

Open letter to the scientific community of mycologists: “Always deposit vouchers”

To help minimise invalid publication of newly proposed scientific names of fungi, Korf (1995) provided advice on how to guarantee valid publication and offered a few simple guidelines for authors, reviewers, and editors. He regretted that “... many of the errors are committed by highly respected mycologists and published in thoroughly respectable journals”. He further emphasised that “although the ultimate responsibility for publishing correct names lies with authors, clearly reviewers and editors are shirking their duties to advise authors of such errors prior to publication”.

To ensure valid publication, names must be introduced according to the requirements of the International Code of Botanical Nomenclature (ICBN; Greuter et al. 1994, Greuter et al. 2000). Since 1990, it has been compulsory to deposit the vouchers for new species and infraspecific taxa, the name-bearing types, in an herbarium or other collection. It is generally accepted that such voucher specimens should be deposited in publicly accessible reference collections such as herbaria.

Voucher collections are invariably necessary not only when new fungi are described but also in connection with scientific studies dealing with organisms, whether by taxonomists, systematists, physiologists, chemists, molecular biologists, pathologists, ecologists, clinicians, etc. It is essential to preserve voucher specimens as dried material or, in addition where possible, as permanently preserved living cultures. When none of the investigated material is preserved, it is impossible to confirm the identity of the investigated taxa. If species concepts have changed, it is particularly crucial to be able to re-identify the organism at a later time. There are several examples of entities once thought to be species but now revealed as species complexes, where the species concept has been or will be changed. These include *Pisolithus tinctorius* (Burgess et al. 1995) and *Paxillus involutus* (Fries 1985; Hahn and Agerer 1999). In such cases, re-identification of the original material is indispensable to knowing which organism was studied so that previous work will continue to be

relevant. In recent years, molecular biological studies have had a tremendous impact on systematics, taxonomy, and ecology. DNA sequences are frequently obtained from fungal cultures. However, all too often there is no exact citation of the fungal material used, such as an unequivocal number referring to collection accession data and the voucher culture, nor even a reference to the institution where material has been deposited. Frequently, only personal or laboratory strain numbers are given, which makes it hard to trace the origin of the fungal material. Only accession numbers allocated by permanent public or other open institutional collections can ensure retrieval of voucher material in the long-term. It is not yet common practice to publish complete collection or isolation data, or to deposit vouchers, except in taxonomic articles.

Conservation of dried fruit-bodies from which cultures are made is also indispensable for checking anatomical and morphological features that cannot be reproduced in culture. The cultures can also be checked using molecular methods after prolonged preservation, in order to exclude the possibility of contamination. While it is rarely possible to culture fungi from dried specimens, the associated collection details are indispensable not only for clarifying the geographical and ecological source, but also for establishing the possibility of recollecting the fungus at the same site. This requires a detailed and exact description of the sampling locality, preferably including geographic coordinates, which is now facilitated by hand-held or wrist-band global positioning devices.

Voucher specimens are equally important for a wide range of other investigations. The remark by Dennis (1960) that “records that cannot be verified are mere waste paper” applies to numerous aspects of our discipline. Studies of the species composition of any habitat depend on properly determined fungi and thus will require dried vouchers deposited in publicly accessible collections. This applies, for example, not only to fruit-bodies, but indeed to any other form of fungal structure, such as sclerotia, or ectomycorrhizas (Agerer

1991) used in scientific work. Ecological, chemical, applied, and physiological studies quite often rely on ecotypes of species which could be considered later, depending upon the species concepts applied, as separate species. In the seventies, Hawksworth (1974), Yocum and Simons (1977) and Ammirati (1979) were among the first to point out the importance of voucher material, particularly in chemical but also other physiological and ecological studies. In ecological studies on ectomycorrhizas, the increasing use made of RFLP patterns or DNA sequences for the detection of the symbionts requires comparison with those of identified fruit-bodies. In many studies, the identified ectomycorrhizas are completely consumed by the extraction and amplification methods. Instead, voucher specimens should be stored, when individual tips of a larger mycorrhizal system have been used. Even more important is the citation and preservation of the fruit-body specimen from which DNA was extracted for comparison with that obtained from ectomycorrhizae.

