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An interactive tool for the identification of airborne and food fungi

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Abstract — The growth of fungi may result in several kinds of food-spoilage: off-flavours, discolouration, rotting and formation of pathogenic or allergenic propagules. Moreover many foodborne fungi produce mycotoxins and thus fungal growth in foods and feeds should be avoided. Much interest has also grown for the fungi present in indoor environments, since exposure to airborne biological agents in both the occupational and residential environments could be associated with a wide range of adverse health effects with major public health impact, including infectious diseases, acute toxic effects, allergies and cancer. An interactive identification tool was created for food- and airborne microfungi at the genus and/or species level, based on morphological and physiological data, using the software FRIDA. The interactive key can also be stored on CD- or DVD-roms, or used on media such as PocketPCs of Smartphones. Our key allows the identification of 59 genera/groups and 217 species belonging mainly to Zygomycota and anamorphic and teleomorphic Ascomycota. The database comes with a set of detailed descriptions of each genus and species, a rich archive of images, a glossary of the most frequent mycological terms, and references to descriptions; in addition, culture condition requirements for identification are provided.

Index Terms — Airborne fungi, food spoilage, fungal identification, indoor fungi, interactive keys.

1 Introduction

Today a growing interest of microbiologists is turned to the study of fungal contaminants of food and air. The growth of fungi may result in several kinds of food-spoilage: off-flavours, discolouration, rotting and formation of pathogenic or allergenic propagules. Moreover, many foodborne fungi produce mycotoxins, and thus fungal growth in foods and feeds should be avoided [1], [2], [3]. In the last decades, much interest has also grown for the fungi present

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in indoor environments, since exposure to airborne biological agents in both the occupational and residential environments could be associated with a wide range of adverse health effects with major public health impact, including infectious diseases, acute toxic effects, allergies and cancer [4], [5].

Although food- and airborne fungi, producing toxins or which cause health hazards, are ubiquitous and belong to the common contamination flora, their recognition is hampered by an incomplete and often confusing literature [1]. Besides, the still poor understanding of many taxonomical groups and the high degree of pleiomorphism in response to environmental changes call for endless floristic, taxonomic and nomenclatural updating.

Moreover, in most of the available books for the identification of fungi the layout follows a hierarchic approach mainly based on classification; hence this approach requires a deep theoretical and practical knowledge of mycology. Even more than for other organisms, therefore, for fungi computer-aided systems are important for the handling of data useful in their identification and as flexible as possible, not necessarily founded on traditional systematic criteria.

We have created an interactive tool for the identification of food- and airborne microfungi at a genus and/or species level. This computer-aided tool can provide access to and simplify the study of fungi by various kinds of users: mycologists, but also those concerned with environmental hygiene (i.e. microbiologists employed in food or pharmaceutical industries), those seeking to create interactive floras, those concerned with the management, planning and conservation of natural resources, and teachers at each educational level.

2 Software

Our interactive identification tool stems from databases created on the basis of morphological, physiological and ecological data of each taxon, using the program FRIDA [6]. Procedures and functions are written in PL/SQL language, running on a Oracle Database engine. FRIDA is flexible, its use does not require the learning of any programming language nor the use of codes to input information and can automatically generate both interactive identification tools, accessible online, and traditional paper-printed identification keys. The keys can be immediately published in the web, and an accessory software was developed to store stand-alone versions on CD- or DVD-ROMs, PDAs (Personal Digital Assistants), and smartphones.

As with most programs for interactive identification, the keys produced by FRIDA are based on a hierarchy of characters, taxa being separated on the basis of those come first in the hierarchy. In our keys, characters are ranked according to the simplicity of observation: macroscopic features of colonies, type of mycelium, presence of ascomata or zygospores, aspect of conidiophores, conidiogenous cells and conidia, etc.

3 The food- and airborne fungi database

The system has produced an interactive key to food- and airborne microfungi which allows the identification of 59 genera and 217 species belonging mainly to

Zygomycota and anamorphic and teleomorphic Ascomycota. The database has detailed descriptions of each genus and species, coupled with a rich pictorial archive of macroscopic and microscopic characters, a brief introduction to the features of the main fungal phyla, explanations of how to cultivate and examine fungi preparing microscopical slides, a glossarium of the more cited mycological terms, and references to descriptions and culture condition requirements.

