*Cortbase version 2 – extensive updates of a nomenclatural database for corticioid fungi (*Hymenomycetes*)*

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Abstract

Cortbase is a nomenclatural database for corticioid (resupinate) fungi (*Corticiaceae* s.l. and related hymenomycetes) with basionyms, synonyms, taxonomically correct names, data on name usage, literature references, and evaluation of nomenclatural status. It is available as an on-line service (http://andromeda.botany.gu.se/cortbase.html) and as an MS-DOS executable for local installation. The database includes 8112 species names; of the 4412 basionyms included, 2101 represent taxonomically acceptable species, 1434 are heterotypic synonyms, and 877 are of uncertain application. The improvements over the previous version include the new, platform-independent on-line search interface, some 800 more corticioid names, numerous additions to the existing data, and six new categories for searching, including searches for location of type specimens and for authors of species names.

Introduction

As traditionally perceived, corticioid fungi (*Corticiaceae* s.l.) form a group of higher fungi (*Basidiomycota*, *Hymenomycetes*) characterized by resupinate fruiting-bodies with a smooth, spiny, warted, or folded hymenophore (Figure 1). Most corticioid fungi are saprotrophes, typically on dead wood, but alternative or complementary nutritional modes, such as symbiotic relationships with higher plants and zoo parasitism, have also been recorded. Good overviews of corticioid fungi are provided by Larsson, Larsson & Kõljalg (2004), Binder et al. (in press), and Parmasto (1986).

The group manifests considerable morphological variation in nearly all respects amenable to measurement or quantification, and the delimitation of the group has since long been a matter of debate (Jülich, 1981; Parmasto, 1986). The family was early on suspected to be artificial (Donk, 1964), and this has been borne out repeatedly in modern phylogenetic studies (Larsson, Larsson & Kõljalg, 2004; Hibbett & Binder, 2002); as molecular studies are beginning to unveil the full complexity of the *Hymenomycetes*, it has gradually become clear that *Corticiaceae* is polyphyletic to an extent rarely seen before in any organism group. With corticioid fungi emerging interspersed amongst non-corticioids in almost all major clades of the *Hymenomycetes*, the notion of corticioid fungi should today be taken to refer to little
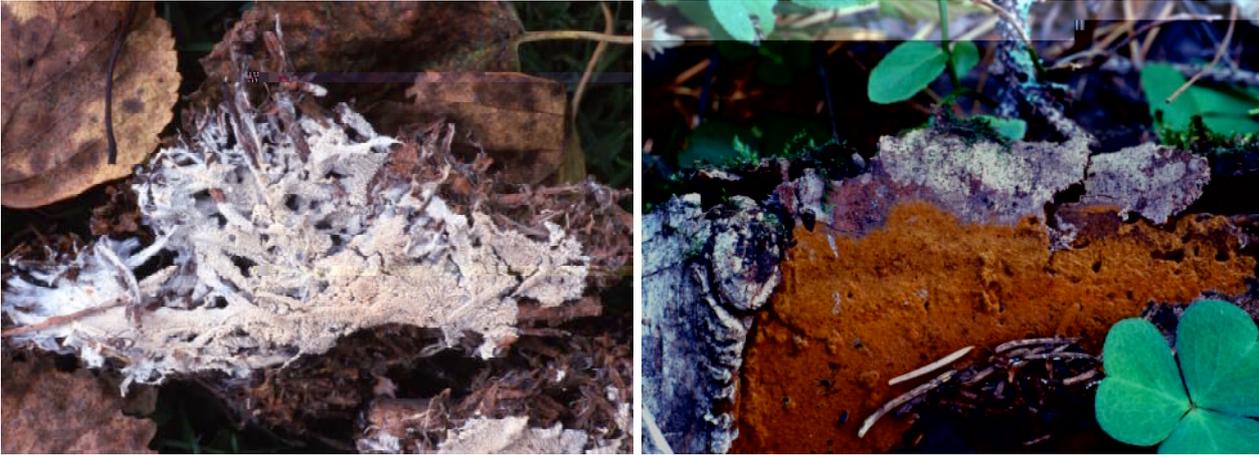
Figure 1. *Trechispora kavinioides* (left) and *Tomentella bryophila* (right), two of the species in Cortbase.

more than a convenient label for an assemblage of similar life forms.

