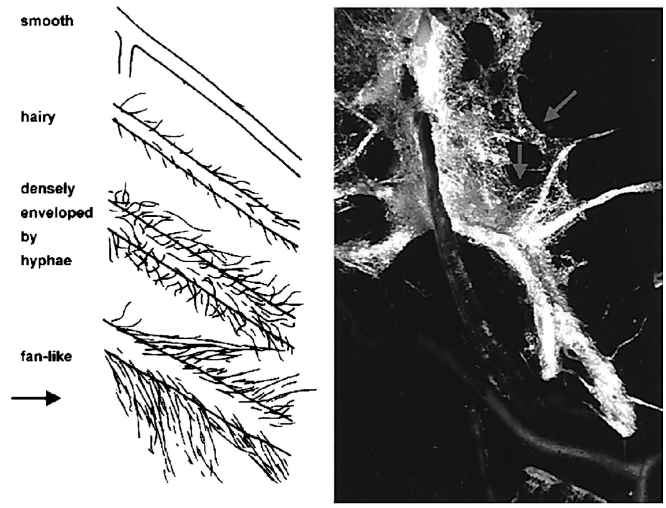

Fig. 6

Figs. 1–6

scriptive data or identification keys which is accepted by the International Union for Biological Sciences, Taxonomic Database Working Group (TDWG). DELTA describes taxa in a form usable by computer applications for creating printed polytomous keys, interactive keys, descriptions in natural language etc. Furthermore, it maintains data sets in a format usable for statistic and cladistic analyses. DELTA data files can be used for interactive identification (Dallwitz et al. 1993; Pankhurst and Pullan 1996). INTKEY is an interactive key program belonging to the DELTA package which uses compiled DELTA-coded data. This program has been included in the DEEMY system with authorization and can be accessed from the hypertext environment as an external program by the 'Key' button.

INTKEY has more capabilities than an ordinary data base program and can preferentially supply the user with the best characters for dividing the remaining set of taxa into more or less equivalent groups. Many additional features make it a powerful tool for diagnostics (Dallwitz et al. 1993), e.g. search for taxa and characters, display and compare full data sets of taxa based on selected characters, or list relevant literature for each taxon. Characters provided by the program (Fig. 3) can be used for determination, and a character that is prevalent or typical for the specimen under investigation can be defined. Character states, even in combination, as well as measurements or ranges of measurements can be entered during the determination process.

A number of deficiences remain due to: (1) poorly characterized ectomycorrhizae, with too few characters examined, which appear as "unknown" in the data sets; (2) the limited number of published descriptions (only 250 of ca. 5400 species of ectomycorrhizae (Molina et al. 1992) have been described in adequate detail and half of these have so far been included in this first version of DEEMY); (3) eurocentric data sets, with most (90%) descriptions of ectomycorrhizae originating from European material, 4% Asian, 3% North American, 2% South American and 1% African material. Of the 22 tree genera considered in DEEMY, 88% of the data stem from seven genera: *Picea* (37%), *Pinus* (17%), *Betula* (12%), *Fagus* (11%), *Pseudotsuga* (4%), *Corylus* (4%) and *Larix* (3%).

References are given to illustrations of the ectomycorrhizae included, either provided by DEEMY and/or presented in other publications. A reference colour photo is supplied for approximately half of the species included in DEEMY and photos published elsewhere are quoted for an additional 20 species. Illustrations provided in the system show most of the typical morphological features; however, it is recommended to consult the additional photographs supplied by Agerer (1987–1996), Goodman et al. (1996), and Ingleby et al. (1990).

'Genus characteristics' provides a preliminary survey on the major ectomycorrhizal features of various fungal genera. As already shown by Godbout and Fortin (1985) and Agerer (1995), some genera exhibit rather uniform mycorrhizal features whereas others appear heterogeneous. In the present version of DEEMY, the states of the five most important characters of 45 fungal genera (Fig. 4) are supplied. A descriptive text is always accompanied by a schematic delineation of these most important features, i. e. mantle structure, rhizomorphs, cystidia, presence and types of anastomoses. These character profiles are defined only on data for the taxa included in DEEMY and are thus to be regarded as preliminary and incomplete. The number of taxa studied (first position) and the number of known species (second position) should be compared to estimate the degree of confidence. 'References' supplies information on the literature used for compiling the data.

DEEMY supplies (1) standardized descriptions of ectomycorrhizae on a global basis, (2) an interactive key to determine ectomycorrhizae using all aspects, (3) character profiles on the fungal genus level, (4) indications whether an ectomycorrhiza isolated from soil may still be undescribed, and (5) general information on the fungal taxa with respect to their ectomycorrhizae. Molecular data will be included in future versions of the system as soon as an agreement is reached on a standard method and a sufficient number of ectomycorrhizae have been examined Agerer (1996).

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Fig. 1 Screen shot of DEEMY hypertext surface with buttons linking to the interactive key application, picture and text pages

Fig. 2 Example of a screen page with state descriptions of key character 7 and links to the relevant illustrations

Fig. 3 INTKEY with 'best' characters to divide the remaining set of taxa in more or less equivalent groups

Fig. 4 Example of a screen page with short genus characteristics and links to illustrations

Fig. 5 Illustrations of key character 10, state 10:Morphology: mycorrhizal surface in detail : densely short-spiny

Fig. 6 Illustrations of key character 33. Morphology: rhizomorph margin: fan-like

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