

What every botanist and zoologist should know – and what every mycologist should be telling them¹



For fungal conservation to succeed, a consistent message is needed. We, as mycologists, should be singing the right song, and we need to make sure too that our friends in botany and zoology are also singing it. This short note is all about the message of that song. As President of the newly established International Society for Fungal Conservation (*see IMA FUNGUS* 1(2): (27–29), 2010; www.fungal-conservation.org), I appeal to you to take on board this message, and to help by spreading it not only to other mycologists but also to botanists and zoologists, and to everyone you know involved in biodiversity work, nature conservation, and ecology.

In the conservation world, fungi are the new kids on the block. The movements to protect birds and mammals have been around for over a century. Plants have been at the core of conservation for decades. Amphibians, fish, and reptiles all now have their Red-Lists, and the last few years have seen a great growth in awareness that invertebrates also need protection. Somehow, somewhere along the line, the fungi missed out, and the reasons don't make happy reading. Right from its earliest days in the 18th century, when Linnaeus categorized all living things either as animals or as plants, the science of biology has failed to

provide fungi with the separate identity they deserve and so urgently need. Fungi are still being treated as lower plants (“they’re part of botany, aren’t they?”) or microorganisms (“I think they’re like bacteria...”) and, either way, the result is that they are overlooked and misunderstood by politicians and the general public alike.

Orphans of Rio. The 1992 Rio Convention on Biological Diversity is a classic example of how that mindset has been disastrous for the fungi. The Convention was framed in terms of animals, plants, and microorganisms: two taxonomic kingdoms and a third group arbitrarily defined on the basis of size. Not surprisingly, these categories fail to accommodate the fungi. Fungi form their own megadiverse biological kingdom which is separate from animals and plants. It has been recognized as such since at least 1970, and cannot possibly be shoe-horned into an arbitrary size category like “microorganism”. After all, the largest individual organism in the world is said to be a fungus. Fungi are the “orphans of Rio” (www.fungal-conservation.org/blogs/orphans-of-rio.pdf): the Convention has given them the right to protection, but none of the means by which this can be achieved, and that's bad for conservation, because fungi are so enormously important. None of the species we work with in nature conservation – humans included – could survive in a world without fungi. And fungi need protection too: nobody seriously supposes that, uniquely in evolution, they have some magical property which makes them immune to habitat destruction, pollution, and climate change.

In conservation terms, fungi have a lot of catching up to do. Conservation is a combination of science and politics. The science says, “populations of these organisms are declining”. The politics says, “something needs to be done about it”. The scientific side of fungal conservation has existed since at least 1985, when the European Council for Conservation of Fungi was established (www.wsl.ch/eccf) but, given the importance of fungi, it's all the more amazing that, until very recently, there was no organization anywhere

in the world explicitly and exclusively ready to take up the political job of lobbying for fungal protection. To be fair, various botanical societies and non-governmental organizations (NGOs) have done their bit to make sure fungi were not totally forgotten, but those honourable efforts, very understandably, could never be more than a side show of their main work to protect plants. The result was that, by and large, the only consideration these beautiful, remarkable and critically important organisms gained from the conservation movement was incidental – and often accidental. That is now changing. The Species Survival Commission of the International Union for the Conservation of Nature (IUCN) has more than doubled the number of its fungal specialist groups and, in August 2010, the International Society for Fungal Conservation was established (*see above*). At last there is an infant conservation movement for the fungi.

This is where botanists and zoologists come in. Botanists and zoologists have an enormously important role to play in helping this movement develop. As informed and educated scientists, they should be aware that the animals and plants in their care cannot survive long-term unless fungi are also protected, so they should understand the huge significance of this emerging movement. They should not need to be told that fungal conservation needs to become much larger because it is working for a kingdom of Life which evidently contains more species than all the plants and vertebrates on Earth put together. Also, they should understand that, at this stage in its development, fungal conservation needs to be promoted to a general public which is unfamiliar with the idea. They are the people with experience of public relations in conservation. They are the people who get contacted when governments, the press, or funding organizations need an expert. They are the people we mycologists need to help us fly this flag.

And that is where you as mycologists come in. The previous paragraph indicates what botanists and zoologists “should” do, but unfortunately that doesn't mean they “do”.