More than 1420 species of corticioid fungi described since 1753 have been synonymized later, and over 870 corticioid names are of uncertain or unknown application. Many species have been combined under several genera; in numerous cases, incorrect author names and erroneous citations have been used in later publications. These and other complications render taxonomic work with corticioid fungi an arduous process, repeatedly calling for name verifications, retrieval of old or otherwise inaccessible literature, and comparison and verification of the literature information itself. To facilitate the process, Parmasto (1997) compiled detailed information on the nomenclature and taxonomy of 7333 corticioid names, presenting the result as a stand-alone database for MS-DOS systems.

The many recent molecular studies of fungi have paved the way for a more elaborate understanding of corticioid fungi and their systematics. Cortbase has been updated to account for the new disclosures, now covering over 8100 corticioid names and more than 4400 basionyms. While the functionality of the MS-DOS version remains the same, a novel, on-line implementation of Cortbase is presented (http://andromeda. botany.gu.se/cortbase.html). It introduces many new search options and ways of compiling and combining information. Both versions are publicly available free of charge; in case of Internet inaccessibility,

the MS-DOS version can be provided on floppy disk by the corresponding author at a price covering handling and postal fees.

Systems and Methods

The mycological data residing in Cortbase have been collected over an extended period of time. The data cover *Corticiaceae* s.l.; additionally, species of other fungal groups, have they been associated with the family in the past, are included as seen fit. For a more elaborate account on the bases for judgment on and explanation of the Cortbase data and data coverage, see Parmasto (1997).

The specifics of the MS-DOS version are described in Parmasto (1997) and remain the same apart from the update of the mycological information. To create an on-line version, the mycological data was imported into a local MySQL database (http://www.mysql.com), the structure of which is shown in Appendix 1. Dedicated search scripts to query the database were written in Perl 5 (http://www.perldoc.com) using the DBI package (Descartes & Bunce, 2000) for communication between database server and search scripts. The scripts were designed to run as CGIs under the Apache web server (http://httpd.apache.org) on a Red Hat Linux server (http://www.redhat. com).

Apart from giving an introduction to Cortbase and providing a link for downloading the MS-DOS version, the main

| Name of function	Description of function
Check a name	*This function returns data on a species name, including its author and the corresponding citation. The basionym and the taxonomically correct name are specified where known.*
Data on a species	*This function returns full data on a species. In addition to providing information on the basionym and taxonomically correct name, it also lists all homo- and heterotypic synonyms, including data on type, anamorphs, sanctioning, time periods for name usage, and nomenclatural status (validly published or not, legitimate or not). In cases where a species has been synonymized with another one, the mycologist proposing the synonymization is specified.*
List accepted and rejected species in a genus	*For any given genus, this function lists, in turn, all accepted species, all rejected species, and all species that at some point have been assigned to the genus but which presently are of unknown systematic affiliation or status.*
Check herbarium for type specimens	*This function lists the types kept in any of the 147 herbaria and collections covered by Cortbase.*
Names by an author	*This function lists all names authored by a specified author. Adherence to internationally accepted author abbreviations (Brummit & Powell, 1992) is expected.*
Suggest species from [partial] epithet	*This function returns all species names where the input word matches the species epithet or forms a subset thereof.*
List all genera in the database	*This function lists all genera in the database.*
List all species with types marked 'In need of restudy'	*This function lists all type specimens that are in need of restudy.*
List all valid basionyms with no data on type	*This function lists all valid basionyms with no data on type. It is hoped that this function together with the previous one will serve to attract attention to areas of corticioid mycology where even small efforts will be of great value.*

Table 1. Functions of the on-line version of Cortbase.

page (http://andromeda.botany.gu.se/ cortbase.html) is the place where the on-line version of Cortbase can be accessed. The page collects the input from the user and directs it to the corresponding Perl script, which parses the input and relays it to the MySQL server with relevant arguments. All matches pertaining to the query are retrieved, and these matches, where appropriate, serve as seeds for complementary queries. The search result is returned to the script, which parses and formats the data. A result page is generated and returned to the user's screen. Error handling, support for multiple hits with the same name, and partial support for weak matches of the user input (such as

Hyphodermum setigera instead of the correct name *Hyphoderma setigerum*) are implemented.

