

Intimate Strangers of the Subterrain

A mycelial metaphor for connectivity

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In nature we never see anything isolated, but everything in connection with something else which is before it, beside it, under it and over it. *Johann Wolfgang von Goethe*

Hidden beneath ferns in a wet Victorian forest, a tiny blue organism ekes out a brief existence on a fallen log. *Mycena interrupta*, or the pixie's parasol, stands just seven millimetres high. From its unseen perch, it exudes enzymes that degrade the lignocellulose of its log, thereby recycling nutrients and creating soil. Invisible spores are released into micro-currents of air from the lamellae beneath its cap. Then, in a matter of days, its reproductive role completed, it collapses and succumbs to the humus of the forest floor.

Such small unnoticed lives seldom receive the necessary appreciation or conservation to protect their existence, or that of the forest and biosphere including humanity. Conservation of fungi is hindered largely by public failure to acknowledge their pivotal role in underpinning the earth's ecosystems.² Moreover, a prevalent disdain for fungi arising from a long mythology of negative associations and misunderstandings has further tarnished their profile.³ Indeed it seems that both a lack of ecological awareness and cultural aversions have induced a kind of *myco-myopia*. In this paper I endeavour to explore human blindness to the importance of fungi and argue for their appropriate inclusion in biodiversity conservation.

The more conspicuous and popularly charismatic flora and fauna have long been the focus of both Australian and global biodiversity conservation. Negligence of the "third f", the fungi, is perhaps unsurprising as most conduct their extremely important business within the darkness of the subterrain.⁴ The ephemeral life of the tiny blue mushroom offers but a mere hint of something far greater, for it is just the reproductive structure of the fungus. The main body of a fungus exists as an often unimaginably vast network of cellular threads called *mycelium*, within soil, leaf litter, wood or other organisms. This complex matrix of interactions provides a vital subterranean life-support system. Indeed fungi are a cornerstone of ecosystem processes, enabling the more visible biota of above-ground ecosystems to exist.

The tiny blue mushroom also symbolises something further in providing the possibility to enter another world of significance and meaning, where *Homo sapiens* not only observe or capture, but actively engage as dynamic co-participants. To explore the value of interacting with this small wondrous life-form is to challenge notions of human exceptionality. That is, we might opt to disregard the imaginary line between humanity

and the rest of the biosphere and reconsider ourselves within “multispecies communities that emerge through the entanglements of agential beings”.⁵ Our capacity to participate with other species within the biosphere is exceedingly complex. As active participants or agents in our interactions, possibilities arise for not just cognitive but sensorial engagement. As the experience moves from “knowing” to “feeling” the potential increases to infuse ethics into the exchange, so that it is not only causal, but also meaningful.⁶ Using fungi as a metaphor for the connectivities of the biosphere, I endeavour to explore ways in which we might capture the public imagination in relation to fungi. I argue that such an approach to conservation requires a genuine melding of scientific, philosophical, ethical and sensorial approaches to not just inform, but to capture public hearts, minds and bodies in the view to inspire a more sensitive way of inhabiting the planet.

Coming home to the biosphere

Fungal conservation has been driven largely by mycologists and conservationists who have endured a history of exclusion and profound ignorance about fungi, even from within the biological sciences. While exemplary progress has been made in the last three decades since increased public interest in fungi spawned a flurry of field guides and mycological societies, the urgency with which we must address the impacts of anthropogenic change on biosystems requires rethinking fungal conservation not just as an environmental issue, but one that acknowledges the various ways in which fungi are enmeshed in human culture. Given that human actions are the major cause of environmental decline, it follows accordingly that humanity should also be a major focus of research into the abatement of this decline.⁷ The immense efforts of scientists advocating for biodiversity conservation have revealed the complexities of the planet and provided an immense foundation of knowledge. However, science offers just one way of knowing. How do we meld this knowledge with the great spectrum of other ways in which the world is translated, understood and valued? Passion for the environment is arguably as important as knowledge in driving biodiversity conservation. While scientific knowledge is an essential precursor to conservation, reliance on scientific reason and justification alone can also inadvertently reinforce nature-culture dualisms with counterproductive results.⁸ Alternatively, an “integrated and conceptually sensitive approach to environmental issues”⁹ that balances knowledge and passion, could provide a more extensive framework and vocabulary within which to protect biodiversity including these unseen denizens of the soil.