¹ A modified version of this note, suitable to pass directly to botanist and zoologist colleagues, is available as a downloadable PDF from the website of the International Society for Fungal Conservation (www.fungal-conservation.org/blogs/message-to-botanists-and-zoologists.pdf)

They are our colleagues and fungal conservation is in their interest too, but they have their own priorities and concerns and they may not always have in mind how important it is for the conservation of animals and plants that they too support action for fungi. Our task as mycologists is to give them that information and appraise them of the action required: to make sure they are aware of the relevance of fungi and to motivate them so that they too ensure fungi are not overlooked. Here, in no particular order, are some ways we can do that. Each is a simple but important message to communicate to our botanist and zoologist colleagues. Each point is also a stance we too should be taking – we can not expect them to act, if we are not also clearly in support.

- **“Fauna and flora” is not shorthand for “biodiversity”.** The same goes for “animals and plants” and “botany and zoology”. These phrases are often used as though they encompass all life. They do not. Each is a lazy and misleading shorthand which generates a misleading signal that inhibits awareness of fungi. In particular, using the terms “flora” and “plants” as though they include fungi, perpetuates a problem which has been festering since the time of Linnaeus. These words are often used in the mistaken belief that “the public won’t understand anything more complicated”. The public is perfectly capable of understanding that there are more than two biological kingdoms: it follows the fortunes of several dozen teams in a football world cup easily enough. Only use “fauna and flora”, “animals and plants”, or “botany and zoology”, when you really do mean just animals and plants.

Where you require a fungal equivalent of “fauna” or “flora”, talk about “funga” or “mycobiota” – they mean much the same and in increasingly frequent use. If you mean biodiversity, refer to “animals, fungi, microorganisms and plants” and – an important point - don’t just add fungi on the end as an afterthought. Fungi are no less important than animals, microorganisms or plants, and the language you use can reflect that in a list with the groups in alphabetical order. Alphabetical order is neutral and carries no implied ranking. Similarly, speak of “botany, microbiology, mycology, and zoology” – again in alpha-

betical order. In making such changes, you will be demonstrating that you have an open mind, and you will be in-step with an increasing number of prestigious bodies and programmes. The *Atlas of Living Australia*, Natural England, the Natural History Museum of London and the Swedish Taxonomy Initiative have all recognized the need to make such changes to their websites.

- **If you see terms misused by others, challenge them.** It’s a bad idea to misuse these terms as a shorthand for biodiversity, and it’s also a bad idea to let others make the same mistake. A quick tour of the websites of institutions responsible for biodiversity, conservation and ecology will show how widespread the above misuses are, and how these phrases continually inhibit the public awareness and profile of fungi. The “fauna and flora” legacy of Linnaeus is a poisoned chalice – an intellectual straitjacket which has done enormous harm to mycology. Botanic gardens, botanical museums, and other botanical institutes with mycological departments or programmes are particularly prone: often totally failing to present fungi to the public.
- **Be sympathetic to the use of fungus-friendly terminology.** Language is important in promoting the acceptance of new ideas. You can help fungi to be recognized in their own right by using words which emphasize their distinct nature. For example, for the fungal collections at the Royal Botanic Gardens Kew, the term “fungarium” has been adopted; fungi are not herbs, so why store them in a “herbarium”? New terminology may sound strange or even comical at first, but you can help by understanding why it is needed, and by being receptive to adopting and using such words where appropriate. Please also avoid terminology which misrepresents fungi. Two classic examples are “lower plants” (a term which is about as appropriate today as the ideas of social stratification in 18th century Europe which gave rise to it) and “primitive organisms” (what is primitive about a design perfect in its apparent simplicity and proven over hundreds of millions of years?).
- **If your own organization deals with fungi, recognize the fact in infrastructural terms, and make it clear to outsiders.** Many national botanic gardens, for example, maintain their country’s fungal reference collection, but that is very rarely reflected in their infrastructure, publicity material, or name. If the plant collection has a dedicated “keeper” or “curator”, the fungus collection, no less important and no less valuable, merits one too, and at the same rank. And what a pity those national fungal reference collections don’t have their own websites; holding a national fungal reference collection is something to be proud of and to celebrate. It deserves its own identity and website. It is regrettable that information about these international treasures is usually confined as an afterthought to a tiny ghetto corner of a botanic garden or museum website. All the visual signals on such websites shout “plant”, and none shouts “fungus”. A separate website for a fungal collection would mean mycologists ceasing to complain about inappropriate logos, mission statements, and “strap-lines”. More significantly, a separate identity for a national fungus collection could provide the institution’s director with an additional argument when looking for money, and would mean the staff have two platforms from which to launch projects, rather than one. It’s good business: everybody wins.
- **When biodiversity or conservation or ecology is being discussed, make sure a mycologist is present.** If you find yourself considering the composition of a panel of experts or other committee and there is no mycologist present, point out the deficiency, and press for a mycologist to be included. You can discuss animal conservation or plant conservation without a mycologist but, if the topic is conservation (or indeed biodiversity, systematic biology or ecology in general), there need to be mycologists included. A classic example occurred in October 2010 on the BBC Radio 4 “World Tonight” programme. A panel of experts on biodiversity was assembled to discuss the Nagoya Summit of the Convention on Biological Diversity, but none of them thought to

