FUNGI FORAGERS

No. 23 February 2021

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)

STATUS OF CFF (PART 2)

In the last edition of Cairns Fungi Foragers (CFF) I had a grump about lack of input, not because I want people to write articles so that I don’t have to, but rather to get people to RECORD their findings and observations. I believed that some of you have surely been finding fungi or been doing research online or just Internet surfing and have found all sorts of fascinating fungal facts. The response to my request was underwhelming. Out of nearly 400 recipients of CFF a half-dozen told me they enjoyed reading CFF and would like me to continue, and one requested a specific article. That was it – NOTHING ELSE!

MORE PANDEMICS TO CONSIDER

Covid-19 is not the only epidemic to consider. The United Kingdom lost most of its elm trees to an epidemic of the fungus Dutch Elm Disease in the 1970s and in about 10 years 30 million elm trees died. Elms were the nation’s second most important source of hardwood timber, a key component of woodlands, and home to at least 80 species of invertebrates. Diseases like Dutch Elm have been criss-crossing the world for centuries, shipped along with exotic trees and shrubs, timber and wood products, even packaging.

With climate change causing wildfires to grow fiercer and more frequent and world leaders vowing to stop forest clearing and to plant trillions of trees to help restore nature and tackle the climate emergency, there’s an urgent need to find ways to fight future epidemics. 2020 was the United Nations Year of Plant Health, so early 2021 is a good time to see how we’re doing……and the blunt answer is badly.

In their native ranges, trees and pathogens evolve in tandem: trees acquire resistance, pathogens try harder, trees ramp up their defences another notch — and so on until they reach a sort of truce where trees tolerate infection and the pathogen does little harm. Transport the pathogens to elsewhere in the World, though, and things can be very different.

In the United States of America there were once magnificent chestnut forests that stretched from Maine to Alabama, from the East Coast west to Michigan and southern Illinois. Chestnut Blight, a fungus native to

China and Japan, was introduced with ornamental Japanese Chestnuts in the early 1900s. It was first reported in 1904 in the Bronx Zoo and by 1940 the fungus killed more than 3 billion native trees and the American chestnut forests had gone.

In the early twentieth century in Europe an unknown disease swept the continent from Scandinavia to southern Italy. Dutch botanists identified the pathogen responsible as a microfungus carried by bark beetles that breed in mature elms. Infected trees try to block the pathogen's progress by plugging their water transport system, suicidally depriving themselves of water. That epidemic died down in the 1940s — but in the late 1960s, a far more aggressive form of the same fungus showed up. Imported to the UK in a consignment of elm logs from Canada and distributed across the nation through the sale of logs from diseased trees, it swiftly dispatched more than 90 percent of the United Kingdom's elms.

Sudden Oak Death, caused by *Phytophthora ramorum* fungus, has ravaged Oak and Tan Oak forests along the United States West Coast. Sudden Oak Death has reached the United Kingdom too, although confusingly here it's mostly killing larch trees, while Ash Dieback, another fungal disease, is poised to reshape the British landscape as dramatically as Dutch Elm Disease once did. In the UK, Ash Dieback was first detected in 2012 — at least seven years after it's thought to have arrived, and by then it had already spread widely. It's now on course to kill an estimated 70 percent of the country's 150 million to 200 million ash trees.

Jarrah trees being killed by *Phytophthora cinnamomi.*

Australia's Cinnamon Fungus, *Phytophthora cinnamomi,* arrived from Southeast Asian cinnamon trees in the 1930s and poses such a risk to our native trees that it is now officially designated a "key threatening process." In 30 years, it began to destroy Western Australia's Jarrah Forest, an internationally important hotspot of biodiversity that is home to hundreds of unique plant, fungus and animal species. The *Phytophthora* fungus attacks roots; starving trees and shrubs of water and nutrients and progressively killing them from the top down — a phenomenon known as dieback. The disease is now widespread throughout Australia, attacking more than 40 percent of native species, including half of the endangered species in the Jarrah Forest, with some close to extinction. It destroys hundreds of iconic species, even grasses.

One of the latest horrors in Australia is Myrtle Rust (*Austropuccinia psidii*), a fungal pathogen that circled the globe and made landfall in New South Wales in 2010. The rust infects trees and shrubs belonging, as the name suggests, to the Myrtle Family — and Australia is home to at least 2,250 native myrtle relatives including eucalyptus, tea trees and paperbarks. With more than 350 Australian species known to be susceptible, within a few years of arrival the disease was doing serious damage to native ecosystems. At least two once-common trees are now known to be critically endangered, and the Native Guava (*Eupomatia laurina*), also called Bolwarra, is at imminent risk of extinction.

