FUNGI FORAGERS

No. 13, February 2019

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

This newsletter is not formally published and 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

REQUEST FOR ARTICLES

The Cairns Fungi Foragers has now been going for two years and this is issue No. 13 yet there has been only a handful of contributions from readers. I research and compile the majority of articles, but feel it is about time some of the 72 people who receive the newsletter, free of charge about every two months, contributed occasionally. If I can do it – so can you. How about an article, ecological notes from the field or even an occasional photograph?

REMINDER: Membership of QMS for 2019 commenced on 1 January (to 31 December 2019) and we recommend that if you are planning to join Queensland Mycological Society (QMS) or renew your existing membership that you do so now for just $25 per person. There are many benefits, including access to members-only parts of the QMS website with masses of information. There is also a free quarterly newsletter, with identifications, field trip reports, etc. Go onto http://qldfungi.org.au to learn more.

Calendars

Just because it's February already, don't be put off. The QMS has produced another superb fungus calendar for 2019. These are available from info@qldfungi.org.au for $15 each for non-members ($10 for QMS members) plus postage. Be different – give the photo-enhanced pix of cityscapes a miss and get fungi instead.

LAUNCH OF POCKET FIELD GUIDE "*Australian Tropical Mushrooms & Other Fungi*"

Following from a very successful project in 2018, a Pocket Field Guide specifically for the Tropical Monsoon region of Australia is about to be launched.

This resource is long overdue for a biodiversity hotspot across the tropics. The pocket guide will illustrate 118 species with an introduction to the Fungal Kingdom and its different life-forms (morphogroups), plus information on substrate, trophic (feeding) role, size, spore print colour, and toxicity for each species. The species chosen are ones that occur commonly in Tropical Australia, and some that are new finds or new distributions in Australia. Drs Sapphire McMullan-Fisher, Matthew Barrett and Frances Guard have combined their knowledge and skills to produce these informative handy brochures. These Pocket Guides will retail at $10 each, with wholesale price for 10 or more at $5 each.

The **Official Launch** of the guides will take place in **Innisfail** (at Terrain, NRM, 2 Stitt St., Innisfail) on **Friday 15th March at 6.30pm**, hosted by the Johnstone Ecological Society. The guest speaker, who will launch the

Guides, is Adjunct Professor Peter Valentine from James Cook University, School of Engineering and Science. This will be a celebration! Please let the organisers know for catering purposes if you will be there. Other guests will include Dr Roy Halling, Boletes expert and Curator of Mycology at New York Botanic Gardens, Dr Barbara Thiers, expert in liverworts and Director of New York Botanic Gardens Herbarium, and Dr Teresa Lebel, mycologist, expert in Australian truffles from National Herbarium, Melbourne.

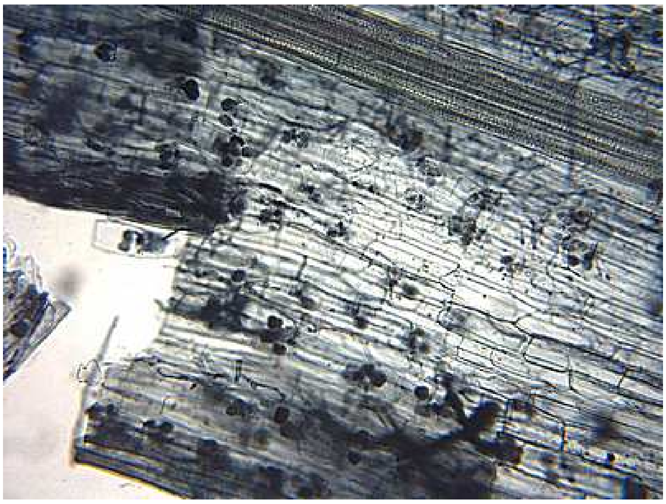
As well, the Johnstone Ecological Society will host an **Introductory Fungi Workshop** on Friday 15th March at 1.30pm, and a **Fungi Walk with the Experts** on Saturday 16th at 9am. Participants are welcome, but must book in. Further **Workshops** will be held at **TREAT, Lake Eacham** on Friday 22nd March at 11.30am, **Kuranda Envirocare** Sunday 24th March at 9.30am, and **Cairns Botanic Gardens (Flecker Garden)** Monday 25th March at 9.00am in the Café adjacent to Friends House. Again, participants are welcome, but must book in. There will be some **Fungi Walks/Forays** in the Malanda, Mt Bartle Frere area on Thursday 21st March, at Davies Creek on Saturday 23rd March and a plant and fungi walk in the Cairns Botanic Garden on the 25th March. Bookings are essential. **For all enquiries, please contact Fran Guard on memsec[at]qldfungi.org.au.**

MYCORRHIZAE

If we classify fungi according to their source of nutrition, we arrive at three main types: saprophytes (decay fungi); parasitic fungi that feed on plants, animals and other fungi - often causing disease or death; and symbiotic fungi – those that work together for the mutual benefit of both. The most important of this last group are the mycorrhizal fungi.