point out the absence of a mycologist. The result was the loss of a great opportunity to educate the public about the full scope of biodiversity. The politicians, press, and funding agencies are unlikely to think of inviting a mycologist – not yet, at least – so getting fungi represented on such occasions is a task which depends on botanists and zoologists, and you have to be imaginative and recognize the situations where an absent mycologist is needed.

- **When projects are being prepared or reviewed, consider whether the fungi should be included.** If you are preparing a project, or refereeing one, or deciding whether or not to fund a project, and the topic is biodiversity, conservation, or ecology, ask yourself if a mycologist should be on the team. You can have a project on animal biodiversity or plant biodiversity without a mycologist but, if the project's title just says "biodiversity", you need a mycologist on board. The title "Biodiversity of the Danube Delta", for example, will give the impression that all forms of life are covered. If there is no fungal component, there is a danger that, when eventually mycologists propose work on fungal diversity of the same area, they will be refused support because the funding body believes the work has already been done. If a project title includes "biodiversity" and it's just about animals or just about plants, insist the title is changed to make that clear or, if the project needs mycologists, make sure they are included right from the start, fully involved in the planning and execution, and not just added as a token.
- **When funding bodies are considering priorities, make sure fungi don't get overlooked.** If you are asked to help a funding body consider priorities for general biodiversity, conservation, ecology, or systematics, make sure mycologists are also involved in the process and the wordings do not exclude their eligibility. Funding bodies, whether research councils or international or national agencies, often have workshops to discuss priorities, but too rarely invite people with fungal expertise. It is so disheartening to submit a proposal on fungi to a fund which claims to focus on neglected

groups of organisms only to receive a rejection with the words, "fungi are not a priority".

- **Recognize that priorities for work on fungi may be different from those for animals and plants.** It is often front page news when a new bird or mammal is reported: so much is known about these groups that the discovery of new species are rare events. For the fungi, the situation is very different. Current best estimates suggest around 95 % of all fungal species haven't yet been discovered. For fungi, the age of exploration has scarcely begun. For fungi, inventorial work and alpha taxonomy are pressing issues. Dismissing this urgent need as "not cutting edge science" does nobody any favours: you can't remove a problem by pretending it doesn't exist. Similarly, in conservation work, the infant fungal conservation movement has needs and priorities which were resolved years ago for plants and vertebrates. Calls for help in developing infrastructure will seem strange to those who have become used to taking such resources for granted: "hasn't this been done already?" In fungal conservation it hasn't, and the need is real.
- **Consider whether your speciality in botany or zoology could benefit by sharing conservation expertise and resources.** If you are working with invertebrates or non-flowering plants, it is likely that many of the difficulties being experienced by fungal conservationists will be similar to those you are facing. Presenting a case for conserving nematode parasites, for example, is not so different from promoting the protection of fungal diseases of plants. You have to cover issues with which the public will have difficulty sympathising, but the conservation of such organisms is critically important for maintaining the full scope of checks and balances in nature. You can help fungal conservation and yourself at the same time by pooling expertise and resources.
- **Don't blame fungi unnecessarily for conservation problems.** With rare animals and plants, fungi are frequently treated as part of the problem ("this endangered plant must be protected from fungal diseases") but often enough the

fungi in question are host-specific, do not threaten the survival of the host, and in such cases will be at least as endangered as the plant on which they grow. Blaming the chytrid *Batrachomyces dendrobatidis* for the deaths of amphibians or *Phytophthora ramorum* for killing oaks and other trees is like shooting the messenger; the underlying problem in these and many other cases is down to humans. To use science fiction-like phrases such as "killer fungus" is great for headlines in the press, but it can make the already challenging work of fungal conservationists so much more difficult.