Native to Latin America, Myrtle Rust was discovered in Brazil in 1884 and spread slowly across South and Central America and the southern US. In 1973, it devastated plantations of Australian eucalypts in Brazil, alerting the world to the risk it poses. In 2005, the pathogen reached Hawaii and since then reaching Asia, the Pacific, Australia and South Africa.

Europe has pathogens from the Americas and America has some from Europe. The US has Chinese pathogens and China has trees dying from American pathogens. Most go undetected until they are on the loose, and each year they cause the loss of crops worth billions of dollars and do incalculable damage in the wider environment. Speedier travel and the rapid expansion of trade, including the movement of billions of plants for the horticulture industry, have proved disastrous. Experts say the scale of global trade is overwhelming attempts to control accidental imports of pests and pathogens.

Myrtle Rust on *Syzygium* leaf. Internet image

Cures and treatments remain elusive; fungicides and vector-zapping pesticides can sometimes help in commercial settings but not in the wider environment, where the task is too big and the remedy too ecologically harmful. In almost every case, the main control strategy is the culling of trees. Better, then, to stop pathogens arriving in the first place: that has led to tougher quarantine procedures, rigorous health checks and tighter regulation of the plant trade.

What can you do to help? Never EVER try to import seeds or cuttings from overseas. There is always the (however remote) chance they may slip through the Border Control net and could contain pathogens. However good our system of quarantine checks, we are going to miss things. Spotting insect pests is difficult enough but think how much harder it is to detect microscopic bacteria and fungi, especially when infected plants often show no symptoms. There's no indication anything is wrong until they hop onto another species, and away they go. To make matters worse, some potential tree-killers aren't yet on any checklist: unknown and unseen, they have a free pass until a sharp-eyed forester, gardener or nature-lover spots trees sickening with a puzzling new disease.

And don't think that seeds, plant cuttings or plants are OK to move around if they are already established in Australia, our own State or even in our suburb. Spotting early signs of disease in commercial plantings can be pretty near impossible with pathogens that are symptomless for many months or even years. Basically, when you are looking at symptoms, you are looking at history. The disease has already moved on. We are aware of this issue in Cairns with Yellow Crazy Ants and other pests and avoid moving potted plants around without careful inspection and knowing they come from a reliable source. Spotting plant pathogens is a lot more difficult.

Once in, if they encounter susceptible hosts — and some pathogens can infect hundreds of species — they establish a foothold and begin to spread. Some, like Myrtle Rust and Ash Dieback, travel naturally via windblown spores, while Sudden Oak Death and Cinnamon Fungus pathogens disperse more in rainwater. But all advance further with human help — distributed through plant sales, in soil-filled tire treads, even on hikers' clothing and footwear.

A good example of introduced fungus. It is believed this hyphal mass probably grew from a single spore introduced accidently into a cave in Western Australia by a cave explorer.

Climate change also figures in the equation: changes in temperature, wind patterns and rainfall aid both survival and dispersal of pathogens, encouraging their expansion into newly hospitable areas. Warmer, wetter seasons see some pathogens spread much more prolifically, while the frost-sensitive Cinnamon Fungus benefits from Europe's increasingly milder winters and is likely to spread northward on that continent.

You cannot always predict if an introduced species will become an issue at a national or a local level. You only know it's a disaster once it is.

Extracted and paraphrased from: Pain, S. (Sept. 28, 2020). Why Tree-Killing Epidemics Are on the Rise. smithsonianmag.com.

FUNGAL CHEMISTRY – MUSHROOMS AND RADIOACTIVITY

We all know that green plants and some green animals can absorb energy from visible light using pigments such as chlorophyll, and then use that energy to break down water and use phosphorous to generate usable chemical energy. This process is called photosynthesis. There is evidence that some fungi may be able to use radioactivity for the same purpose.

Hyphae and black fruit bodies of a radiation "consuming" fungus at Chernobyl (Internet image)

After the Chernobyl Nuclear Power Plant disaster in the Ukraine in 1986 certain fungi species were found growing inside the destroyed reactor. Subsequently, experiments with three different types of fungi have shown that melanin, a black pigment also found in human skin, can absorb the high levels of energy in radiation and somehow turn it into a biologically useful (and benign) form, akin to a version of photosynthesis. Scientists have been able to see significant growth of the black fungi relative to the white ones in a radiation field and it is believed ionizing radiation changes the electron structure of the melanin molecule and that fungi with a natural melanin shell (for example the soil-dwelling *Cladosporium sphaerospermum* and yeastlike *Wangiella dermatitidis* varieties), which, when deprived of other nutrients, grew better in the presence of radiation. They also report that fungi induced to produce a melanin shell (e.g. the human pathogen *Cryptococcocus neoformans*) grew well in such levels of radiation, unlike those without pigment. Further, an albino mutant strain of *W. dermatitidis* failed to thrive as well as its black cousin when exposed to 500 times the normal amount of ionizing radiation (still well below the level of radiation necessary to kill tough fungal forms).