Mycorrhizal fungi were briefly introduced in the very first article in the very first Cairns Fungi Foragers (CFF No.1 February 2017) because they are so fundamental and important in our existence. This article expands on the original. A glossary of technical words (**in bold**) is provided at the end of the article.

The term mycorrhizae is from the Greek mykos meaning fungus and riza meaning root. Mycorrhizae are a symbiotic (sym = together, biotic = life) or co-operative “mateship” between a fungus and a plant, to the benefit of both. The fungus may live within the cells of a plant’s roots, known as **arbuscular mycorrhizal (AM)** fungi, or attached to the outside of the plants root cells, known as **ectomycorrhizal (EM) fungi.**



Microscope photograph of arbuscular mycorrhizae (AM) inside the root cells. Borrowed from https://en.wikipedia.org/wiki/Arbuscular_mycorrhiza

Ectomycorrhizal fungi (EM) growing on plant roots. Borrowed from https://en.wikipedia.org/wiki/Ectomycorrhiza

The mycorrhizal arrangement is helpful to both because the plant passes sugars made using photosynthesis and sunlight to the fungus and the fungus passes the plant nitrogen, phosphorous, minerals such as copper and zinc and other substances which it has extracted from the leaf-litter and soil. The enormous surface area of the fungus mycelia help the plant by passing water to the roots, helping the plant in times of drought. It has been shown that water is moved by fungi from wet areas to dry areas within days and that this can, in turn, result in up to 2,800 times increase in carbon available to the plant and a 2.5 - 3.5 times increase in **enzyme** activity within the soil. The fungus can also protect plants from certain bacterial, fungal and viral diseases as many produce antibiotic substances, and can modify soil acidity to make it more hospitable for both the host and the fungus. There are many plant seeds, such as orchids, that won't germinate unless their fungal partner is present, so presumably the fungus produces some enzyme or other chemical that causes or helps the seeds to germinate.

The earliest fossils in which mycorrhizae have been detected are around 460 million years old, and it is believed that mycorrhizae may have been what permitted green plants to leave the seas and begin to colonize land. Mycorrhizae are present in 92% of plant families (80% of all species) with more being found all the time. It has been suggested that maybe as much as 95% of all plants on the planet have mycorrhizae. There are a few exceptions, such as members of the Banksia / Grevillea family (Proteaceae) and perhaps some aquatic plants, although little research has been done on the subject.

Root and foliage growth of a plant without (left) and with (right) mycorrhizae
Borrowed from https://www.usemyke.com/en-us/tips/benefits-of-mycorrhizae-for-your-plants-and-trees/

Without mycorrhizae a few species would survive but grow very poorly. For example, all the fruit trees including mango, stone-fruits and citrus, coconuts, coffee and tea, grapes, melons, peanuts, all the tree nuts such as pecans, walnuts and cashews, all the herbs and spices, all bamboos and palms, all grain crops like wheat, oats and barley, sweetcorn, all the beans and peas, all the cactus species, all the flowering plants such as roses and daisies, cacao (chocolate), all vegetables such as carrot and celery, cucumber, lettuce and tomatoes, all the animal fodder grasses and clover, fibre crops such as cotton, flax and hemp, timber species such as eucalyptus, teak and pines, rubber trees, sugar cane and tobacco have mycorrhizae. In other words, all our foods, both vegetable and animal, are dependent on mycorrhizae. All our clothing and natural building materials are also dependent on these fungi. We can't even say that electricity, metals and plastics are not dependent on fungi because the fuel we burn in power stations and mining operations, and the plastics we use, were derived from coal, oil or natural gas and these fossil fuels were created by green plants that lived with their associated mycorrhizal fungi before they became fossilised.

The AM mycorrhizae appear to be the most ancient type and have remained virtually unchanged since they first appeared in the fossil record. AM are formed only by fungi in the fungal division Glomeromycota and although AM are found in 85% of all plant families, and occur in many crop species, they do not produce large fruiting bodies and so go unnoticed. Nonetheless, one very important thing they do is to produce a special protein called glomalin, which is one of the major stores of carbon in the soil. Glomalin also helps bind the soil together, slowing or preventing erosion, making it lumpy so it drains well but holds moisture, and making the soil sufficiently cohesive (sticky) that animals such as earthworms can burrow through it without their burrows falling in around their ears (if they had ears!). Glomalin thus improves soil structure in all soils but particularly in damaged farm soils.