- **Recognize that fungi have conservation needs which may differ from those of animals and plants.** Taking South Africa as an example, it is well-known that, for bird diversity, the Karoo area of South Africa is a hotspot while Cape Province is unremarkable. Factor in the plants, and the picture changes dramatically: Cape Province is arguably the most important place in the world for plant diversity. The same can be true for fungi: places which are unremarkable for animals and plants may be special for them. At present, fungi are not or rarely taken into account when identifying areas of high biodiversity and, as a result, there is a danger that globally important hotspots are being overlooked.
- **Recognize that mycologists have experience and skills which can enhance your conservation work.** The Global Biodiversity Information Facility (GBIF) is a good example of a project which would have benefited from this. It attempts to handle all biodiversity in a huge and generally admirable on-line resource (www.gbif.org) telling you when and where species occur, and that makes it great for distributional information. One thing it doesn't do, however, is tell you how different species are associated. That's a pity, because you need such information in ecosystem conservation. For example, you can find hundreds of records of almost any plant you like on the GBIF website, but no information about what grows on and around them, even though plants need their associated organisms – the mycorrhizal fungi and the pollinators, for example – to

survive. It has been estimated that, on average, a single plant species has around 15 species of organisms of diverse kinds associated with it². A system for noting associated organisms was missed when GBIF's on-line resource was set up, because such associations are not routinely recorded in botany. For some reason, the voice of mycologists, for whom it is standard practice to record associated organisms, did not get heard. Take time out to explore the mycological website www.cybertruffle.org.uk/robitalia/eng and you will see complex associations between different organisms handled in a fully flexible way: you too need that flexibility.

- **Give mycologists a voice.** If, as a botanist or zoologist, you are asked about fungi, it is good to reply, "fungi need conserving, and fungal conservation needs resources", but it is even better to say, "I am a botanist / zoologist; fungi are not my speciality; you need to consult a mycologist" – and point the enquirer in the direction of a suitable person.
- **Treat fungi and mycology on a par with animals and zoology or plants and botany.** The "Flora do Brasil" website (<http://floradobrasil.jbrj.gov.br/2010>), in so many ways a superb production, is a good example of unequal treatment of fungi and plants (by including fungi in a "flora", even the title is misleading). The website has a long list of co-ordinators, at least one (and often several) for each flowering plant family. For the whole of the fungi, however, there are only two co-ordinators. What is the message? "Flowering plants are important and every family needs a lot of attention,

but as for fungi, they're not important: it's OK just to have a couple of people handling the whole kingdom". Is that the message we, as conservationists, want to send politicians? We are hiding the very problem we need to expose: a chronic shortage of specialist mycologists. We are tacitly condoning a political error. If flowering plants need co-ordinators at family level, then so surely do fungi. Consider the impact of listing on that website every fungal family known for Brazil against the words "no co-ordinator available".

- **Include mycologists in decision making.** If fungi are indeed the "orphans of Rio", mycology has up to now been the orphan of the conservation world, and orphans, as everyone knows, don't get included in family decisions. When mycologists ask to participate in the infrastructure of conservation – the councils and committees where decisions are made, don't dismiss them with the words, "you can't possibly be interested in getting involved with all this tedious administration". If it is important for a botanist or zoologist to be there, it's also important for a mycologist.
- **Be sympathetic to the idea of positive discrimination for fungal conservation.** Fungal conservation is so far behind animal and plant conservation, that a very reasonable argument can be put for positive discrimination in favour of work on fungi. The first step in protecting fungi is to ensure that mycologists themselves do not become extinct. Resources urgently need to be diverted in that direction, just as greater resources are directed to protecting the most endangered animals. If that

ever happens, there will be the temptation to complain about fungi receiving "special treatment". But it is not "special treatment", as would be the case if fungi were allocated resources proportionally greater than their species numbers justified. Ring-fencing a small part of often limited resources so that fungi don't get left completely outside the conservation movement does not amount to special treatment.

