Mediterranean lichens on-line

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Summary

Grube, M. & Nimis, P. L.: Mediterranean lichens on-line. – Taxon 46: 487-493. 1997. – ISSN 0040-0262.

In the frame of a project of the OPTIMA Commission for Lichens, a workspace has been created on the Internet for the compilation of a checklist of Mediterranean lichens. The World Wide Web now offers quick access to the lichen checklists of several countries, and facilitates the coordination of future work through a common format of data presentation. As a first step, the checklists were placed on the Web as plain text files, except for the lichen data from Slovenia, which are organized in a relational database. Placing new information on the Web is equivalent to a kind of publication, which raises some issues which need being discussed.

Introduction

Checklists, defined as sufficiently exhaustive inventories of taxa in a set of Operational Geographic Units (Crovello, 1981), often include basic biodiversity data. They are indispensable for retrieving the vast amount of information that has accumulated through centuries of research. They provide a basis for specimen identification, for critical re-appraisal of poorly known taxa, and for focusing exploration on poorly investigated areas. In the past, one used to publish at intervals updated and improved lists, biodiversity assessment being an open-ended task. The best proof for a checklist to have fulfilled its mandate in serving the scientific community is its soon becoming outdated.

The advancing technology in the field of interactive data access and retrieval is providing scientists with new, powerful tools and entails a genuine revolution in data availability. The spread of the Internet, the advent of the World Wide Web, and recent progress in the development of Web servers and Web browsers have eliminated all major obstacles to the creation of on-line databases. Several herbaria already grant access to information on their holdings via the Web, examples in the lichenological field being the lichen type specimens register at the U.S. National Herbarium (Anonymous, 1997), the lichen herbarium inventory of the University of Oslo (Timdal, 1997), and the lichen database of the Fytoteket in Uppsala (Anonymous, 1996). A further new online research tool is "LIAS" (Rambold, 1996), a taxonomic information system based on the DELTA format (Dallwitz & al., 1993), aimed at standardizing taxonomic data for a wide range of lichens and lichenicolous fungi. DELTA formatted data can be transformed into natural language descriptions of taxa, or used to generate computerized (interactive) identification keys. For expert input via file transfer protocol (FTP), so-called LIAS modules are available as specific files.

It is nowadays cheap and easy to interconnect databases, thus enabling continuous on-line interaction among different centres. "Publication" of a product updated on-

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line by a permanent flow of new information is the spot-on solution for open-ended biodiversity inventories.

In this paper we outline a major project centred on publishing, updating and critically revising distributional data on lichens and lichenicolous fungi of the Mediterranean region, by means of the Internet and discuss some open problems originating from the completely new way of "publishing" offered by the Internet.

The OPTIMA lichen checklist project

An international project was launched in 1989 by the OPTIMA Commission for Lichens, aimed at the compilation of an overall checklist of Mediterranean lichens and lichenicolous fungi. The *Lichen Med-Checklist* was envisaged as an open process, involving several stages with increasing levels of accuracy. As a first step, individual checklists are compiled for all Mediterranean countries (or major subdivisions of countries), from Macaronesia through North Africa and southern Europe to S.W. Asia (see Nimis, 1996). For every country, a Regional Adviser has been appointed, to filter relevant information, contact other lichenologists if necessary, and compile the corresponding list. Also, several specialists of given taxonomic groups have been designated, to provide original data and critical remarks. By 1996, lists for the following countries have appeared in print: Israel (Galun & Mukhtar, 1996), Italy (Nimis, 1993), Macaronesia (Hafellner, 1995), Morocco (Egea, 1996), Turkey (John, 1996), Tunisia (Seaward, 1996), and Ukraine (Kondratyuk & al., 1996). Checklists for other countries are in preparation, several to be published in 1997.

The editing of a volume with five regional checklists (Nimis, 1996) was an instructive test run for this kind of product: upon submission of the manuscripts, several authors almost immediately asked to update their checklists by adding new data. Clearly, any such checklist was to be out of date by the day it was published, calling for continuous updating and immediate access to the updated product by the scientific community. A working space on the Internet was therefore created for the *Lichen Med-Checklist,* and presently seven national checklists (for Israel, Italy, Morocco, Slovenia, Tunisia, Turkey, and the Ukraine) are available on-line (Grube, 1996). Some of them (e.g. that of Italy) already differ conspicuously from the printed original version. The checklist for Slovenia has never appeared in print.

Mediterranean lichens on-line

As a first step, the checklists were put on the Web as plain text files. The possibility of remote access to or downloading of simple text files is already a substantial progress. With the aid of Web browser functions and word processing programmes, such files can be used in a limited way as simple, searchable databases. Starting from the master page, one can access the lists for individual countries by clicking on a map, or by hypertext links. Large checklists, as for Italy, are segmented for quicker access. The head pages for individual countries include links to a literature reference document, to the email contact with the regional coordinator, and to an entry form for additions, corrections and critical comments for anybody's use (Fig. 1). However, only the coordinators, who critically filter the flow of new information, are authorized (by password) to implement changes in the checklist. They are also responsible for regular backups, to avoid eventual information loss.