The beautiful big *Amanita* species are amongst the most-often seen mycorrhizal fruit bodies on trees and shrubs. These were growing on the roots of *Gillbeea adenopetala* (Pink Alder) a Cairns rainforest tree

Frequently seen are the large fruit-bodies of EM fungi which include dozens of well-known genera such as *Amanita, Boletus* and its relatives, *Cantharellus, Clavaria* and other coral fungi, *Cortinarius, Entoloma* (not all species)*, Pisolithus* and many of the other puffballs, *Hebeloma, Inocybe, Lactarius, Lyophyllum, Russula,* and *Tricholoma.* Some, such as *Amanita,* form mycorrhizas with many different plants while others such as some of the *Boletus* group are found with only one or two particular plant hosts. An individual tree may have 15 or more different EM partners at one time, but the relationship may not be as simple as it appears. For example, **nutrient**s can be shown to move between different plants through the fungal network. In North America carbon has been shown to move from Paper-birch trees into Douglas-fir trees, thereby promoting succession in some North American forest **ecosystems**. In other words, the individual trees "talk" to one-another via the "soil-wide web" – I guess we could call it "tree-mail". This system is known to be present in both rainforest and eucalypt forest in Australia but is not well-studied. It allows trees to assist their seedlings by passing nutrients to them via the tree-mail system and to warn other trees on the same soil-wide web that leaf-eating insects or leaf-eating mammals (and perhaps even gardeners or foresters) are around. This gives the message-receiving trees the opportunity to produce distasteful or poisonous chemicals in their leaves to deter the pests.

Whether similar roles are played by fungi in Australian forest succession, such as rainforest drying out and becoming eucalypt forest after physical damage to the forest, or a drying climate, has not yet been investigated.

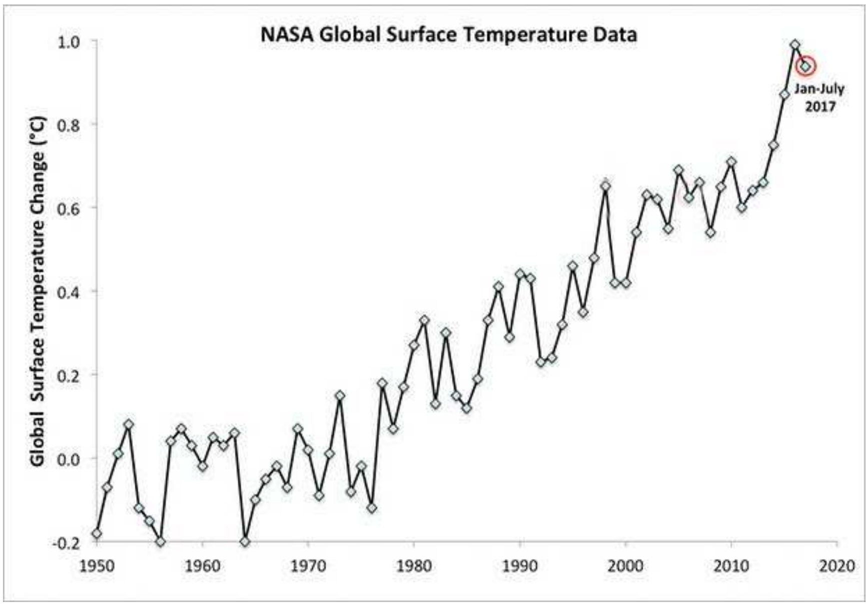
The EM fungus *Laccaria bicolor* has been found to lure and kill springtails (tiny animals that live in the soil and leaf litter) to obtain nitrogen, some of which may then be passed to the mycorrhizal host plant. It seems that some EM fungi lack the enzymes involved in breaking down plant cell walls, thereby preventing damage to the plant root cells during early growth. By contrast, other EM fungi may have the ability to live either as EM fungi or independently, breaking down litter and soil to obtain their nutrition independent of any plants.

Farming methods such as ploughing, crop rotation, adding fertiliser (especially super-phosphate which is high in toxic metals), and pesticides (such as glyphosate weed-killer), kills or damages mycorrhizal structures.

This in turn reduces the fungus' ability to provide nutrients for the plant, requiring the addition of more fertiliser, which kills more fungi, etc., in a vicious cycle.