- **Send feedback.** If we are to change public awareness of fungi and their importance, the change needs to be monitored. So if you see a website which needs changing, for example, take a copy of the page³ as it is, before lobbying for change. You can then, hopefully, subsequently take a copy of the eventually revised page, improved as a result of your action. Feedback on all the issues bulleted here would be appreciated, particularly for "before and after" examples of successful changes is welcome. Such cases can be used as examples to inspire action by others.

How to summarize? The recently established International Society for Fungal Conservation and the IUCN Species Survival Commission's fungal specialist groups want to be welcomed and supported by conservationists as a whole. In the broadest sense, botanists and zoologists need these bodies if the organisms they care about are to be protected. Ask them, sympathetically and positively, to receive and implement the suggestions listed above, and ask them to make space for us, so that we too can play our part in this valuable international effort. It means we are knocking on doors. The examples of problems cited here have been included with no relish or enthusiasm, but rather in the hope that they will be recognized and ameliorated. Our aspiration is to have a voice for fungi alongside botanists and zoologists. We believe mycologists are needed when conservation policy is determined. In fact, the issues dealt with here clearly relate to mycology as a whole⁴. Make sure, though, that botanists and zoologists understand that, compared with them, we are beginners. They have been working in conservation for decades, with resources and expertise which we can

² Hawksworth DL (1998) The consequences of plant extinctions for their dependent biotas: an overlooked aspect of conservation science. In *Rare, Threatened, and Endangered Floras of Asia and Pacific Rim* (C-I Peng & P P Lowey II, eds): 1–15. [Monograph Series No. 16.] Taipei: Institute of Botany, Academia Sinica.

³ Pressing <Shift PrintScreen> and pasting into Microsoft Paint is one easy way to do this.

⁴ Hawksworth DL (1995) Challenges in mycology. *Mycological Research* **99**: 127–128.

Hawksworth DL (1997) Orphans in "botanical" diversity. *Muelleria* **10**: 111–123.

Hawksworth DL (2003) Monitoring and safeguarding fungal resources worldwide: the need for an international collaborative MycoAction Plan. *Fungal Diversity* **13**: 29–45.

Hawksworth DL (2009) Mycology: a neglected megascience. In: Rai M, Bridge PD (eds) *Applied Mycology*: 1–16. Wallingford: CABI Publishing.

only dream about. When we mycologists participate, it is likely that our inexperience will show. We will be stretched (there are far too few of us), and we will, inevitably, make mistakes. But without the experience, without taking the first steps, how will we learn to walk let alone run? We need botanists and zoologists as

teachers. Their help is needed to change attitudes and to raise the profile of fungi at all levels, so that it becomes the rule for them to be included rather than, as now, the exception. That is the very first step we need to take in protecting fungi. After that, the real problems begin.

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Some problems in the International Code of Botanical Nomenclature (ICBN) and some suggestions for solutions



Having been involved in the sharp-end of many aspects of fungal nomenclature for some four decades, latterly as the person responsible for checking the names deposited in MycoBank, I have come to recognize several problems in the current system of nomenclature, the International Code of Botanical Nomenclature (ICBN⁵) causes mycologists – and possible ways to address these problems, either within the ICBN or any future independent MycoCode.

Taxonomy in the Code

The ICBN, the *Code*, is concerned with nomenclature, and should stay away from taxonomy as much as possible, and restrict itself to regulate the consequences of taxonomy with regard to naming the accepted taxa. Some involvement in taxonomy is necessary, because the area of concern has to

be delineated. This is attempted in Preamble 7: “The rules and recommendations apply to all organisms traditionally treated as plants, whether fossil or non-fossil, e.g. blue-green algae (*Cyanobacteria*); fungi, including chytrids, oomycetes, and slime moulds; photosynthetic protists and taxonomically related non-photosynthetic groups.” The glossary of terms defines ‘plant’ as follows: “Any organism traditionally studied by botanists”. As a botanist is a plant scientist, the definition can be translated as ‘plants are organisms traditionally studied by plant scientists’. As such the term is defined with itself, and consequently the definition is circular and meaningless.