To increase flexibility of access, the checklist data are now being transferred to relational databases linked to the Internet, a move that has already been implemented for the checklist for Slovenia (see Table 1). By means of a query form everyone can freely search the database. We used the relational database management system ORACLE, already adopted for the botanical information system SysTax (Hoppe & Boos, 1996) and for the lichen database of the *Red list of lichens of Switzerland* (Wey, 1996). The ORACLE Web server, which can be accessed through any of the standard Web browsers, provides an interface to the Slovenian database. In the data model used, only the floristic (FLO) and geographic (GEO) data tables (see Table 1) are unique to the checklists for a particular country, whereas the ecological (ECO) and taxonomic (TAX) tables contain general, taxon-linked information. It is also possible to introduce links to data from outside sources, e.g. the ecological indicator values proposed by Wirth (1992), or the resources of a geographic information system (GIS).

Future developments

A distributed database is planned next, to provide quick and easy access to complex information via the Internet (see Green, 1994). It will comprise multiple databases physically located at different nodes and accessible individually, each ideally with its own coordinator. Data from local databases will be merged to produce an
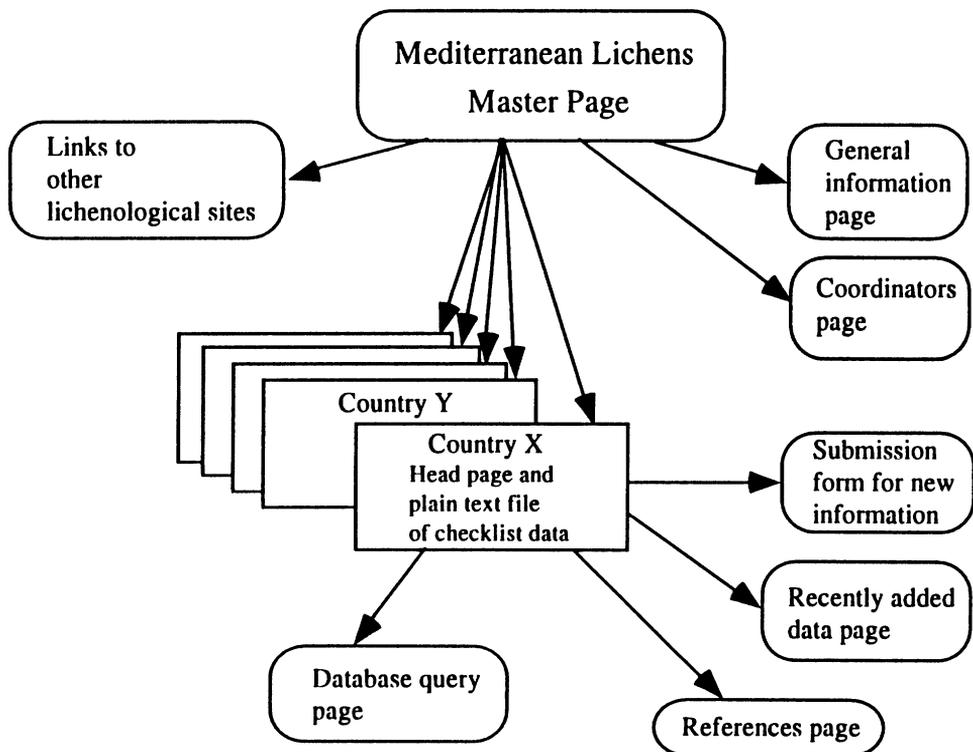

Fig. 1. Links in the Mediterranean lichen Web pages.

Table 1. Tables of the Slovenian lichens database.

Table	Content	Validity range	Fields
FLO	floristic information	local	species grid locality reference rem_vouch date
GEO	more detailed geographic information for localities, especially old synonyms of literature data.	local	grid department locality altitude coordinates old_names remarks date
ECO	ecological information for species	general	species light temperature humidity toxitolerance remarks date
TAX	taxonomic information for species	general	species author reference synonyms remarks date

overall checklist of lichens for all Mediterranean countries. The data flow for the generation of the overall list in a distributed database model is outlined in Fig. 2.

The automatic merge of the regional databases will require the application of standards, ideally those adopted by the Taxonomic Databases Working Group (TDWG, see Hollis & Brummitt, 1992) such as were developed by Hollis & Brummitt (1992) for geography, Bisby (1995) for names, Brummitt & Powell (1992) and Kirk & Ansell (1992) for authors' names, the ITF standard (IUCN-elements) for conservation status and reliability of information, and the POSS standard for occurrence status. Elements from the data models set up by the Common data structure for European floristic databases project (CDEFD; Berendsohn & al., 1997), and the International Organization of Plant Information (IOPI; Berendsohn, 1997) will also be considered.