The cracked and pitted hard-skinned puffball *Scleroderma* is mycorrhizal on the roots of Alexandra Palms (*Archontopheonix alexandrae)* in the Cairns Botanic Garden. It can be up to 10 cm in diameter.

Mycorrhizae allow survival of seedlings that would otherwise never compete, in effect increasing the number of plant species in any given place. Below-ground variety of fungi is one of the major reasons for above-ground plant richness in ecosystems. Even in gardening, a rich mycorrhizal collection reduces transplant shock, extends the growing season, plants grow larger, flower earlier and produce higher fruit and seed yields, provide protection from attack by soil-borne diseases and improves the ability of plants to tolerate environmental stress such as drought.



We have a warming climate, as shown in the NASA diagram at right, and farmers and gardeners are looking for ways to grow healthy plants, while minimizing the use of water and expensive chemicals. The demands on water have never been greater than they are today and with rising population demands are likely to further increase. Soils have become nutrient deficient due to more than a hundred years of over-intensive farming, overuse of chemical fertilizers and from the effects of industrial pollution. The reason fertilisers lead to nutrient-deficient soils is that the fertilisers contain metals that kill the soil fungi, allowing the fertilisers to rapidly leach out of the soil which then requires more fertilisers, and so on. Pressure on land is rising rapidly and human populations are increasing in areas where natural soils have been removed by human over-use or through becoming deserts as the climate warms. Mycorrhizae can play an essential role by improving plant health in poor soils and, through their ability to store large amounts of carbon, they may ease some of the effects of global warming.

Glossary

Arbuscular mycorrhizal (AM) fungi – mycorrhizal fungi that live within the cells of a plant's roots.

Ecosystem – the association with and relationships between fungi, plants and animals with each other and the environment in which they live

Ectomycorrhizal (EM) fungi – mycorrhizal fungi attached to the outside of the plants root cells.

Enzyme – proteins produced by cells to help chemical reactions to take place.

Nutrients – any substances, including minerals, that are needed by a fungus, plant or animal to keep its cells functioning and to grow.

DECAY FUNGI

(Part 1 – FUNGI THAT DECAY PLANTS, ESPECIALLY WOOD)

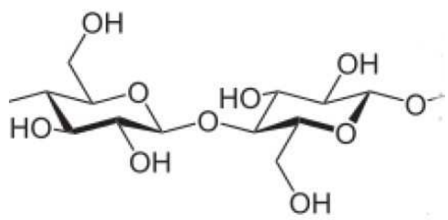
In addition to mycorrhizal fungi, there are many that have the primary role of decay. Fungi that decay wood, fallen leaves and mulch, animal carcases, and even other fungi are vital for breaking down complex materials and converting them into nutrients that plants and even animals and other fungi can use – in other words they are the recyclers in the environment.

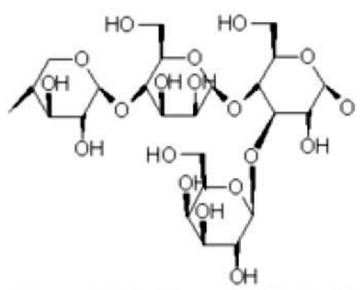
There are considered two basic types of recyclers; those that decompose wood and woody materials such as mulch, and those that decay animal and fungal tissues. Some of these can become pests or diseases, such as wood-rotting fungi that damage plantation trees, or grow on us, such as ringworm and tinea. This first part of our discussion on decay fungi deals with decay of wood.

Plant (Wood) Decay

Plant matter both living and dead is constantly under attack by fungi, insects, bacteria and the weather. For example, even in carefully managed timber plantations it is estimated roughly one-tenth of forest products are destroyed each year by decay. In natural or near natural rainforest, and even in our gardens, this proportion is probably much higher but if this didn't happen we would be quickly buried in a sea of dead plant debris. Fungi have a major role to play in the decay process, not only of trees but also shrubs, grasses, mosses and, of course, all dead and dying branches, stems, roots, leaves and fruit - if it's organic, it decays.

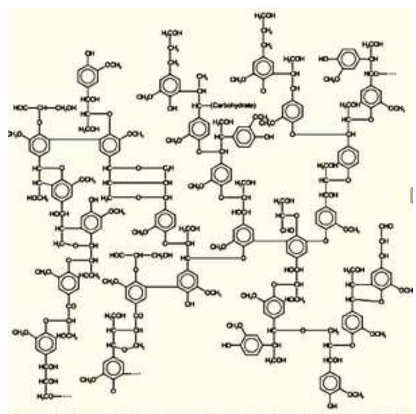
In order to understand decay of plant material we first have to understand what this debris is made up of. The three major components of woody material are cellulose, hemicellulose and lignin. **Cellulose** is a chain of up to 15,000 linked glucose molecules joined end to end in an unbranched chain. A diagram of what a tiny part of a cellulose molecule might look like is at right. Cellulose is a component of the cell wall of all green plants including mosses and ferns, many forms of algae, some fungi and some bacteria. Most wood is made up of about 40–50% cellulose.