Although taxonomists have not yet established a stable system embracing all life-forms, a definition of a part of that system can not avoid the use of the system as it is conceived now (or at any time in the past, provided a date is given). Hence Preamble 7 could better be revised to read, for example: “The rules and recommendations apply to all organisms classified in the kingdoms *Plantae*, *Fungi* and *Chromista*, as well as in the *Acrasiomycota*, *Cyanobacteria*, *Dictyosteliomycota*, *Myxogasteromycota*, *Labyrinthulomycota*, *Plasmodiophoromycota*, and *Protosteliomycota*”. Maybe this enumeration is incomplete, for example considering the changing views on *Microsporidia* and the recent recognition of cryptomycota, but one or more other phyla can be added when needed. The addition “whether fossil or non-fossil” is superfluous, but can be considered as elucidating.

In other areas the *Code* gets itself unnecessarily, and not unambiguously, involved in taxonomy. It does so for example in two different ways in Art. 13, the Article dealing with starting point dates for the nomenclature of different groups, and the concept of “sanctioning”. Since 1983, the starting point date used for fungi was brought into line with that used for most organisms subject to the *Code* – 1 May 1753. In order to minimize the consequences of name changes for mycologists, who at that time used 1801 or 1821, the principle of sanctioning was introduced. It states, that names in the *Uredinales*, *Ustilaginales*, and *Gasteromycetes* (s. l.) adopted by Persoon (*Synopsis methodica fungorum*, 31 December 1801) are sanctioned, and all names accepted by Fries (1821–1832) in the three parts of *Systema Mycologicum* with *Elenchus Fungorum* and *Index*.

But what are “Gasteromycetes”? The term has seen many changes in circumscription since 1821, but which should be adopted by mycologists? There are three possibilities:

1. Accept the state of the art. That would, in this case, mean that the rule was meaningless as mycologists no longer accept “Gasteromycetes” as a taxon in any rank. Molecular studies have unequivocally established, that gasteromycetous groups are usually terminal branches in the development of many agaricoid, boletoid, russuloid, and other groups of *Basidiomycota*. But, more importantly, taxonomic concepts are not stable, and such state-of-the-art solutions should be avoided, as they are contrary to the intention of stability, as expressed in Preamble 1.

⁵ McNeill J, Barrie FR, Burdet HM, Demoulin V, Hawksworth DL, Marhold K, Nicolson DH, Prado J, Silva PC, Skog J, Wiersma J, Turland N (eds) (2006) *International Code of Botanical Nomenclature (Vienna Code) adopted by the Seventeenth International Botanical Congress, 2005*. [Regnum Vegetabile Vol. 146.] Ruggell: A. R. G. Ganter Verlag.

2. Accept the concept of Persoon (1801). However, Persoon did not have a concept of “Gasteromycetes”; that term actually originates from Fries (1821). Also, Persoon included together with homobasidiomycetous gasteromycetous fungi – which were distributed among four different main groups – *Pucciniomycota* (*Puccinia*, *Uredo*), *Myxomycota* (e.g. *Arcyria*), ascomycetes (e.g. *Onygena*) and various groups of anamorphic *Ascomycota* and *Basidiomycota* (e.g. *Trichoderma*, *Sclerotium*), a very heterogeneous mixture the mycological community would not accept – for example the placement of *Onygena* or *Elaphomyces* as gasteromycetous.

3. Adopt the concept as accepted in 1983, the year this provision came into force for fungi. This option would be closest to the intentions of the *Code*, but such practice would force the users of the *Code* to acquaint themselves with that concept.

Moreover, there are more problems when trying to establish which name has been sanctioned and which has not, because both works contain many inconsistencies.

There is a simple solution for this problem: publish an approved list of the taxa considered sanctioned by Persoon and Fries⁶. Once agreed, it would be unambiguous. Such a list can be incorporated in the *Index Fungorum* – *Mycobank* system, and will as such be easily available, both as a list and also implemented in the nomenclature.