Engaging the thinking of other disciplines provides alternative fora for re-framing the nature-culture dualism that can undermine conservation thinking. This dualism represents more than a simple dichotomy but embodies all the inevitable tensions of synthesising existing patterns of thought with novel approaches.¹⁰ A more expansive spectrum of thinking could offer a myriad of interpretations of nature and culture. This could provide opportunities to both resituate *Homo sapiens* within the biosphere, as well as to re-imagine the biosphere within cultural and ethical frameworks, by addressing environmental, social and ethical issues.¹¹ Synergies distilled from the intersection of the sciences and humanities could provide new lenses, vocabularies and contexts from which to reconsider our existence within the biosphere including interactions with fungi. Bridging the disciplinary divides of language, methodologies, conceptual frameworks and modes of representation of environmental issues is inevitably challenging. However, the greatest challenge perhaps lies in how to achieve complex understanding within contrasting ideologies and knowledges.¹² One approach to highlighting the significance of fungi to humanity could begin with recognising that

Homo sapiens share more in common with fungi than perhaps commonly realised – that they are, in fact, our phylogenetic older siblings.¹³

Meeting the relatives – fungi as phylogenetic older siblings

The ephemeral life of the tiny blue mushroom is paradoxically juxtaposed to its ancient history. First appearing during the late Precambrian (~570 million years ago), the persistence and significance of fungi may be difficult to comprehend within the vertiginous magnitude of geological time.¹⁴ Lichens are believed to have been the first fungi to form beneficial mutualisms, allying with photosynthesising organisms such as green algae and cyanobacteria. While originally classified with plants, recent insights into the cellular features, metabolic pathways and trophic nature of fungi have revealed a shared evolutionary lineage with animals. Indeed, those who struggle to contemplate *Homo sapiens*' arboreal past may be further challenged to grasp the idea of fungi as our phylogenetic older siblings.¹⁵ These findings have immense implications for the understanding of the origins of life and the significance and biospheric function of fungi.

However, despite such remarkable findings, fungi, an entire kingdom of potentially 5.1 million species, rarely enter the consciousness of many Australians.¹⁶ The charismatic species that jostle their way onto the world's RED lists or win the badge of flagship species are those perceived as either important, attractive, or, oftentimes, as somehow resembling humans.¹⁷ Only a meagre 0.03 percent of the world's fungi have been evaluated by the world's most authoritative RED List, that of the International Union for Conservation of Nature.¹⁸ The discovery of this linkage between fungi and animals provides an opportunity, albeit an especially ambitious one, to promote fungi as being that one step closer to humanity and hence perhaps more amenable to our empathy and attention.

Subterranean intimacies

While some fungi such as the tiny blue mushroom perform a saprophytic role by decomposing organic matter, others are entwined in intimate unions with plants known as mycorrhizal relationships.¹⁹ These mutually beneficial exchanges between fungi and the great majority of higher plants are the foundation from which both underground and aboveground ecologies function. The fossil record and molecular studies confirm that the roots of the earliest land plants co-evolved with fungi to form specialised "fungus roots", that is, mycorrhizas. In this relationship fungi assist plants by expanding the surface area of their roots, increasing their capacity to exploit much greater volumes of soil and thereby maximising access to water and nutrients. They achieve this by either penetrating or sheathing the rootlets of plants, providing an "intelligent" interface between plant and soil, allowing for the selective uptake of nutrients while excluding toxins. In this reciprocal arrangement, the plant returns the favour by supplying the fungus with sugars produced through photosynthesis. While some plants and fungi form exclusive partnerships, the majority interact with a range of partners. Hence, one fungus may unite the root systems of numerous plant species.