In a distributed database model, agreement on certain points must be enforced (Green, 1994), the most important being data consistency. The data in the Mediterranean lichen checklists are not yet consistent, due to different sources of information and unsettled taxonomic problems. By using the common framework provided by Web pages, efforts to achieve a balanced and uniform data format can be more easily coordinated. Taxonomic and nomenclatural consensus will be achieved through a small working group operating under the authority of the OPTIMA Commission for Lichens. Once standardized data for all countries is available in a distributed data-

base, consistency checks can ensure that errors are filtered out. Correct orthography and format of name entries will be achieved by automated comparison with a standard thesaurus of names prepared by the above-mentioned working group. As soon as a common data format is approved, the current checklist data, including those for Slovenia, will be imported into databases supporting the agreed standards and will be linked with morphologic and taxonomical data produced by the LIAS project, eventually permitting the generation of on-line interactive identification devices for any species included in one of the checklists.

Problems

The publishing of continuously updated on-line databases brings about several problems, some yet unsolved.

Clear copyright and citation regulations are wanting. Meanwhile, information already published elsewhere should not be made available via the Internet except by prior permission of the authors and publisher and the source should always be cited. The citation of on-line publications, which are subject to ongoing changes, must be standardized. In molecular biology, items from gene databanks are commonly cited, and inclusion of gene sequence data in recognized databases is a standard pre-publication requirement for articles in that field. However, gene databank entries differ from on-line checklists (Bilofsky & Burks, 1988): by being reasonably constant rather than perpetually changing. The accurate citation of a Web page must therefore include the date at which it was accessed, in conformity with the standards of the American Psychological Association (Anonymous, 1994) and Modern Language As-
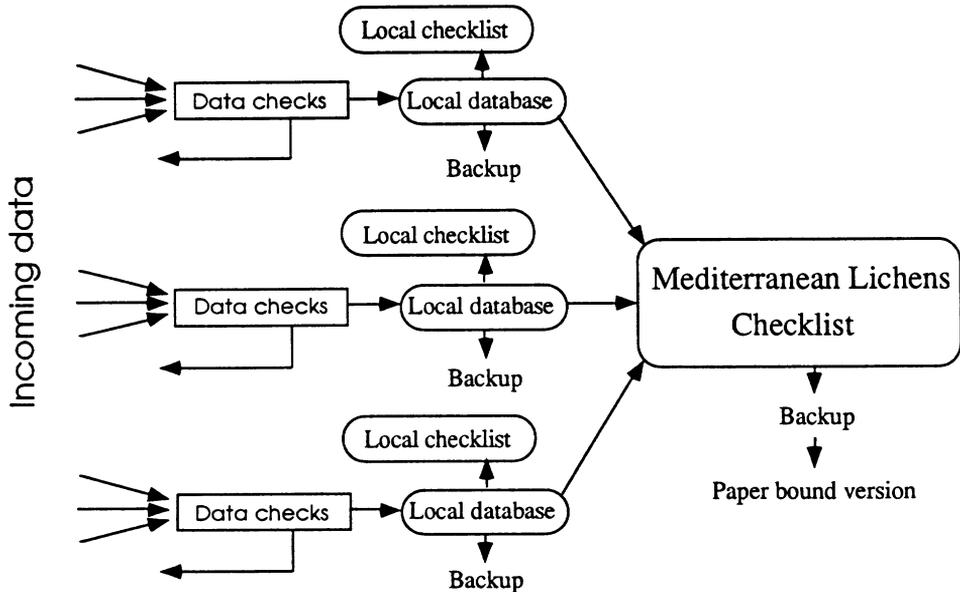

Fig. 2. Data flow for the generation of the Mediterranean lichens checklist by automatized merge. Information in rounded boxes is being made available via the Internet.

sociation (Gibaldi, 1995). Even so, two important problems remain: addresses on the Web are subject to change, so that the citation of an given address, correct at a given time, may become unworkable later; and even if the address remains unchanged, it is often impossible to retrieve the state of the information present at an earlier date. Even with the specification of a given date, Web citations may thus be inadequate for referencing purposes; we suggest that, in addition, they should state the location of a static representation of the data, either as a backup on a compact disk (CD) or as a printout. The lichen checklist data will be backed up regularly on CD, and any Web citation should mention the corresponding backed-up version of the data.

Data quality considerations might well become a controversial issue. A review process for scientific Internet publications should be considered. Information already published in printed form has often undergone prior peer review and, if so, can be placed on the Web without problems of quality. When new information is placed of the Web, the quality control issue becomes relevant. We propose that authors of checklists seek approval by a recognized specialist prior to publishing on-line, and acknowledge the specialist's advice explicitly. Our own checklist pages are also subjected to an inherent review process by the local coordinators.

A further important requirement is that the location of voucher specimens be mentioned (in the field REM-VOUCH of the FLO-table), to enable later checking of the information source. We will of course refrain from placing the names of new taxa, or potential new combinations, on the Web, unless and until, in a future *International code for botanical nomenclature,* the definitions of effective publication be amended to include on-line electronic information.

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