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Impact of information technology on future floras

Abstract

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Some important facilities offered by the information technology to innovate the development of traditional floras are illustrated and discussed. These include: random access interactive tools for the identification of species, low cost, easy updating, virtually unlimited space for high resolution images and texts, on-line utilities, strong synergy between authors and users. It is argued that the combination of printed books with integrated digital utilities and data-sources is the most desirable structure for future floras.

Introduction

In plant taxonomy, classification aims at reconstructing an evolutionary history, which is usually represented by means of phylogenetic trees. One of the first examples of hierarchical classification of the living organisms is provided by the Tabulae Phytosophicae, created by Federico Cesi about 400 years ago. The goal of the dichotomies of Federico Cesi is actually the same of the bifurcations of a modern cladogram, i.e. the ordination of groups of living organism on the basis of their reciprocal similarities and relationships.

Until a recent past, the analysis of the objects to be classified was essentially based on their outer look, and groups were made on the basis of observable features, but the adoption of cytochemical and molecular analyses has made modern taxonomy less and less based on morphological criteria. As a consequence, the classical dichotomous keys are getting more and more unfriendly to the user, at least for the higher taxonomical ranks. See, for instance, the morphologic heterogeneity of the plant genera which are currently ascribed to the families *Plantaginacee* and *Caprifoliacee* in the APG classification (www.mobot.org/MOBOT/research/APweb/).

In the last two decades, many changes took place, not only in the systematic approaches to the classification of plants, but also in the number and kind of potential users of such classification. The increasing popularity of the "wilderness experience" and the raised public concern on themes like the conservation of biodiversity and ecosystems, of which vascular plants are the most visible part, created a new demand for qualified botanical information from a number of non-specialists, for educational, recreational and commercial

purposes. Unfortunately, the enthusiasm of non-specialists seldom matches a sound botanical knowledge, mainly for the following two reasons: the use of a classical flora is too difficult for a beginner and in most cases popular floristic books do not offer complete and updated information enough on the flora of any given place.

Information technology offers a number of facilities to make easily accessible authoritative and updated floristic information to a wide readership. In the following paragraphs, some functions and possibilities offered by interactive digital tools to the authors and users of a flora will be commented.

Classification and identification

The approach followed by the classification of species is hierarchical; it is based on current phylogenetic hypotheses, and the tools traditionally used for the identification of objects are dichotomous keys, which are rather coherent with the bifurcations of phylogenetic trees.

The word "classification" has been often used as a synonym of "identification", but the meanings of the two words are different, since an identification procedure just aims at finding the name for a specimen, eventually in order to get information on it. Therefore, "identification" is a more comprehensive term: the process behind must not necessarily be hierarchic, nor based on phylogenetic hypotheses, and it is polytomous, meaning that all diagnostic characters do have the same rank and there are many ways to start the identification procedure.

In the case of vascular plants, there are many ways to identify a specimen. One possibility is to trace back to its origin by following the bifurcations of its phylogenetic tree, but this is not always the easiest and quickest one. For instance, plant species can be ordered on the basis of the chromatic differences of the flowers, or according to the shape and integrity of their petals. There are several possibilities, not necessarily based on morphologic characters, but also on "fuzzy" criteria, like the preferred habitat types, or the geographical distribution. Each single attribute leading to an ordination of the objects, even if not relevant from the phylogenetic viewpoint, or too "feeble" for dichotomous keys, can represent a useful criterion for the identification of plant species.

Random-access interactive tools

Bulk of the knowledge on a certain species can be broken down and organized into non-hierarchical categories by means of fields and variables implemented in a database. Through the simultaneous combination of different attributes the universe of species belonging to any flora can be easily split into smaller groups, which makes the identification procedure easier and faster. The combination of different queries facilitates the identification of a species through many possible ways, depending on the user's choices instead of the current phylogenetic hypotheses.

Starting from this basis, many interactive identification tools have been developed, during the last 30 years. The oldest one is the Australian system of softwares named "DELTA

Intkey", which started to be developed in 1971. It has been applied in many countries and for different groups of organisms (http://delta-intkey.com/). Another example from Australia is "LucID", developed at the University of Queensland, and particularly used for educational products like the interactive CD for the Identification of endangered Australian plants (http://www.lucidcentral.org/). In Europe, the Dutch package "IdentifiIT" has been used to implement the Interactive Flora of NW Europe (http://nlbif.eti.uva.nl). In the USA, "MeKA", created at the Berkeley University, is a useful tool for the identification of biological specimens, but not only: its very first application was an interactive identification tool for Ukuleles (http://ucjeps.berkeley.edu/meacham/meka/)!

In Italy, the software FRIDA has been created at the Biological Department of the University of Trieste, and it is currently applied in the project Dryades, counting many applications on vascular plants, but also on fungi, lichens and algae (http://www.dryades.eu/).