Although visualising or imagining this covert interplay may be challenging, mycorrhizal relationships represent an inordinately vast matrix of interconnections uniting species, kingdoms and biosystems.²⁰ Given the implications of these symbioses not just in supporting "natural" ecosystems, but also in driving agricultural systems, stabilising soils, improving water quality and the integrity of crops, the near total absence of fungi on conservation agendas seems staggeringly negligent. Determining why fungi have been overlooked requires an understanding of public attitudes toward fungi. Exploring historical perspectives on fungi provides a valuable starting point for examining the various perceptions of this curious kingdom.

The challenge of being bizarre

Two hundred and twenty years ago, the French naturalist, Jacques Labillardière, encountered a most bizarre organism near the remote southern tip of Tasmania.²¹ He may have in fact smelt it before seeing it, for this species possesses a foul odour that effectively mimics that of rotting flesh or faeces. But what he discovered was neither flesh nor faeces, but fungus. The oozing brown slime responsible for its stench was possibly seething with fervently feasting flies. This cleverly disguised dipteran amuse-bouche was in fact the spore mass of the fungus. In this remarkable union, the fly procures a feed while the fungus exploits the fly's craving for the putrid and capacity to serve as an airborne spore distribution mechanism. Together, fungus and fly represent an example of an ingenious mutually beneficial symbiosis that characterises fungi as connectors of life-forms. Along with its malodorous funk, this species' ostentatious appearance was what perhaps caught the Frenchman's eye as its most peculiar fruit body emerges from a gelatinous egg-like sack, magically unfolding up to ten elongated red "tentacles" and hence earning it the common name starfish fungus or anemone stinkhorn.

Its generic name, *Aseroë*, is derived from the ancient Greek for *disgust* (*Asē*) and *juice* (*roē*) while its specific epithet, *rubra*, refers to its red colouration.²² It belongs to a group commonly known as the phalloids with its relatives exhibiting equally idiosyncratic morphologies. While occurring widely from lowland Tasmania to the Pacific Isles to South Africa, it regularly springs up in Australian suburban gardens, often inciting reactions of alarm. It took Labillardière eight years to publish an account of his unusual find, with *Aseroë rubra* being the first fungal species to be described in Australia. Unsurprisingly, it was those fungi that exhibited dramatic and persistent fruit bodies that were among the first to be documented, although it was still a further thirty odd years before the next fungal species caught the eye or nose of European naturalists and was formally described.²³

According to his diaries, it is unlikely that Labillardière sought knowledge about *Aseroë rubra* from the local Ninene women.²⁴ In perhaps overlooking the important role of women in many cultures as keepers of fungal lore, a vital opportunity to tap into indigenous knowledge of Australian fungi may well have been missed. While Aboriginal Australians are known to have used various fungi for food, medicinal, ceremonial and other purposes, it is not known how the Ninene regarded *Aseroë rubra* as few ethnomycological studies exist in Australia.²⁵ However, how this species was perceived by a Sydneysider who recently discovered it in his garden is expressed on the Australian Fungi Blog as:

I found this disgusting fungi (sic) in my garden. I digged (sic) them up and dumped into a bin. However, within a week, they started to grow and now they invade the garden so quickly. Is there any way to exterminate hyphae without damaging my plants?²⁶

Such antagonism towards *Aseroë rubra* was expressed by other contributors to the blog, their main interest being to find an effective way to kill it. Others were concerned that the fungus was killing their trees, or could kill their dogs or children. Such violently adverse reactions reflect a deep-seated disdain, which appears to have transpired largely from fear and ignorance of fungi rather than from any documented evidence of this species' apparent lethality. No Australian field guide, for example, mentions *Aseroë rubra* as being a threat to either trees, dogs or children. Given that "deadly poisonous" species are thought to represent a miniscule minority of the currently known fungal species worldwide, these reactions seem somewhat unfounded.²⁷ Fortunately there are those who think otherwise with one blog contributor commenting "...let these mysterious life forms thrive and decorate our gardens".²⁸

The overwhelming majority of the earth's biodiversity, including fungi, invertebrates and protists, is largely invisible. Those advocating for fungal conservation face the challenge of conserving not only what is inconspicuous, but also what is often deemed undesirable. To raise the bar even higher, there is the additional challenge of conserving the unnamed, as people rarely value what they cannot name and the great majority of fungi are yet to be formally described. Fungal conservation requires understanding of what species exist and where they exist, as well as the processes that threaten their existence. However, efforts toward understanding public perceptions of fungi could also greatly inform fungal conservation. While many cultures revere fungi for their value as food and medicines and the mind-expanding potential of hallucinogenic species, English-speaking cultures have historically regarded fungi less favourably.²⁹ Australia's original English-speaking colonisers brought with them an unhealthy mycophobia that still persists today. Understanding public aversion to fungi and finding ways to erode negative perceptions should underpin effective fungal conservation.