Voucher cultures are urgently needed when clinically relevant fungi are investigated and their etiologic data and their impact on human beings have to be evaluated (de Hoog and Guého 1985). Further, where cultural or chemical features are crucial for the evaluation of newly described fungi, such as yeasts, the non-availability of cultures can make interpretation impossible and frustrate other researchers (Banno et al. 1993; Hawksworth 1984). Sufficient information on clinical direct microscopy or histopathology results to determine whether an isolate is medically significant or a biomedical contaminant is essential for later evaluation. In cases of apparently exotic fungi, a brief notation of relevant patient travel history is strongly recommended.

Additional documentation requirements apply to strains deposited in the major service collections of fungal cultures, such as ATCC (American Type Culture Collection, Manassas, Virginia, USA), CBS (Centraalbureau voor Schimmelcultures, Baarn/Utrecht, The Netherlands), or IMI (CABI Bioscience UK Centre, Egham, Surrey, UK). These and other culture collections often provide forms for depositors to simplify the documentation process. In such major collections, the cultures are safely stored with cryopreservation methods, and may be revived at any time. For sporulating fungi, citation of the allocated accession number is generally enough to meet the goal of reproducibility of scientific results, i. e. to confirm the identity of the species studied. However, comparison with naturally grown material is only possible when the original collection or isolation details have been cited. A completely different situation arises in cultures which are sterile and thus cannot be identified by normal methods. Preservation of vouchers is particularly important for such cultures, together with exact collection data of the fruit-bodies and the herbarium or other collection in which they have been deposited. Misidentifications can then be detected, new species concepts applied to the mate-

rial, and further collection of new living material from the site of the original fruit-body might still be possible.

The addresses of public and open institutional dried reference collections and herbaria can be found in *Index Herbariorum* (Holmgren et al. 1990), and those of microbial culture collections in the *World Directory* (Sugawara et al. 1993). These works both contain generally applied acronyms, which are convenient and informative enough for citation. Public and institutional collections ensure that the material in their care is well-cared and preserved in a proper way for centuries, and they usually loan dried material free of charge, subject to certain requirements. Whilst the long-term maintenance of private herbaria is often uncertain and the mailing expenses exceed a private budget, nearly all of the international herbaria and other institutions that house fungi will warmly accept properly dried and documented fungal material. Living cultures are normally supplied for a charge to cover the cost of preparation and carriage, again subject to particular regulations that may apply. Details vary and may be found in the catalogues and on the web sites of the collections.

Particularly in recent years, certain behaviour of the scientific community has set tongues wagging, especially in relation to falsified data in publications concerning human cancer. It is a fundamental principle of science that research work must be reproducible. Reproducibility requires that repeated studies can be made using the same dried material or cultures as the original study. As a consequence, publications lacking unambiguous reference to the locations where the critical study material can be accessed by later researchers should not be accepted for publication. They are of no or only limited scientific value in that they cannot be reproduced. Editors and referees in all aspects of mycology are often confronted with such situations and it is, therefore, necessary to include advice on the deposition of voucher material in the instructions for authors (e.g. Hawksworth 2000) and to regard this as a prerequisite for publication.

All scientists are responsible for their results, not only in relation to the scientific community, but also to those who support their research, i.e. the taxpayer, charities or other funding agencies, and ultimately society at large. The general public expects integrity from the scientific community. It is the responsibility of individual scientists, referees, and editors to rigorously apply the highest standards and make every effort to ensure that published research will be reproducible. Reproducibility in mycology is irrevocably and inextricably connected to the precise citation of voucher specimens and cultures.

