



BOTANISTS AND ZOOLOGISTS FUNGAL CONSERVATION NEEDS YOU

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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 as either animals or 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 micro-organisms ("they're certainly not animals or plants...") 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 [CBD] is a classic example of how that mindset has been disastrous for the fungi. The convention was framed in terms of animals, plants and micro-organisms: two taxonomic kingdoms and a third group arbitrarily defined on the basis of size. Not surprisingly, these categories fail to

accommodate the fungi: take a look at the logo for the United Nations Decade on Biodiversity - a startling example, nearly 20 years on, of how the Convention still fails to take account of fungi: two bird species, two mammal species, some fish, three plants and an insect. This logo will be in use for ten years: where are 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 "micro-organism". After all, it has been claimed that the largest individual organism in the world is a fungus. Fungi are the "orphans of Rio" [www.fungal-conservation.org/blogs/orphans-of-rio.pdf]: the convention has given them theoretical 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 creation, 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 botanists, botanical societies and NGOs have done their bit to make sure fungi were not totally forgotten¹, 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 got from the conservation movement was incidental and often accidental. That is now changing. The IUCN Species Survival Commission has more than doubled the number of its fungal specialist groups and, in August 2010, the *International Society for Fungal Conservation* was established [www.fungal-conservation.org]. There is now an infant conservation movement for the fungi.

This is where you come in. Botanists and zoologists have an enormously important role to play in helping this movement develop. As informed and educated scientists, you are aware that the organisms in your care cannot survive long term unless fungi are also protected, so you understand the huge significance of this emerging movement. You don't have to be told that fungal conservation needs to become much larger because it's working with a biological kingdom which probably contains more species than all the plants and vertebrates put together, and you know that, at this stage in its development, fungal conservation needs to be promoted to a general public which is unfamiliar with the idea. You are the people with experience of public relations in conservation. You are the people who get contacted when governments, the press or funding organizations need an expert. You are the people we mycologists need to help us fly this flag. That means you need to be aware of fungi and make sure they aren't overlooked. Here are some bullet points suggesting ways to do that.

¹ and if you're one of them, please don't stop - your work is valuable and appreciated!

- **Don't use "fauna and flora" as shorthand for biodiversity.** It isn't. The same goes for "animals and plants" and "botany and zoology". These phrases are very often used as though they encompass all life. They don't. It's a lazy and misleading shorthand which gives the wrong signal and strongly inhibits awareness about fungi. In particular, using the terms "botany", "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" if you really do mean just animals and plants.

If you want a fungal equivalent of "fauna" or "flora", talk about "funga" or "mycota" or "mycobiota" - they all mean much the same and are all in increasingly frequent use. If you mean biodiversity, talk about "animals, fungi, micro-organisms and plants" and - an important point - don't just add fungi on the end as an afterthought. Fungi are no less important than animals, micro-organisms or plants, and the language you use can reflect that status if you list the groups in alphabetical order. Alphabetical order is neutral and carries no implied ranking. You can also talk about "botany, microbiology, mycology and zoology" - again in alphabetical order. Don't be afraid to make such changes. You will be demonstrating that you have an open mind, and you will put yourself in good company. 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.

Case Study 1 - a success

At the Tenth CBD Conference of the Parties (Nagoya, Japan, 2010), the *Global Strategy for Plant Conservation* was reviewed. In the document under review, fungi were mentioned briefly, separately from lichens, both of them in the context of "lower plants", with the statement that it was optional to include them in the strategy. *The International Society for Fungal Conservation* pointed out that this gave the misleading impression that lichens were different from fungi, that both belonged in the plant kingdom, and that their conservation was somehow optional. Botanists and mycologists jointly called for this to be corrected. The revised wording made clear that lichens were fungi, that fungi were not plants, and that, being separate from plants, they merited their own separate conservation strategy. This was a small but highly significant step towards getting fungal conservation properly recognized at a political level. The plant strategy is now clearer and scientifically more accurate. The door leading to some fungal equivalent of the plant global strategy has opened very slightly. Everybody wins.

