FUNGI FORAGERS

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OUR PURPOSE: TO RAISE AWARENESS AND INTEREST IN FUNGI OF THE CAIRNS REGION

This newsletter is not associated with any club or organisation but is emailed free of charge to anyone who may be interested. Anyone who wishes to contribute to the newsletter with observations, anecdotes, corrections, comments or photographs is welcome to do so. Although this “newsletter” is science-based we try not to make it too “scientific”. We recognise that there are school children, bush-walkers and others just interested in fungi, and we hope this leaflet will become a medium for furthering that interest. **The emphasis is on fungal biology and ecology** rather than identification.

Barry Muir, Editor Jenn Muir

Field meetings to find interesting species of fungi (not necessarily edible species) are known as 'forays', after the first such meeting organized by the Woolhope Naturalists' Field Club, Herefordshire, England, in 1868 and entitled "A foray among the funguses" [*sic*]. The Woolhope Club was an early member of the British Mycological Society founded in 1896. (Wikipedia)

A FUNGUS BY ANY OTHER NAME

Paraphrased and summarised from Pouliot, A. (2018). *The Allure of Fungi.* CSIRO Publishing.

The choice of words and expressions affects the way fungi are perceived and valued. Russian mycophile Valentina Pavlovna Wasson, considered the word fungi “is an ugly, half-assimilated alien, detached and cold in its emotional personality”. Wasson considered the word toadstool as “soaked in condescension and repugnance”. Fungi have been viewed for centuries with negative associations, both literally and symbolically, in the English language. The menacing image of the mushroom-shaped cloud from volcanic eruptions and nuclear explosions, instils fear and dread.

While the economy and love relationships are described with positive botanical references, being said to bud, blossom and bloom, what are perceived as the societal scourges of crime, scandals, pornography, bigotry, racism, gambling, street clashes and even potholes in the road, are all said to ‘mushroom’. ‘Mushroom’ is also used more generally to depict rapid, sudden or unexpected growth, but more troublesome associations of its use as a verb are favoured by Australian newspaper journalists: ‘Shanty towns are mushrooming on the fringes’ (Canberra Times, 1994); ‘Bigotry, xenophobia, racism and ugly Muslim baiting are mushrooming’ (Conversation, 2015); ‘a disturbance at a Los Angeles high school mushroomed into street clashes between Negro crowds and police’ (Canberra Times, 1967). These headlines represent just a few of the hundreds of examples of the negative use of ‘mushrooming’.

Negative associations of ‘mushroom’ as a verb seem less common in European languages. The French ‘*pousser comme des champignons*’ (sprouting like mushrooms) generally means rapid growth and usually entails feeling genuinely surprised at the development of something rather than a criticism of it. Any negative use in French is probably an English corruption. In the Swedish language, ‘*växa upp som svampar ur marken*’ (to spring up like mushrooms out of the ground) does not carry a negative connotation and simply describes a sudden abundance. To be a *svampplockare* (mushroom picker) is perceived positively, and politicians and TV personalities regularly claim to partake in this reputable pastime searching for edible fungi. In the Finnish language the equivalent expression also means abundance with no negative connotations: ‘*kasvaa kuin sienia sateella*’ means to grow like mushrooms in the rain. There is no negative tone in it; it just means that there is plenty of something.

Negative associations for fungi in English go beyond mushrooming. A quick look at synonyms for fungi on various freely available online thesauri reveals wildly inaccurate and derogatory words. Some such as the 'Power Thesaurus' provides a rather nonsensical jumble of life forms including: alfalfa, moth, worm, ivy, kelp, pimple, viper and yam, making it difficult to draw any connection to fungi at all. Others such as www.thesaurus.com list synonyms for fungi including: affliction, bane, blot on the landscape, canker, contamination, corruption, curse, decay, dump, evil, eyesore, infestation, glop, goo, gunk, mildew, mud, muck, mire, mucus, ooze, pestilence, pollution, rot, scourge, scum, sludge, waste, withering and woe. Roget's Thesaurus gives the option to search synonyms for 'fungus' under the subheadings, 'plant', 'dirt' or 'blight'. As the Internet is a preferred information source about life for many people, particularly younger generations, it is easy to see how warped and erroneous fungal synonyms can easily mushroom!

These synonyms have probably evolved from the combination of the effects of a relatively small selection of pathogenic microfungi, supplemented by ignorance and fertile imaginations. Yet the great sweep of fungi within this vast and diverse kingdom are tarred with the same brush. How did fungi come to be so maligned and muddled in the English language? The historical use of words for fungi provides a good starting point to examine the evolution of fungal language.