Melanin seems to absorb ultraviolet rays, acting as a natural sunblock for human skin. Melanin is very good at absorbing energy and then dissipating it as quickly as possible," says Jennifer Riesz, a biophysicist at the University of Queensland in Brisbane, Australia. "It does this by very efficiently changing the energy into heat." Other scientists at the Albert Einstein College of Medicine speculate that the melanin in this case acts like a step-down electric transformer, weakening the energy until it is useable by the fungi. The energy becomes lower so it can be used by the fungus as chemical energy. These scientists argue that protection doesn't play a role, it is just energy conversion.

Fukushima radioactive fungi (Internet image)

The Japanese Fukushima Daiichi Nuclear Power Plant accident in 2011 was caused by a massive earthquake and tsunami and resulted in wide-range radioactive contamination in the surrounding environment. After the accident, research studies for the radioactivity of wild mushrooms were conducted in Fukushima and other prefectures around Japan and were also monitored in China and Northern America. These studies indicated that the radioactive contamination levels in mushrooms might depend on species and genus.

An experiment was undertaken at the International Space Station in December 2018 and January 2019 to test whether fungi could be used as protection against radiation, especially in space. The experiment used *Cladosporium sphaerospermum*. Results were published in July 2020 and seemed promising.

FUNGAL CHEMISTRY – THE COMMON TOXIC CHEMICALS AND THEIR IMPACTS

(largely paraphrased from Wikipedia)

The last edition of CFF discussed some toxic fungi. This article provides information on the chemicals that make them toxic. Most toxic chemicals in fungi fall into seven groups, as below.

Alpha-amanitin: amatoxins are found in some mushrooms in the genus *Amanita*, but also in some species of *Galerina* and *Lepiota*. When consumed, for 6–12 hours, there are no symptoms. This is followed by a period of gastrointestinal upset (vomiting and profuse, watery diarrhea). This stage typically lasts 24 hours. At the end of this second stage severe liver damage begins. The damage may continue for another 2–3 days and kidney damage can also occur. Some patients will require a liver transplant and overall mortality is between 10 and 15 percent.

Orellanine: a few species in the very large genus *Cortinarius* contain this toxin. It causes no symptoms for 3–20 days after ingestion. Typically around day 11, the process of kidney failure begins, and is usually symptomatic by day 20. These symptoms can include pain in and near the kidneys, thirst, vomiting, headache, and fatigue. People who have eaten mushrooms containing orellanine may experience early symptoms as well, because the mushrooms often contain other toxins in addition to orellanine. A related toxin that causes similar symptoms but within 3–6 days has been isolated from some toxic *Amanita*s.

Muscarine: muscarine is found in mushrooms of the genus *Omphalotus,* and also in The Fly Agaric *Amanita muscaria*, although it is now known that the main damaging effect of this mushroom is caused by ibotenic acid. Muscarine can also be found in some *Inocybe* species and *Clitocybe* species, and some red-pored *Boletes.* Muscarine stimulates certain receptors of the nerves and muscles. Symptoms include sweating, salivation, tears, blurred vision, palpitations, and, in high doses, respiratory failure.

Gyromitrin: is found in mushrooms of the genus *Gyromitra* and a gyromitrin-like compound has also been found in mushrooms of the genus *Verpa*. Stomach acids convert gyromitrin to monomethylhydrazine (MMH), a compound employed in rocket fuel. It affects multiple body systems and blocks an important neurotransmitter leading to stupor, delirium, muscle cramps, loss of coordination, tremors, and/or seizures. It causes severe gastrointestinal irritation, leading to vomiting and diarrhea. In some cases, liver failure has been reported. It can also cause red blood cells to break down, leading to jaundice, kidney failure, and signs of anemia.

Coprine: Coprine is found mainly in mushrooms of the genus *Coprinus*, although similar effects have been noted after ingestion of certain *Clitocybe*. Coprine inhibits aldehyde dehydrogenase (ALDH), which, in general, causes no harm, unless the person has alcohol in their bloodstream while ALDH is inhibited. This can happen if alcohol is ingested shortly before or up to a few days after eating the mushrooms. In that case the alcohol cannot be completely metabolized, and the person will experience flushed skin, vomiting, headache, dizziness, weakness, apprehension, confusion, palpitations, and sometimes have trouble breathing.