- **Don't describe fungi as micro-organisms.** Imagine a parallel universe, where everything we know is turned upside-down: a universe where biodiversity is described as Chromista, Fungi, Monera, Protozoa and macro-organisms. As a botanist or zoologist, you might very reasonably object ("but animals are totally distinct, and lots of them are much smaller than the larger fungi - lumping them with plants sends out a scientifically confused message and denies them the separate identity they deserve"). By using the term "micro-organism" in this universe, that is exactly what you are doing to the kingdom of Fungi. And on this planet, that stance is catastrophic for conservation of biodiversity.

If fungi are grouped with micro-organisms for conservation purposes, the implication is that the resources, facilities and expertise for their conservation should come through microbiology. Unfortunately, those resources, facilities and expertise don't exist. While writing this note, I visited websites of some prominent microbiological societies (*American Society for Microbiology*, *Australian Society for Microbiology*, *Chinese Society for Microbiology*, *International Union of Microbiological Societies*, *Interregional Microbiological Society of the Russian Federation*, *Society for General Microbiology*, *South African Society for Microbiology*). I looked for "conservation". It wasn't encouraging. There were lots of references to "gene conservation", but nothing at all for conservation in the sense of protection of nature.

Microbiologists are not geared up for conservation. Nearly 20 years after the CBD was established, the world of microbiology has yet to realize that conservation is an issue which needs to be addressed. That can only mean one thing: wherever the CBD's huge resources for biodiversity conservation are being directed, they are not going into protecting microbes. It is not in the interests of animal and plant conservation to see such important and vulnerable organisms as fungi being consigned to that particular black hole.

- **If you see these 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 shows how widespread the misuse is, and makes evident how much these phrases inhibit public awareness of fungi. The Linnean "flora and fauna" legacy is a poisoned chalice - an intellectual straitjacket which has done enormous harm to mycology. Botanic gardens, botanical institutes with mycological departments, and museums of natural history are particularly prone: they often totally fail to present fungi to the public. No wonder fungi are so overlooked.
- **Be sympathetic to the use of fungus-friendly terminology.** As is evident from the foregoing examples, language is important in promoting acceptance of new ideas. You can help fungi to be recognized in their own right by using words which recognize their distinct nature. At the UK's national fungus collection in Kew, the term "herbarium" has been abandoned: fungi are not herbs, so why store them in a "herbarium"? Instead, the word "fungarium" has been adopted. New terminology like this always sounds strange and even comical at first, but you can help by understanding why it is needed, and by being receptive to adopting and using such words. 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 you are looking for something primitive, try *Homo sapiens*, a recent upstart with a very untested design unlikely to last long).

- **If your own organization deals with fungi, recognize the fact in infrastructural terms, and make it clear to outsiders.** If you edit a scientific journal relevant to fungi, is that relevance reflected in its title, its objectives, its editorial board? Changing a long-established journal title is challenging, and may have short-term consequences for the all-important impact factor, but can we really continue publishing scientific journals claiming to cover fungi but having titles like *American Journal of Botany*, *Canadian Journal of Botany* or *Plant Biosystems*? If your journal claims to cover all groups of organisms like, for example, the recently established *European Journal of Taxonomy*, is it appropriate for it to be described as a “journal for descriptive taxonomy, in zoology, botany and paleontology”? Where are the fungi? Where are the mycologists on the editorial board?

Many national botanic gardens - this is another example - maintain their country’s fungal reference collection, but that is very rarely reflected in their infrastructure or publicity material. If the national botanic garden has a director, the national fungus collection, no less important and no less valuable, needs one too, at the same rank. And what a pity those national fungal reference collections don’t have their own websites. Having a national fungal reference collection is something to be proud of. Something to celebrate. It deserves its own identity. It deserves its own website. It’s a shame that information about these international treasures is usually confined as an afterthought to a tiny ghetto corner of a botanic garden website. What a pity that all the visual signals on those 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 would give the institution’s director 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 conservation is being discussed, make sure a mycologist is present.** If you find yourself on a panel of conservation experts, look around. If there isn’t a 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 in general, you need to have a mycologist present. The same goes for biodiversity and ecology. 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, 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 won’t think to invite a mycologist - not yet, at least - so getting fungi represented on such occasions is a task which depends on you, 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 or 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, the result will be 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 says “biodiversity” and it’s just about animals or just about plants, insist the title is changed to make that clear. If the project needs mycologists, it will need them right from the start, fully involved with the planning, and not as a token or afterthought.
- **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 or ecology, make sure mycologists are also involved in the process. Funds often have workshops to discuss priorities, but they rarely think to 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’s front page news when a new bird or mammal is reported: so much is known about these groups that 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