Words to describe fungi have long histories dating back almost two millennia, although their precise etymologies are difficult to verify. Spellings and meanings change over time and between authors, and most historical accounts are usually too ambiguous to determine which species were being described. However, fungi did not entirely go unnoticed during the Medieval Period. Over 50 authors mentioned them, even if only cursorily. Pier Antonio Micheli and Flemish botanist Carolus Clusius were exceptional in including folk knowledge in their mycological recordings. Mycological understanding was slow to progress during the Medieval Era as scholars were yet to enjoy the revelations of the microscope. Meanwhile, fungal folk knowledge was growing. However, as it was mostly oral it largely went unrecorded. This was especially true of any knowledge held by women.

The development of medieval medicine, particularly during the eleventh century, saw fungi begin to be included in written texts. Although the efficacy of the remedies and antidotes in surviving manuscripts is dubious, consumers put their faith in them for half a millennium, as few alternatives existed. The Benedictine abbess and herbalist Hildegard von Bingen documented her observations of fungi in her encyclopaedic work on natural history *Liber Simplicis Medicinae* (the first of the nine-book *Physica*) written around 1155. She used several different words to describe fungi and differentiated those that grew in soil from those on trees, the former considered by Hildegard to be harmful and poisonous. Some of her writing on fungi, especially "magic-mushroom" fungi, still remain a mystery today as she wrote about them in a code that has never been fully deciphered. (Editor's note: that seems like a good idea – we will see later what happens when idiots get hold of information).

Fungi captured the attention of other medieval writers including the German Catholic Bishop and philosopher Albertus Magnus, who documented fungi in his book *De vegetabilis et plantis libri septem* published in 1250. The German scholar Konrad von Megenberg (c. 1309 - 1374) also mentioned fungi in his compendium of various natural history themes called *Buch der Natur*.

The exact origin of the word mushroom is uncertain but it probably has either Welsh or Old English roots, evolving from *mushrumps* through various spellings to 'mushroom'. Other authors suggest it could be a corruption of the Old French words *mousseron* or *moisseron*. Early references to fungi from between 1440 and 1732 include *muscheron, moushrimpes, mushrumpes* and *mucerons*. Over the centuries, scholars have drawn connections between *mousseron* and moss (*mousse* meaning moss in French and being a habitat where fungi commonly grow). Its origins have also been associated with the alternative meaning of *mousse* as sea-foam or spume, in concert with archaic ideas about fungi developing from glutinous froth or foam.

The book *The Allure of Fungi* by Allison Pouliot (2018, CSIRO Publishing), is not taxonomic in nature but contains a wealth of anecdotal and science-based information. It is a strongly recommended read, with detailed comments on a wealth of Australian and overseas fungi and their ecology. The Editor recommends it and thanks the author profusely for the enlightenment.

PHOTOGRAPHING FUNGI FOR IDENTIFICATION PURPOSES

Some people take stunning pictures of fungi because they are beautiful in form or colour and make highly artistic images, often worth framing. Sometimes these pictures are sent to mycologists for identification, but it is often quite difficult to identify fungi from pictures. In these days of digital imaging, it costs nothing to take extra pictures, so take several. The key to good photographs is focus, focus and focus again. Take several to make sure at least one is in focus, especially with the very convenient but difficult to hold still telephone cameras which often have fingerprints on the lens!

All fungi

- Take a picture of the overall habitat, such as a section of the rainforest or a picture of the paddock. It can be very helpful in understanding the habitat.
- A closer (but not too close) image to show whether the fungus is growing on wood, soil, old termite mounds, leaf litter, mulch, etc. A picture of a rotting log, for example can show what the decay state of the wood is, and that can help in identification of both the wood and the fungus.
- Photograph the cluster of fungi if it is in tiers and take special note of whether there are root-like structures growing from It and out over the surface of the wood. Photograph those structures (called rhizomorphs).
- Some fungi experts and photographers will only take photographs by natural light. That is fine, but often leads to colour distortions (especially too much blue on cloudy days or in the rainforest) or unwelcome shadows. Take another couple of pix using flash – the colour rendition is usually better, and the harsh background shadow caused by the flash sometimes helps to highlight features like fine hairs or scales. On the other hand, some fungi that have distinctive surface structures, such as do Earthstars and Coral Fungi are better photographed in light from the side as it highlights the texture.