Sensory pathways to empathy

Human reactions to *Aseroë rubra* reveal that fungi can certainly ignite both the senses and the emotions. One may even consider fungi to be extraordinarily "expressive" organisms. Fungi reveal themselves through the peculiarities of their morphologies, colours, textures, smells and habits, thereby imparting something of their character. We acknowledge the individuality of species by assigning them names, but rarely address our emotional responses to them. Understanding and articulating such responses requires first hand encounters that could enliven our feelings about fungi. To experience fungi through multiple senses is a way to intimately know them. Even the most potent or poetic written descriptions of "nature" cannot capture the multisensory and energetic experience of physical presence in "nature". Without sensorially experiencing fungi, they are more likely to remain purely in the realm of the cognitive.

As communication technologies rapidly accelerate the transfer of information to vast audiences, one might hope that they had also catalysed public environmental awareness. However, the gulf between humanity and the rest of the biosphere seems to grow ever wider. Possibilities for physical and sensorial encounters with fungi (and with "natural" environments generally) have rapidly diminished as Australia becomes increasingly urbanised and more people reside in concreted landscapes. The parallel between shrinking knowledge of "natural" environments and increasing urbanisation is well documented.³⁰ While the media have popularised larger scale environmental issues, especially those of a sensationally catastrophic nature, intimate knowledge of local environments is declining. Long term observations of local environments that are perceptive to minute variations in space and time are vital to understanding the biosphere in its greater complexities. Those who actively engage in conservation efforts, including fungal conservation, usually do so at a local level. A great challenge lies in trying to scale-up local knowledge and values to a national and global level.

The increasing divide between humanity and the rest of the biosphere and the subsequent suite of social, psychological, physiological, emotional, ethical and other impacts, often referred to as a "nature deficit", is well known.³¹ What does it mean to our evolution as ethical beings to grow up without a deeper understanding of and empathy for other organisms? Furthermore, increasing addiction to electronic entertainment as an alternative to outdoor activity has diminished our sensory world and hence the capacity to directly experience and interpret our surrounds.³² One may also question the evolutionary implications of sensory loss as humanity becomes ever more confined to urban environments. It is perhaps unrealistic to hope that future

generations will advocate for environmental protection when they have not had the opportunity to develop environmental empathy. While it is often asked what kind of planet will be left to future generations, a more pertinent question might also be concerned about the health of future generations – physically, mentally and ethically – that will be left "to" the planet. Although numerous initiatives to re-engage people with "natural" environments have arisen in recent decades within schools and communities, few have included fungi or explored them as a metaphor for connectivity between humanity and the rest of the biosphere.

Fungi provide a rich and powerful metaphor and conduit to assist people to understand such connections. Metaphor is a dynamic tool for building knowledge and enabling new insights and connections by relating thoughts from one sphere to another.³³ Most pertinently, metaphors provide other ways in which to interpret the world. Stamets puts forward an interesting claim in suggesting that the internet is simply an extension of a biological model, mimicking perhaps the interconnectivities of fungal mycelia as a means of relaying information. Given this link, he therefore considers that the existence of the internet should not be construed as happenstance.³⁴ To pursue the idea of fungi as a metaphor for connectivity, in the same way that fungal mycorrhizas provide plants with an interface between plant and soil, we too possess a sensory interface that allows for mediated exchange between our internal and external environments. Our senses allow us to not only experience our surrounds but sensation, or aesthesis, forms the very core of embodied experience. In situ sensate experience can ignite intrigue and catalyse connection. For the person who has never reclined on her/his back and peered up into the mind-bending microcosm of a mushroom's underbelly, concepts, such as species extinction or earth jurisprudence or valuing nature, remain all the more abstract, removed from the senses, disconnected from humanity. According to environmental psychologist Louise Chalwa, without direct and sensate experience with nature, "we forget our place, we forget that larger fabric on which our lives depend".³⁵ It is arguably through not just cognitive understanding, but through physical sensate presence that one can deeply experience "nature". Only then perhaps, can the borders of culture and nature begin to dissolve. Rachel Carson famously reminded us that, "It is not half so important to know as to feel when introducing a young child to the natural world".³⁶