Case Study 2 - a success

In 2010, the *Zoological Society of London* organized a special symposium entitled “*Foundations of Biodiversity*” to emphasize that organisms other than vertebrates need conservation. In its original form, the meeting announcement began with the words, “Invertebrates and plants represent the majority of earth’s biodiversity...” In response to a request from mycologists, this was changed, at first, to “Invertebrates, plants and fungi...”. Following further comment about importance and alphabetical order, it took its final form as “Fungi, invertebrates and plants...” A great result: scientifically accurate, clear and unambiguous. Everybody wins.

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 and in such cases will be at least as endangered as the plant on which they grow. Blaming the chytrid fungus, *Batrachochytrium dendrobatidis*, for the deaths of amphibians is like shooting the messenger. The fault lies with humans. Talk about a science fiction-like “killer fungus” is great for headlines in the press, but it makes 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’s 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 taken into account at all in 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. You can find hundreds of records of 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 pollinators and the mycorrhizal fungi, for example - to survive. A system for associated organisms got 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 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’s good to reply, “fungi need conserving, and fungal conservation needs resources”, but it’s even better to say, “I’m a botanist / zoologist, fungi are not my speciality, you need to talk to a mycologist” and point the enquirer in the direction of a suitable person. That way, you are helping to give fungal conservationists a voice.
- **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 expert 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 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

Case Study 3 - a success



To celebrate a national exhibition about fungi in 2005, the Jardín Botánico Nacional [National Botanic Garden] of Havana commissioned a special logo aimed at attracting children. The logo, reproduced above, emphasizes that fungi and plants are equally important and need each other. Another great result: a simple clear amusing message. Everybody wins.

with the words, “you can’t possibly be interested in getting involved with all this tedious administration”. If it’s 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 sent 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”. Please resist that temptation: it’s not special treatment. Special treatment would be if fungi were allocated resources proportionally greater than their species numbers justified. Ring-fencing a small part of our very 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, the change needs to be monitored. So if you see a website which needs changing, for example, take a copy of the page as it is (<Shift PrintScreen> and paste into Microsoft Paint is one easy way to do this), before lobbying for change. You can then - hopefully - take a copy of the revised page improved as a result of your action. I will be most grateful for feedback from you on all of this, and particularly for examples of successful changes.
- **Join us!** This is the last point. If you are interested in conservation, and you want to see the animals and plants you cherish protected, and their future less insecure, then you need to join the young movement for fungal conservation. Visit the Society’s website [www.fungal-conservation.org], where you can download a membership application form, and you can help from the inside: we need you.

How to summarize? As long as the public is presented with confused, conflicting and scientifically incorrect messages which muddle the fungi with micro-organisms or plants, mycology will remain the orphan of the life sciences, excluded from family decisions, just as the fungi with which it works will remain the orphans of Rio. For animal and plant conservation to be successful in the long-term, fungi need to be promoted as the critically important and independent biological kingdom which they really are: it’s better for botanists, better for zoologists, better for everybody.

The recently established *International Society for Fungal Conservation* and the IUCN Species Survival Commission’s fungal specialist groups wants to be welcomed and supported by conservationists. In the broadest sense, you need these bodies if the organisms you care about are to be protected. We ask you sympathetically and positively to receive and implement the suggestions listed in this work, and we ask you to make space for us, so that we too - the mycologists - can play our part in this valuable work. That 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.

Do remember, though, that compared with you, we are beginners. You, as botanists and zoologists, have been working in conservation for years, with resources and expertise which we can only dream about. When we mycologists participate, it is likely that our inexperience will show. We will be stretched (there are only a few of us), and we will make mistakes. It’s inevitable. But without the experience, how will we learn? We need you as teachers. Your help is needed to change attitudes and to raise the public profile of fungi 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.