Mushrooms and similar life forms ON SOIL or mulch

- Put something standard like a coin in the picture for size or buy yourself a small ruler with obvious markings ***in millimetres***. Things like lens caps are of limited use (e.g., is the lens cap off a 600 mm or a 40 mm lens)? Similarly, car keys can be variable, as are lollies, boots and hands.
- A photograph of the mushroom cap is great but MUST be accompanied by a picture of the underside of the cap and the stalk. Remember that the fungus is a fruit, like an apple on a tree. It won't kill the fungus if you pick one of the mushrooms and lay it on its side so a picture can be taken of the stalk, and whether it has a ring on the stem, scales or hairs, gills, the way the gills attach to the stalk, spines or pores and other features. To photograph the underside, you do NOT need to get down to fungus level – just collect one and put it in a convenient place such as on a nearby log. There are no fungi that will harm you if you just pick them, unless you are highly allergic – bear in mind that some people come up in a rash just by touching a commercial shop mushroom. If you are worried, use two twigs as chopsticks.
- Some fungi that grow on soil, such as some of the *Amanita*'s, have a sac at the base of the stalk or a long rooting stalk called a shank, or a bulbous tuber-like structure called a sclerotium under the soil, and this is a valuable character to note. For that reason, use a twig or a pocketknife to dig up the fungus, rather than snap it off at the base.
- Try and get a close-up of where the stalk joins the cap. How the gills or pores are situated in relation to the stalk is a vital piece of information. Sometimes, with careful manoeuvring you can even see if there are joining pieces between the gills, whether the gills branch, or how thick the walls of pores are.
- If the fungus bruises or changes colour after you handle it, take a "before and after" pic.

Mushrooms and similar life forms ON WOOD

- Same as on soil but try to get a close-up of where the fungus emerges from the wood. A ring of hyphae, what colour they are, and the presence of rootlike structures called rhizomorphs can give vital clues.

Bracket fungi on trees

- Similar guidelines to above. Photograph the fruit body from above, from the side so its thickness can be estimated and the underside to show whether it has gills, pores or spines, or no visible structures at all.

- Using your pocketknife or brute strength cut or break a piece off the fruit body and take a close up of its internals. Colour, structure and bruising is extremely helpful.
- Photograph the cluster if it is in tiers and take special note of whether there are root-like structures growing from it over the surface of the wood.

YEAST

You may be unaware that yeast is, in fact, a fungus. The word "yeast" comes from the Old English *gyst* meaning to "boil", "foam", or "bubble" undoubtedly from observation of frothing beer or rising bread. Yeast fungi are probably one of the earliest domesticated organisms and archaeologists working in Egypt have found grinding stones and baking chambers for yeast-raised bread, as well as drawings of 4,000-year-old bakeries and breweries.

Yeasts are single-celled fungi that evolved from multicellular ancestors and have been around for hundreds of millions of years. At least 1,500 species are currently recognized, and they constitute about 1% of all described fungal species. Although single-celled, some species have the ability to form strings of connected budding cells known as false hyphae. Most measure about 3–4 micron (a micron is 1/1000th of a millimetre) in diameter, although some are larger. Yeasts, like all fungi, may have asexual and sexual reproductive cycles. The most common mode of vegetative growth in yeast is asexual reproduction by budding, where a small bud (also known as a bleb or daughter cell) is formed on the parent cell. The nucleus of the parent cell splits into a daughter nucleus and migrates into the daughter cell. The bud then continues to grow until it separates from the parent cell, forming a new cell. Some yeasts reproduce by splitting instead of budding, thereby creating two identically sized daughter cells.

The yeast species *Saccharomyces cerevisiae* converts carbohydrates to carbon dioxide and alcohols in a process known as fermentation which is the basis for baking and the production of alcoholic drinks. *S. cerevisiae* is also an important model organism in modern cell biology research and yeasts have recently been used to generate electricity in fuel cells and to produce ethanol for the biofuel industry.

Yeasts are very common in the environment and occurring naturally on the skins of fruits and berries such as grapes, apples, or peaches, and on exuding plant sap. Others are associated with soil and insects. *Candida* and other yeasts have been found living between people's toes as part of their skin flora and yeasts are also in the gut flora of mammals and some insects (in scarab beetles yeast aids the digestion of plant cells by fermenting some sugars) and even deep-sea environments host an array of yeasts. An Indian study of seven bee species and nine plant species found 45 species of yeast from 16 genera in the nectaries of flowers and in the honey stomachs of bees. Most of the yeasts associated with bees were members of the genus *Candida.* Yeast acting as an endophyte (see CFF No. 18, February 2020) in the nectaries of the Stinking Hellebore plant (*Helleborus foetidus* from Europe and Asia) have been found to raise the temperature of the flower, which may aid in attracting pollinators by increasing the release of fragrances.