References

- Agerer R (1991) Characterization of ectomycorrhiza. *Methods Microbiol* 23:25–73
- Ammirati J (1979) Chemical studies of mushrooms: the need for voucher collections. *Mycologia* 71:437–441
- Banno I, Barnett JA, Déak T, Gams KW, Golubev WI, Guého E, Hawksworth DL, Hennebert GL, Hoffmann P, Jong, S-C, Kurtzman CP, Lachance M-A, Martini A, Nakase T, Pitt JI, Roberts IN, Slaviková E, Spencer-Martins I, Suihko M-L, Uruburu F, Yarrow D (1993) Unavailable new species. *FEMS Microbiol Lett* 108:i
- Burgess T, Malajczuk N, Dell B (1995) Variation in *Pisolithus* based on basidiome and basidiospore morphology, culture characteristics and analysis of polypeptides using 1D SDS-PAGE. *Mycol Res* 99:1–13
- De Hoog GS, Guého E (1985) A plea for the preservation of opportunistic fungal isolates. *Diag Microbiol Infect Dis* 3:369–372
- Dennis RWG (1960) *British Cup Fungi*. Ray Society, London
- Fries N (1985) Intersterility groups in *Paxillus involutus*. *Mycotaxon* 24:403–409
- Greuter W, Barrie FR, Burdet H-M, Chaloner WG, Demoulin V, Hawksworth DL, Jørgensen PM, Nicolson DH, Silva PC, Trehane P, McNeill J (1994) International code of botanical nomenclature (Tokyo Code) Koeltz, Königstein
- Greuter W, Barrie FR, Burdet H-M, Demoulin V, Filguerias TS, McNeill J, Nicolson DH, Silva PC, Skog JE, Trehane P, Turland NJ, Hawksworth DL (2000) International code of botanical nomenclature (St. Louis Code). Koeltz, Königstein
- Hahn C, Agerer R (1999) Studien zum *Paxillus involutus* Formenkreis. *Nova Hedwigia* 69:241–310
- Hawksworth DL (1974) *Mycologist's handbook*. Commonwealth Mycological Institute, Kew, Surrey
- Hawksworth DL (1984) Fungi in culture. *Nature* 310:18
- Hawksworth DL (2000) *Mycological Research: instructions and guidelines for authors*. *Mycol Res* 104:119–127
- Holmgren PK, Holmgren NH, Barnett LC (1990) *Index herbariorum, part I. Herbaria of the world*, 8th edn. New York Botanical Garden, New York (<http://www.nybg.org/bsci/ih/>)
- Korf RP (1995) Authors, reviewers, and editors of articles proposing new names: a few guidelines. *Mycotaxon* 54:413–419
- Sugawara H, Ma J, Miyazaki S, Shimura J, Takishima Y (1993) *World directory of collections of cultures of microorganisms*, 4th edn. World Federation of Culture Collections World Data Center on Microorganisms, Riken, Wako, Japan
- Yocum RR, Simons DM (1977) *Amatoxins and phallotoxins in Amanita species of northeastern United States*. *Lloydia* 40:178–190
- Reinhard Agerer, Munich, Germany; Joe Ammirati, Seattle, Washington, USA; Paul Blanz, Graz, Austria; Régis Courtecuisse, Lille, France; Dennis E. Desjardin, San Francisco, California, USA; Walter Gams, Baarn, The Netherlands; Nils Hallenberg, Göteborg, Sweden; Roy Halling, Bronx, New York, USA; David L. Hawksworth, London, UK; Egon Horak, Zürich, Switzerland; Richard P. Korf, Ithaca, New York, USA; Greg M. Mueller, Chicago, Illinois, USA; Franz Oberwinkler, Tübingen, Germany; Gerhard Rambold, Bayreuth, Germany; Richard C. Summerbell, Baarn, The Netherlands; Dagmar Triebel, Munich, Germany; Roy Watling, Edinburgh, Scotland