A quite complete and recently updated list on the "Programs for interactive identification and information retrieval" was published by Dallwitz (2007), the inventor of the Delta Intkey System.

Information technology and Floras

Floras are the most important tool for the identification of species and filing of information on the plant taxa living in a certain region. For about three centuries, they have been firmly clung to the encyclopaedic tradition of the eighteenth century, which conceived them as a catalogue of species, arranged in systematic categories (genus, family, order, class) and accompanied by dichotomous keys, descriptions and illustrations. Most of the oldest floras are still remembered for their accurate and rich iconography, but in the long run the tradition of botanical drawings has faded away, and the illustrations of modern floras tend to be more deficient than in the past. As a consequence, floras became, over time, more and more stuff for specialists. Paradoxically, while many efforts were done to make the knowledge accessible to everybody and to stimulate the public interest on scientific themes, floras progressively thinned out the iconography and decreased the length of the descriptions of species, becoming definitely unappealing to the beginners.

On the other hand, little efforts have been made to integrate the morphologic descriptions in the floras with information on species biology and ecology, so floras do not seem to be encyclopaedic works any longer, because they do not include all the available information on any given species; rather they look like unpractical handbooks where to find a name for herbarium specimens and, whenever possible, some general notes on the species distribution.

Some important facilities offered by the information technology to innovate the planning out of traditional floras are discussed below:

Classical dichotomous keys can be flanked by random access interactive tools, which can help non-expert users in identifying specimens, so to reach the available information on a given species.

In traditional floras, the Linnean name is the only way to designate unequivocally a certain species. The Linnean nomenclature is based on a phylogenetic classification that is subject to frequent changes in consequence of the recent advances in phylogenetic research (Nimis, 2001). In the interactive classifications tools, the Linnean name is just one of the variables that are used to define an object and it can be easily updated without changing the structure of the identification tool. With reference to the Italian flora, the numerical codes proposed by Pignatti in 1978 are an example of remarkable far-sightedness, but they have reached a real utility after the diffusion of personal computers and scientific databases.

All traditional floras are bound by the limited space of printed pages. A significant advance towards the satisfaction of the non-expert readership can be made by supplying the text with images and glossary. Information technology provides virtually unlimited space for high resolution images and texts. Moreover, concepts and terminology can be commented and/or illustrated by on-line utilities, like glossaries or illustrative tables. This will hold the encyclopaedic tradition of floras forever.

Due to high editorial and publishing costs, traditional floras are conceived to keep on the market for at least a decade, before being replaced by a new edition. A digital flora or digital complements of a printed flora can be frequently updated at reduced editorial costs and publishing is practically costless. The updates can be made regularly available on-line, e.g., to all registered users. This is an optimal condition for open-ended works, like floras are per definition.

A digital flora (or its digital complements) can be linked to many websites, including regional data banks on georeferenced floristic records and map services. The accessibility and connectivity of a digital flora is much higher than in a traditional flora, so that authors and users can interact on-line very easily, to create contents, share knowledge and improve the performances of the digital archives and data bases.

Discussion

Information technology offers many possibilities to innovate the planning out of a traditional flora in all its fundamental parts: keys, descriptions, illustrations and updates.

The future challenge for the authors of floras is to balance innovation and tradition in the best way. There is no doubt about the importance of books and the documentary value of printed paper. No doubt, as well, on the pleasure that to leaf through a book still gives to the reader. No doubt, a handy field flora on paper is still more practical and safe in the field than any electronic equipment using internet technology. No doubt there are still people not hanging on the internet all the time. But the most recent information on plant species (digital images, georeferenced records, polytomous keys...) cannot be regularly added into traditional flora volumes only.

The combination of printed books with integrated digital utilities and data-sources is the most desirable structure for future floras, “integrated” meaning that printed and digital contents should support each other without overlaps. The second edition of the Pignatti’s flora

of Italy will try to comply with this strategic vision: a software, called FID, that means Flora Italiana Digitale (Italian Digital Flora), has been constructed and designed to integrate the second edition of the Pignatti's flora, which is expected to be published by the end of 2010. The FID will link together interactive polytomous keys, an on-line thesaurus, illustrations and one template per each single species, including a distribution map (referred to the Italian regions), ecograms, a text-box and up to 24 high-resolution colour images.

Up to now, the digital components of the second edition of the Pignatti's flora are the result of the cooperation of more than 140 people, who provided information and contents for the flora. One relevant point is the direct involvement of secondary schools for testing polytomous keys and usability of the contents. A second relevant point is the lack of sponsors and their material, so that all the contents will not only help in presenting and making more accessible information on the plant species, but they will also celebrate the praiseworthy synergy of people sharing the same passion for the beauty of the floristic research.

We do hope that similar initiatives and future developments of the FID will help in filling the gap between the instruments and techniques currently used for the promotion of commercial goods and those commonly used for the enhancement of biodiversity and natural ecosystems, that, even if not tradable, greatly contribute to improve the quality of our lives.

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