The interactive keys are usable in two different ways [7]: 1) a simple identification tool based on a traditional dichotomous system, in which the user selects between two options which are explained by means of descriptions, pictures and drawings of the different characters (Fig. 1), 2) a multi-entry query interface in which the user can operate simultaneously a non-hierarchical choice of one or more different characters; FRIDA will select all the taxa with the selected (tagged) characters, and for them it will produce a dichotomous key coupled with pictures of each taxon.

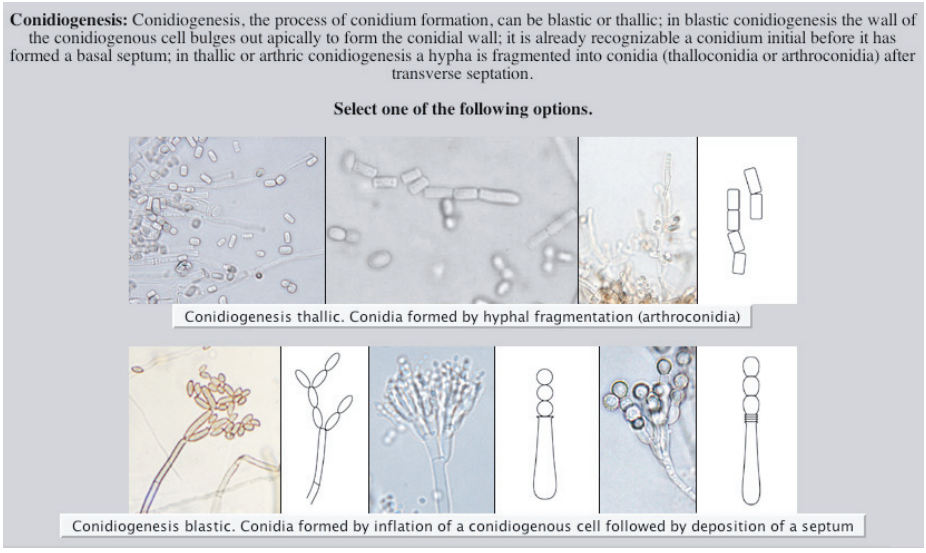

Fig. 1 – Example of a dichotomous key in which the selection between different options is supported by pictures, drawings and descriptions of the most difficult terms.

At the end of an identification process, the system displays a taxon (genus/species) page, reporting the scientific name, a description, and any other information the author has stored in the system (habitat, micotoxins, etc.), as well as an image, and a link to all the images of the same species stored in the image archive. Another important tool of FRIDA is the possibility to insert in the database geographical and ecological data, physiological features, data on the association of a fungus to peculiar substrates, etc. These data can be used to create “filters” which are specific identification pathways encompassing only the species which share the selected character. The “filters” are very useful, since they simplify the identification pathway by reducing the set of species included in a key.

4 Discussion and Conclusions

Since contamination of fodder and foodstuffs and inhalation of propagules suspended in the air exposes people and animals to health risks because of the presence of species producing toxins and MVOC or causing allergies or infections, the use of our key could be useful for biologists working in local health units and similar organizations, as well as in the checking of quality control and environmental hygiene. The prevention of fungi that contaminate indoor environments and cause food spoilage can only be carried out successfully, if the fungal species are known [1]. Knowing the properties of the contaminant species makes it possible to optimize the preservative profile of the food and the hygienic measures in the indoor environments.

However, the identification of these microfungi by means of traditional methods still remains problematic, and exclusively accessible only to a small number of experts. Computer-aided tooks can create a revolution, since they use, in a multi-dimensional way, a wealth of morphological and physiological data, plus the ecological information usually hidden in the large ocean of scientific literature. Traditional keys have several drawbacks that can be avoided by computer-aided tools [7]:

1. Being printed on paper, their content is frozen and hence nomenclatural-taxonomic changes and the discovery of new species render them rapidly outdated. Computerised systems, on the contrary, can be updated and corrected in real time.
2. Traditional keys are rigid. They contain a huge amount of information which is fixed into the format and the logical structure selected by the author. Computerised tools permit to reduce the set of organisms using different combinations of morphological, physiological, ecological, distributional characters i.e. special habitats, mycotoxin production and physiological features (temperature, water activity, pH…).
3. Databases are accumulative. A small database can be the starting point for future expansions.
4. Outputs can be edited in several different formats, from simple texts to illustrated books.

In conclusion, our key, especially if integrated with existing systems based on physiological and molecular criteria, could promote the identification of this important group of organisms even by unskilled persons who lack specific mycological expertise.

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