Implementation

The on-line version of Cortbase features nine possible search options: CHECK A NAME, DATA ON A SPECIES, LIST ACCEPTED AND REJECTED SPECIES IN A GENUS, CHECK HERBARIUM FOR TYPE SPECIMENS, NAMES BY AN AUTHOR, SUGGEST SPECIES FROM [PARTIAL] EPITHET, LIST ALL GENERA IN THE DATABASE, LIST ALL SPECIES WITH TYPE MARKED AS 'IN NEED OF RE-STUDY', and LIST VALID BASIONYMS WITH NO DATA ON TYPE
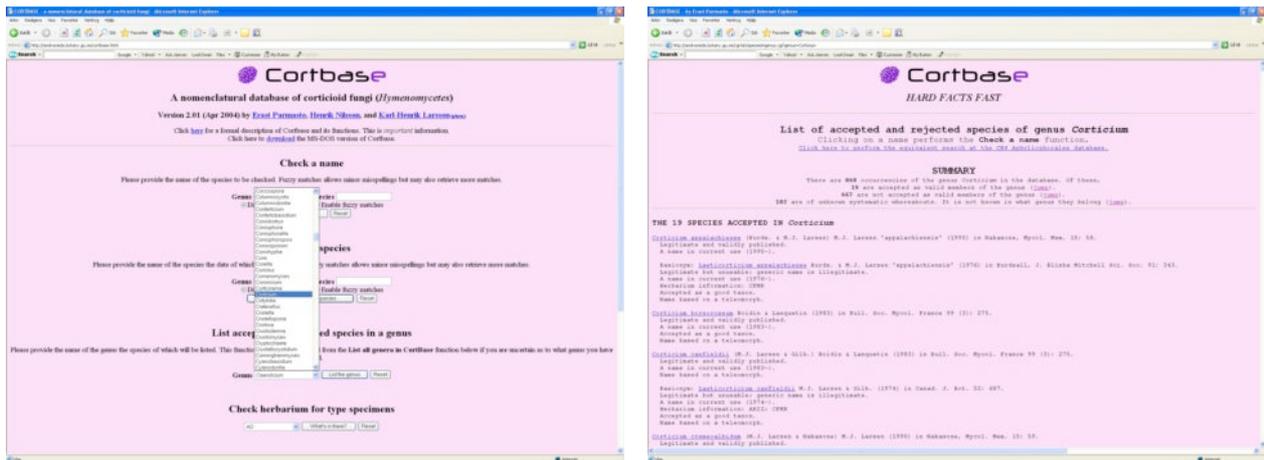
Figure 2. The on-line user chooses to list the complex genus *Corticium* (left). The output (right) consists of a list of all accepted, rejected, and uncertain species names of the genus.

(Table 1). For the four entries CHECK A NAME, DATA ON A SPECIES, NAMES BY AN AUTHOR, and SUGGEST SPECIES FROM [PARTIAL] EPITHET, the user is given text fields where to type the relevant search string. The other search options are provided with pre-defined values presented in pull-down menus for quick selection (Figure 2).

In common for all nine search options is an extensive interlinking to facilitate rapid information retrieval of nested matches; for example, when listing accepted and rejected species in a genus, all species names are linked to the CHECK A NAME function, the result of which in turn is linked to DATA ON A SPECIES. Where applicable, each search run is provided with a link to the corresponding search in the *Aphyllophorales* database at CBS http://www.cbs.knaw.nl/databases/index.htm. For a discussion of the terms relevant to interpretation of nomenclatural and taxonomical information (such as sanctioning, periods of name usage, and taxonomically correct names), the reader is referred to Parmasto (1997).