Coprinus comatus is considered edible yet contains coprine toxin

Ibotenic acid: Ibotenic acid converts to muscimol upon ingestion. *A. muscaria*, the "Fly Agaric" mushroom, is known for the hallucinatory experiences caused by muscimol, but some other Amanitas contain the same compound. Fatalities have been associated with *Amanita* and consumption of any of these mushrooms is likely to be dangerous. The effects of muscimol vary, but nausea and vomiting are common. Confusion, euphoria, or sleepiness are possible. Loss of muscular coordination, sweating, and chills are likely. Some people experience visual distortions, a feeling of strength, or delusions. Symptoms normally appear after 30 minutes to 2 hours and last for several hours.

Arabitol: is found in small amounts in oyster mushrooms (*Pleurotus ostreatus*), and considerable amounts in *Suillus* species and *Hygrophoropsis aurantiaca* (the "False Chanterelle"). Arabitol is a sugar alcohol, similar to mannitol (the sugar that makes up about 50 % of commercial *Agaricus bisporus* mushrooms), which causes no harm in most people but causes gastrointestinal irritation in others.

IS THERE ANY CHANCE OF HARM FROM BREATHING IN FUNGAL SPORES WHEN WE ARE OUT IN THE BUSH?

This excellent question was raised by Shane K., one of CFFs readers. The short answer is ‘no’, although there is one dangerous and common large (up to 100 mm or so, but usually smaller) fungus that is widespread in Queensland. It is *Schizophyllum commune* and it is dangerous to breathe in the spores of this fungus as they are known to have germinated in people’s lungs causing serious infections. Although common, the chances of accidently encountering it are small. Below are several pictures so it can be recognised.

Fungi are increasingly recognised as an important part of our own internal environment, with the right mix of fungi in a "mycobiome" playing a role in our gut and skin health. Occasionally, however, we encounter one of the “bad guys”, but these are nearly always moulds of some kind.

Fungal lung infections are less common than bacterial and viral infections but are more difficult to diagnose and treat. Because fungi are everywhere in soil (about 75,000 species have been identified), it is not possible to consider eliminating fungal infections. They mainly affect people living in hot, wet, geographic areas (sound familiar?) and those with immune deficiency, and their virulence varies from causing no symptoms at all to causing death.

Rates of human fungal infections have surged over the last 20 – 30 years. There are more and more people with cancers of immune cells of the blood, bone marrow and lymph nodes, and those with human immunodeficiency virus (HIV) infection. There is also a massive increase in the number of patients taking immunosuppressive drugs to avoid rejection of transplanted organs or stem cells and as treatment for autoimmune diseases, such as rheumatoid arthritis. Immunosuppressive drugs such as corticosteroids for asthma and joint inflammation are too frequently prescribed and the numbers of people with serious medical issues like smoking or diabetes has greatly increased, often owing to poor lifestyle. Out-of-control population growth, increasing density of urban development, and natural mould-causing disasters such as flooding caused by cyclones and hurricanes, which have been proven to be increasing in frequency due to climate change, are also strongly implicated.

The commonest fungus that will potentially infect our lungs is *Aspergillus*, a mould common in compost heaps, air vents, mouldy ceilings, poorly ventilated bathrooms and in airborne dust. Breathing its spores is unavoidable. Most people inhale hundreds of *Aspergillus* spores every day without being affected, but if the immune system is weakened by drugs or the person has AIDS it can grow rapidly.

Interestingly, *Aspergillus* infections are usually treated medically with a class of anti-fungal agents called azoles and, occasionally, surgery. Azoles are cheap, potent, and non-toxic to us, but they are also used extensively by farmers to protect their crops. Widespread use of azole fungicides in agriculture has had the unintended effect of pushing *Aspergillus* to develop resistance to the chemical so it is now harder to treat.

Another nasty fungus causes cryptococcal meningitis and has been known for hundreds of years, but only became an issue with the HIV epidemic, where it was one of the biggest killers. One species, *Cryptococcus gattii*, can also infect healthy people, especially in tropical and subtropical regions although, with global warming, it is now spreading into temperate areas. It is endemic in Australia, seems to be associated with *Eucalyptus* trees and has been implicated in meningitis in forestry workers and koalas.

A number of recent studies suggest that climate change has disrupted the natural habitat of some fungi, leading to significant changes in their distribution and impact. One example is the noticeable increase in the incidence of the fungus coccidioidomycosis, which has been linked to distinct patterns of environmental and climatic change in parts of Arizona in the USA between 1998 and 2001.

The most effective way of preventing fungal infections if you are immune-compromised is by avoiding activities that are associated with sources of the spores but otherwise there is little need to worry.

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