A black yeast has been recorded as a partner in a complex relationship between ants, their symbiotic fungus, a fungal parasite of the fungus and a bacterium that kills the parasite. The yeast has a negative effect on the bacteria that normally produce antibiotics to kill the parasite, so may affect the ants' health by allowing the parasite to spread. For more on ants and fungi see CFF No. 20, June 2020.

Certain strains of some species of yeasts produce proteins called yeast killer toxins that allow them to eliminate competing strains. This can cause problems for winemaking but could potentially also be used to advantage by using killer toxin-producing strains to make the wine. Yeast killer toxins may also have medical applications in treating yeast infections.

Marine yeasts have been isolated from seawater, seaweeds, marine fish and marine mammals. Some marine yeasts originated from terrestrial habitats and have survived in marine environments. Some marine yeasts are able to produce numerous chemical substances and vitamins with potential applications in the food, pharmaceutical, cosmetic, and chemical industries as well as for environmental protection. A marine yeast was successfully used to produce ethanol using seawater-based media which will potentially reduce the use of fresh water in manufacturing bioethanol as fuel.

Some yeasts may find application in the field of pollution repair. One such yeast, *Yarrowia lipolytica*, is known to degrade palm oil mill effluent, TNT (the explosive), and other hydrocarbons such as fats and oils. It can also tolerate high concentrations of salt and heavy metals and is being investigated for its potential as a heavy metal absorbent. Even the common bakers and brewers yeast *Saccharomyces cerevisiae* has the potential to absorb and detoxify pollutants like arsenic from industrial effluent.

Yeast is used in nutritional supplements for livestock and in human foods, especially those marketed to vegans. It is often referred to as "nutritional yeast". Nutritional yeast is a deactivated yeast, usually *S. cerevisiae*. It is naturally low in fat and sodium as well as an excellent source of protein and vitamins, especially most B-complex vitamins, although it contains little or no vitamin B12 despite claims to the contrary. Thus, some brands of nutritional yeast have added vitamin B12, which is produced separately by bacteria.

Some “probiotic” supplements use the yeast *S. boulardii* to maintain and restore the natural flora in the gastrointestinal tract. *S. boulardii* has been shown to reduce the symptoms of acute diarrhea, reduce the chance of some gut infections, reduce bowel movements in some Irritable Bowel Syndrome patients, and reduce the incidence of antibiotic-, traveller’s-, and HIV/AIDS-associated diarrheas.

Vegemite© and Marmite© are made by adding salt to a suspension of yeast, making the yeast cells shrivel up and causing the yeast's natural digestive enzymes to break their own proteins down into simpler compounds, a process of self-destruction. The dying yeast cells are then heated to complete their breakdown, after which the husks (yeast with thick cell walls that would give poor texture) are separated.

About 20% of biopharmaceuticals are produced using *S. cerevisiae*, including insulin, vaccines for hepatitis, and human serum albumin.

Some species of yeast are opportunistic pathogens that can cause infection in people with compromised immune systems. Yeasts of the genus *Candida* cause mouth and other infections in humans, known as candidiasis. *Candida* is commonly found in the mucous membranes of humans and other warm-blooded animals but sometimes these same strains can become pathogenic. The yeast cells sprout a hyphal outgrowth, which locally penetrates the membranes, causing irritation and shedding of tissues such as the lining of the mouth.

Yeasts are able to grow in acidic foods causing the food to spoil. The growth of yeast within food products is often seen on their surfaces, as in cheeses or meats, or by the fermentation of sugars in juices, syrups and jams. Some can also grow in the presence of common food preservatives like acetic acid (vinegar), benzoic acid, and sulphur dioxide.

FUNGI IN ANTARCTICA

In CFF No. 19 (April 2020) we discussed the breakup of Gondwana and the possible implications for fungal species. You may have noticed that there was one continent left out of the discussion: Antarctica.