Discussion

The past few hundred years of mycological research have left in their wake a plethora of fungal names, some of which are used still today, but most of which are not. The mounting of fungal names and information on name changes, further accelerated by molecular techniques, is the result of a continual striving for correctness and completeness. Given the role of the species as the basic unit in systematic biology, it is in the interest of the sound advancement of the latter that we take every step feasible to ensure and maintain a correct species taxonomy and nomenclature. Yet, when conferring with older literature, one realizes that it is important to be able to keep track of not only present, but also past, names. Cortbase represents an attempt to account for the nomenclature and, as far as possible, taxonomy of corticioid fungi and to list information relevant to their interpretation and re-evaluation.

Cortbase is a nomenclatural rather than a taxonomic database. Nevertheless, lest the database be of but marginal use to a wider audience, the taxonomically correct name of each record is indicated where known; the "taxonomically correct name" is taken to be the name used in the most recent surveys of corticioid fungi by Hjortstam (1987), Ginns & Lefebvre (1993), Hjortstam & Larsson (1995), and in subsequent papers by the same and other authors. Some fungal names are characterized by lack of consensus or uncertainty as to their correct application, but we have tried to be consistent in using the latest research results – we feel that it would be counterproductive to execute taxonomic rearrangements in the database. In the interest of completeness, the search option DATA ON A SPECIES presents all available names for a record.

Apart from accessibility and platform independence, the chief reason for the partial

migration of Cortbase onto the Internet is the efficiency with which the latter enables integration of data resources and repositories - immense benefits are to be gained through such exchange. Information to further enhance Cortbase includes species descriptions, illustrations, and distribution maps. We share the need for such information with large-scale initiatives like Assembling the Fungal Tree of Life (Lutzoni et al., 2004), UNITE (http://unite.zbi.ee), and Tree of Life (Baldauf, 2002), which to various extent have taken up compiling pertinent data. As a first step we have started to assemble literature references where to find good descriptions and illustrations of basionym taxa. We hope to gradually add new features to Cortbase using our own as well as external data; we welcome usage of Cortbase resources by external initiatives after establishment of initial contact.

The new version of Cortbase is technically significantly improved and features numerous updates of existing information as well as some 800 new additions. This notwithstanding, many fungal names remain to be sorted out, and we would be surprised should there not be any mistakes or errors in the present dataset. We warmly welcome contributions of any form to the Cortbase development, and we extend a plea to everyone who has information relevant to our efforts to contact us.

Acknowledgements

References

Baldauf S. L. 2002. The tree of life is a tree (more or less). *Trends Ecol. Evol.* **17**: 450-451.

Binder M., Hibbett D. S., Larsson K.-H., Larsson E., Langer E. & Langer G. 2004. The phylogenetic distribution of resupinate forms across the major clades of homobasidiomycetes. *Syst. Biodiv.*, in press.

Brummit R. K. & Powell C. E. (ed.) **1992.** *Authors of Plant Names*. Royal Botanical Gardens, Kew.

Descartes A. & Bunce T. 2000. *Programming the Perl DBI.* O'Reilly & Associates, Sebastopol.

Donk M. A. 1964. A conspectus of the families of *Aphyllophorales*. *Persoonia* **3**: 199-324.

Ginns J. & Lefebvre M. N. L. 1993. Lignicolous corticioid fungi (*Basidiomycota*) of North America. *Mycol. Memoir* **19**. APS Press, St. Paul.

Hibbett D. S. & Binder M. 2002. Evolution of complex fruiting-body morphologies in homobasidiomycetes. *Proc. R. Soc. Lond. B* **269**: 1963-1969.

Hjortstam K. 1987. A check-list to genera and species of corticioid fungi (*Hymenomycetes*). *Windahlia* **17**: 55-85.