Lack of understanding of fungi and various cultural aversions mean that they are fairly unlikely to attract interest and concern in their own right. One might then question how we can make the great leap to insert arguments about the value of fungi into the public forum. The mere suggestion of "justice for mushrooms" would likely trigger loud guffaws all round, especially given how infrequently environmental ethics arise in public debate. In the previous issue of this journal several authors discussed the challenges of gaining ethical recognition of plants.³⁷ Achieving ethical recognition of fungi for the numerous reasons discussed seems considerably more challenging. The key to arousing public interest in fungi perhaps relies on elucidating the connection between the conservation of fungi and the health and well-being of humanity. By connecting humanity with fungi, the issue becomes one not just of conservation of fungi, but also of humanity. Remembering that fungi are our phylogenetic older siblings could be an important first step.

Hope in a tiny blue mushroom

Huge challenges exist in our efforts to incorporate and reconcile the great suite of values ascribed to "nature", including those of the tiny blue mushroom. The future existence of the planet's biodiversity requires many of us to think and act differently. In particular this involves new ways of conceiving of human agency and our dynamic

dependence on the rest of the biosphere. The earth's capacity to maintain the planet's life-support systems needs repositioning within the realm of human moral consideration. While science has provided us with a vast body of knowledge, it is only through the cultural-social context of our lives that this knowledge derives meaning and power.³⁸ Further scientific knowledge is necessary to better understand and protect the biosphere, but a fundamental change in our dominant values is perhaps even more urgently required.³⁹ Ultimately, conservation of fungi and, indeed, of all biodiversity will struggle to progress within the timeframe of the need for change unless we rethink the nature-culture dualism. While we categorically depend on the rest of the biosphere for our survival, as Val Plumwood reminded us, much of nature also depends on culture to ensure its protection and support its dependency on a healthy atmosphere.⁴⁰

Engagement with the biosphere through sensate experience also relies on another oft-forgotten factor in fungal conservation. Hope remains one of the most vital and powerful drivers of pro-environmental behaviour without which the media onslaught of environmental doom can precipitate a pessimistic slide into ambivalence, apathy and inaction. While acknowledging that hope can also manifest as illusory optimism based on denial or wishful thinking rather than agency, positive correlations exist between hope and pro-environmental behaviour.⁴¹ Individuals with higher levels of environmental hope have greater capacity for constructive thinking and are more likely to become actively engaged.⁴² The key once again lies in connectivity. Hope comes from inspiration and inspiration comes from sensate in situ experiences of "nature". Given these relationships between emotion and environmental engagement are well documented, emotional responses to fungi should perhaps become a major focus of conservation initiatives.

Fungal conservation is unlikely to be a priority of any political candidate at the next election, the one thereafter and probably not the one after that. There will always be seemingly more pressing and relevant issues that will take precedence over fungal conservation. But as organisms that maintain ecosystem health, greatly influence the success or failure of our terrestrial food production and offer the potential to counter the environmental damage of the Anthropocene, fungi are surely worthy of more than a cursory afterthought in biodiversity conservation. While individual fungal species certainly exhibit their curiosities, it is what they collectively represent in the much greater scheme of connecting the biosphere that needs to be better understood and communicated. Advocating for biodiversity conservation is notoriously difficult. Promoting the significance of the tiny blue mushroom - of fungi as a metaphor for the complex interconnectivities of our planet - could provide one more greatly needed option to encourage a rethinking of humanity's place within the rest of the biosphere.

NOTES

1. Alison Pouliot is an ecologist and environmental photographer. She wishes to thank the two anonymous reviewers for their valuable comments.
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