Although 70% of the Earth’s freshwater is in Antarctica and that water is almost exclusively locked up in ice. In some ice-free areas of the continent, such as the McMurdo Dry Valleys, precipitation is represented only by snow, and even then is less than 100 mm a year. Less than 1 percent of Antarctica is not covered by ice, so there are few places for plants and fungi to grow. In fact, there are only two species of flowering plants, Antarctic Hair Grass and Antarctic Pearlwort, so life is tough. The sole source of moisture available for fungi is water melted by the sun during the southern summer. Fungi and other organisms are mostly found along the coasts where melted water occurs more frequently. Freezing, of course, leads to dehydration as you can prove for yourself by putting a slice of bread in the home freezer for a couple of days then tasting it after thawing – dry as an old bone!

One of the very few larger fungi (unidentified) from Antarctica. It was discovered on Amsler Island in 2012. Amsler Island is on the Antarctic Peninsula close to South America, so probably one of the warmer spots.

Fungi in Antarctica fundamentally depend on their resistance to dehydration. Most of the fungi (there are not many species) recorded in the Antarctic are forms that reproduce by simple and very rapid production of specialised cells or fragments that then blow around or spread to new locations, rather than reproducing by spores. Filamentous forms and yeasts are most common. Interestingly, the lichens, made up of algae with symbiotic fungi (just like plants with mycorrhizae) have abundant sexual structures although, at extremes, they shift to a life form that lives *inside* rocks a few millimetres below the surface.

Some of the fungi and lichens that are very resistant to dehydration produce "antifreeze" in their cells, usually as concentrations of glycerol or sugars, are tolerant to very low levels of oxygen when they are buried under ice and are found in micro-habitats such as cracks in rocks or tiny pools that thaw in the sun. Research has shown that in protected niches subject to warming by the sun, temperatures at the micro-scale can be far higher than outside temperatures. Even so, most of the Antarctic fungi overcome the worst environmental conditions in a state of dormancy and active growth only occurs occasionally.

Ultraviolet light (UV) is damaging to DNA, proteins, cell membrane and structures within cells and since the 1980s, emissions of human-caused chlorofluorocarbons, (CFCs) have led to a depletion of the ozone layer and this process is continuing despite stopping their use. Ozone stops UV rays. Some fungi have evolved pigments to protect against UV and some have taken to living within the rock or under the soil surface.

Derived largely from:

Ruisi, S, Barreca, D, Selbmann, L, Zucconi, L & Onofri, S. (2007). Fungi in Antarctica. Rev. Environ. Sci. Biotechnol. 6:127–141. DOI 10.1007/s11157-006-9107-y

Photograph from: Rejcek, P. (2012). Mushrooming Problem? Fungi Makes Rare Appearance Near Palmer Station. Antarctic Sun. National Science Foundation Office of Polar Programs.

FUNGAL CONSERVATION

Plants produce and animals consume, but fungi are the great supporters and recyclers. Without them life as we know it could not be sustained on this planet. Yet only 56 species of fungi have had their conservation status globally evaluated for the International Union for the Conservation of Nature (IUCN) Red List Index (RLI) which provides trends within different taxonomic groups, biodiversity as a whole and a list of the most critically endangered species. The 56 for fungi, when compared with 25,452 plants and 68,054 animals (2018 data) is astoundingly poor. Likewise, if you review the top twelve mainstream conservation journals for scientific papers on fungus conservation you will find that only about 3% of the papers deal with fungi. In addition, that coverage was mostly concerned with the threats that these organisms pose to other wildlife.

The United Nations Conference on Environment and Development (UNCED), also known as the Rio de Janeiro Earth Summit, the Rio Summit, the Rio Conference, or the Earth Summit was held in June 1992, to make decisions tailored to promote a sustainable planet for future generations. The summit entailed the idea that changes in human behaviour could progress toward the desired transformation for the environment. Amongst the documentation from the two-week deliberations and meetings included "The Convention on Biological Diversity", the convention relevant to fungi, and aims to conserve and protect biodiversity, biological resources and safeguard life on Earth, as an integral part of economic and social development. At the time of inception, the convention was ratified by 196 parties, including Australia, and requires governments to submit reports and plans describing their activities to protect nature. However, of documents evaluated from over 100 countries, a quarter failed to mention fungi at all, and in more than half fungi were not clearly distinguished from plants.

Australia stopped producing these reports in 2015 and replaced them with another reporting system which is less detailed and less auditable. The latest document, called "Australia's Strategy for Nature 2019–2030, Commonwealth of Australia 2019" makes no mention of fungal conservation.

Editorial Contacts:

Barry Muir, correspondence PO Box 15003, Edge Hill, Queensland 4870; or email unit57.may@gmail.com