Hjortstam K. & Larsson K.-H. 1995. Annotated check-list to genera and species of corticioid fungi (*Aphyllophorales*, *Basidiomycota*) with special regard to tropical and subtropical areas. *Windahlia* **21**: 1-75.

Jülich W. 1981. Higher taxa of Basidiomycetes. *Bibl. Mycol.* **85**: 1-485.

Larsson K.-H., Larsson E. & Kõljalg U. 2004. High phylogenetic diversity among corticioid homobasidiomycetes. *Mycol. Res.* **108**: 983-1002.

Lutzoni F., Kauff F., Cox C. J., McLaughlin D., Celio G., Dentinger B., Padamsee M., Hibbett D. S., James T. Y., Baloch E., Grube M., Reeb V., Hofstetter V., Schoch C., Arnold A. E., Miadlikowska J., Spatafora J., Johnson D., Hambleton S., Crockett M., Shoemaker R., Sung G.-H., Lücking R., Lumbsch T., O'Donnell K., Binder M., Diederich P., Ertz D., Gueidan C., Hall B., Hansen K., Harris R. C., Hosaka K., Lim Y.-W., Liu Y., Matheny B., Nishida H., Pfister D., Rogers J., Rossman A., Schmitt I., Sipman H., Stone J., Sugiyama J., Yahr R. & Vilgalys R. 2004. Where are we in assembling the fungal tree of life, classifying the fungi, and understanding the evolution of their subcellular traits? *Am. J. Bot.*, in press.

Parmasto E. 1986. On the origin of hymenomycetes (what are corticioid fungi?). *Windahlia* **16**: 3-19.

Parmasto E. 1997. CORTBASE - A nomenclatural database of corticioid fungi (*Hymenomycetes*). *Mycotaxon* **61**: 467-471.

Column	Description of column
Accno	*Each entry (species name) in the database is given a unique, sequential accession number.*
Genus	*The genus of the entry.*
Species	*The species epithet of the entry.*
Author	*The author(s) of the species name.*
Year	*The year when the species was described.*
Publication	*The publication where the species was described.*
Sanctioned	*(Basionyms only) Species names sanctioned though any of Fries' works are kept track of here (1=1821, 2=1822, 3=1828, 4=1829, 5=1832, 6=1832 index).*
Typus_info	*Additional, miscellaneous info on type; e.g., geographical location of collection spot*
Basno	*The accession number of the basionym of the entry.*
EQBNO	*Used to handle cases where the basionym is a taxonomic synonym; points to the basionym of the correct name.*
EQBSEC	*As above; lists the author(s) who asserted the synonymy of the basionyms.*
EQNO	*The accession number of the correct name of this entry.*
REPLN	*If the entry is a nomen novum, the accession number of the replaced name is kept here.*
Morph	*(Basionyms only) Sexual (T=teleomorph) or asexual (A=anamorph) stage.*
TelBasNo	*As above; if the entry is an anamorph, this field holds the accession number of the teleomorph.*
EQSEC	*(Basionyms only) Reference to the publication / author asserting that EQNO is the correct name for this species.*
Herb	*(Basionyms only) The location of the holotype and any known isotypes.*
TypeStat	*Lists the condition of the type: G=good, U=uncertain (needs re-examination), P=poor, L=lost, N=lectotype not yet selected.*
NomStat	*Nomenclatural status of the name: N=not validly published, I=validly published but illegitimate, R=rejected under this generic name, G=legitimate but unusable (generic name illegitimate), L=legitimate and validly published.*
OldUse	*Name used before 1924.*
NewUse	*Name used 1925-1954.*
NowUse	*Name used 1955-1969.*
CurrUse	*Name used 1970 or later.*
TaxStat	*The status of the taxon: A=accepted as a good taxon, D=dubious taxon, C=confused taxon*

Appendix 1. Cortbase stores the mycological data in a one-table MySQL database, the structure of which is shown here. The left column holds the name of the column in the database, and the right column provides a description of the information stored in that column.