Another problem arises, when the concept of the sanctioning author does not agree with the concept of the author he cited as the source of the name. What is then sanctioned: the concept of the original author or that of Persoon or Fries? In my opinion, there is only one acceptable answer. When a name has been sanctioned with an author citation, the concept of the original authors, rather than that of the sanctioning author, has been sanctioned. When it turns out this concept is different from that of the sanctioning author, there are two possibilities. Either not to sanction the original concept, but that of the sanc-

tioning author, but then with the original author's name dropped in favour of Persoon or Fries, because the latter author(s) effectively introduced a new taxon, or at least a concept not covered by the original pre-1801/1821 author. It would be unfair (and in my opinion unethical) to attribute a name used in a different way to the original author, while explicitly stating that the concept of the taxon is not what this original author intended, but a misapplication, a corruption of the original concept. The other possibility is to accept the data of the original author as the one to be followed. Unfortunately this reasoning is not generally accepted and continues to generate proposals to modify the *Code*.

What is a species name?

It appears, that the concept of a species name varies between various Articles and Principles in the *Code*: Art. 6.3 states: “In this *Code*, unless otherwise indicated, the word “name” means a name that has been validly published, whether it is legitimate or illegitimate.” And Art. 23: “The name of a species is a binary combination consisting of the name of the genus followed by a single specific epithet”. This is unambiguous: every valid binary combination is a species name. However, Principle 4 is not in agreement with this: “Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the Rules, except in specified cases.” There are now two possibilities: either the *Code* is conducting taxonomy without giving any guidance, or the concept of ‘name’ differs from that in Arts 6 and 23, because:

1. To establish the ‘correct name’, there has to be at least one synonym, or there is nothing to establish
2. There are three kinds of synonymy: homotypic (syntypic or obligate) synonyms based on the same type, heterotypic (taxonomic or facultative) synonyms based on different types, and avowed substitutes (new names or nomina nova) introduced to avoid homonymy.

3. Nomenclatural rules can regulate the choice of the homotypic synonyms, because these, once established, need to follow rules like homonymy and priority.
4. However, the choice between heterotypic synonyms (excluding avowed substitutes) is purely a taxonomic decision and as such not subject to the *Code*.

In summary, under Principle 4 a species name is the total of synonymous names, while under the other Articles ‘species name’ applies to every valid binary combination. Consequently Principle 4 has to be reformulated.

Consequences of hierarchy

The *Code* recognizes a hierarchical system of taxa, with primary ranks on various levels, each of them harbouring one or more secondary lower ranks. Taxa of different rank cannot compete to be the correct name at one of those ranks, not even when the contents are exactly the same. For example, *Welwitschia mirabilis* is the only species in the genus *Welwitschia*, which is the only genus in the family *Welwitschiaceae*, which is the only family in the order *Welwitschiales*. Although the order has exactly the same contents as the species, they cannot be considered synonyms as they operate at different ranks, because this situation is not stable, as the content of one can change, while the content of the other remains the same. For example, the finding of a second species of *Welwitschia* would change that situation. Synonymy between different ranks in a hierarchical system cannot be allowed. That applies for both primary and secondary ranks: a species can only be a synonym of a species, a variety only of a variety, a genus only of another genus, and a subgenus of a subgenus.

However, although the *Code* provides the provisions for the ranks of primary level, it does not do so for secondary ranks: if a variety can only be a synonym of a variety than there should always a variety name available for each species, in other words there should be an autonomous variety name for every species. Arts. 22.3 and 26.3 rule that autonyms for infrageneric and infraspecific ranks are only created with the valid publication of a name at that level, and not in other cases.

Remarkably, the *Code* itself presents a logical argument, because when later a published variety is no longer recognized,

⁶ The basis for such a list has been provided in the following publication, although it did not cover all names first or only sanctioned in the Introduction to the first volume of Fries' *Systema Mycologicum*: Gams W (1984) An index to fungal names and epithets sanctioned by Persoon and Fries. *Mycotaxon* 19: 219–270.

the autonym still remains. If the *Code* considered these taxa as synonyms, it should rule that autonoms are no longer available in such a case, because otherwise the *Code* itself has created an automatic synonym, and that is contrary to its intentions as expressed (second importance) in the Preamble.

The solution for this problem is simple: allow the use of autonoms at all secondary levels when needed. This would necessitate the following rule at various places (family, genus, species): “The valid publication of any name in a primary rank automatically establishes a corresponding autonym for any secondary rank residing under that primary rank.”

The necessity to regulate ranks above family

Although the *Code* recognizes primary and secondary ranks above the family level, it does not regulate their use. While the normal conditions for valid publication apply, there is no requirement to designate a type, and the Principle of priority does not apply. In the current situation, with the ongoing inflation of ranks in order to address the major clades found with molecular techniques, this is no longer satisfactory. The regulation could follow that of families, and as a starting point for validity the well-received article of Hibbett *et al.* (2007)⁷ could be selected.

One fungus, one name: the removal of Art. 59

The development and affordability of molecular techniques have fostered the acceptance of the idea, that study of less than 10 loci of the genome is sufficient to establish relationships in the fungal kingdom, regardless of the facts that parsimony is a teleological approach of a random situation, evolution is not a one-directional event, individual genes are known to tell quite different stories, and overall sampling of the species of fungi is still way below the critical mass. However, development will continue, more and more full genomes will become available, leading to more understanding and in some cases a very different view of systematics.

Provided that the mycological community prefers to adapt the current *Code* instead of going for a MycoCode, no sim-

ple adaptation of that *Code* will suffice to keep the amount of disadvantageous name changes and thus the damage to the user to a minimum. Following the rules of priority of teleomorphic names above anamorph names (when both states have been named) or equalize the priorable status of anamorphs and teleomorphs and blindly following the rules of priority does not bring the required flexibility. Moreover, it is clear that only for a rather limited groups of ascomycetes are sufficient data available to classify the group reliably. Finally, it is very likely that criteria will change when the next generation of sequencers becomes available and much larger fragments can be sequenced, allowing many more genes to be considered.

However, for some important groups both sufficient information and active working groups of researchers are available, as in the case of, for example, *Aspergillus*, *Penicillium*, *Fusarium*, and *Trichoderma* – these could serve as models on how best to proceed in other genera. In close collaboration with the user community, proposals can be prepared for naming, and once agreed these names could be accepted as conserved – although there is no current mechanism for the adoption of such lists in the *Code*. For this kind of protection, the recommendation of an appropriate specialist working group should suffice, avoiding the involvement of the permanent Committee for Fungi.

Although it will take a long time before all ascomycetous groups have been revised, the *Code* has to be adapted to avoid unnecessary naming in the near future. New anamorph and teleomorph names should both be acceptable as holomorph names, also when the teleomorph is known, and a new teleomorph name should not be allowed when an anamorph name is already available. In this databases can be of assistance.

Potential contributions of databases to the stability of names

Nomenclatural databases, and in particular the interlinked *Index Fungorum*/*Mycobank* databases, can significantly contribute to the accessibility and stability of fungal names, and so contribute to the realization of the primary intention of the *Code* as stated as the first importance in the Preamble. In particular, they can or could:

- incorporate approved lists of sanctioned names in a similar way to conserved and rejected names.
- add the status of the name (valid, valid but not available because of sanctioned or conserved or rejected status, illegitimate). Although they formally have no status, also a number of invalid names will be included, because in that place often important data have been published and they may merit subsequent validation.
- register all new names, with a minimum of additional data, including those required for a valid publication.
- screen and correct the names linguistically if necessary, and also register the gender of the genera.
- register provisional environmental “candidate” species (and other taxa), with the data that will be required according to an internationally agreed protocol.
- register newly proposed neotypes, lectotypes, epitypes (including teleotypes), with collection accession number and additional data.
- register anamorph-teleomorph relations which have been confirmed or established with either molecular evidence or from cultures of single ascospores from ex-type cultures.
- develop and add a program designed to establish the nomenclaturally correct name for a given name at any rank from the available synonyms.
- assist in cleaning the number of species names according to agreed criteria (e.g. lack of type specimen, forgotten name with insufficient description, agreed nomen dubium). Such names should be considered as rejected, or declared impriorable, but reinstatable with a new priority date if and when new data become available.

These comments are made in anticipation of them being taken into consideration in future revisions of the *Code*, or the development of an independent MycoCode.

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⁷ Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF *et al.* (2007) A higher-level phylogenetic classification of the Fungi. *Mycological Research* 111: 509–547.