Hemicellulose, unlike cellulose, consists of only 500–3,000 sugar molecules, may have other types of sugars as well as glucose, and the molecule may be branched, as shown in the diagram at left. Hemicellulose occurs together with cellulose in almost all plant cell walls and while cellulose is crystalline, strong, and resistant to breakdown, hemicellulose is unstructured and with little strength. It is therefore more prone to decay than cellulose.

Lignin molecules are very complex, as shown in the diagram at right. Lignin is the key structural material in the support tissues of most plants and some algae but not in mosses or ferns. Lignin is particularly important in the formation of cell walls, especially in wood and bark, because it lends rigidity and does not rot easily. The chemical composition of lignin varies from plant species to species but is very complex. Lignin is unusual because of this variability and lack of a definite structure. Its most common function is strengthening of wood. Lignin fills the spaces in the cell wall between cellulose and hemicellulose and links with them to form a tight structure. The lignin structure is generally different between softwoods like pines and hardwoods like most of our rainforest trees. It is different again in less woody plants like palms, grasses and herbs.



There are basically three types of wood decay; white rot, brown rot and soft rot. These terms come from the forestry industry, but are useful to us as well. Fungi that cause white rot will decay cellulose, hemicellulose

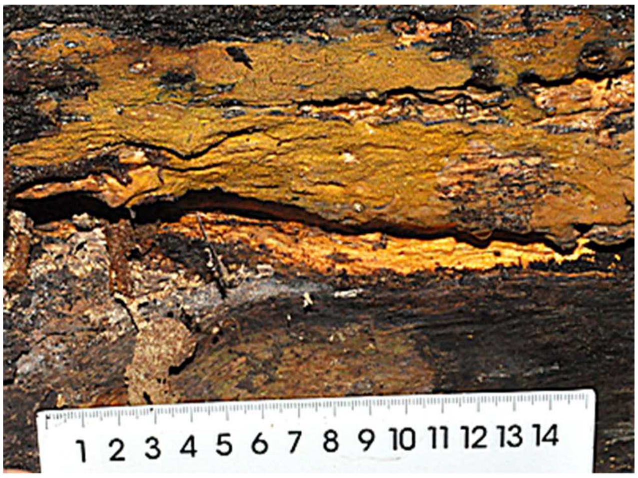
and lignin. The lignin is brown, so its decay and loss leaves white cellulose and hemicellulose behind. Then the hemicellulose, being more fragile, is next to go, being broken down by hydrogen peroxide manufactured by the fungus. The decayed wood looks white and crumbly because only the cellulose remains and generally decay is from the centre of the wood (or woodchip) outwards. White rot fungi are all members of the Basidiomycete fungi (the common mushroom types) and prefer hardwoods although they also decay some softwoods.

White rot in hardwood. The lignin has all been consumed, leaving white fibrous cellulose and some remnant hemicellulose. Some of the fungal hyphae are visible

Armillaria, Ganoderma (the Conk fungi), *Schizophyllum commune*, *Trametes versicolor* (Turkey Tail) and *Pleurotus* (Oyster Mushrooms) are typical white rotters that usually enter living plants via wounds on the branches, trunk or roots. That is why selective logging in forests often eventually leads to the death of the surviving trees – they become infected by fungi through the wounds caused by falling trees breaking branches and scraping bark off trunks. The decay impact may extend for many metres up or down a tree trunk away from the point of infection. Note, however, that *Pleurotus ostreatus* for example, will not grow on a living tree, unless it is already dying from other causes. Some fungi, e.g. *Stereum ostrea* goes so far as to poison its host tree with cyanide compounds to kill it, then consumes the wood. *Schizophyllum* behaves differently again; the fungus colonizes trees stressed by heat, sunburn or drought, as well as wounds. It generally occurs on cut and fallen wood and dead parts of living trees. Although some of the white rot fungi cause diseases, not all of them do. Various white-rot fungi are also grown by humans as a source of food - for example the delicious Japanese Shiitake mushroom (*Lentinula edodes*).

Brown rot fungi are also Basidiomycetes and decay hemicellulose first, then cellulose but leave most lignin untouched. The lignin is brown, so brown, fragile, blocky (because of the cell shape) fractured wood remains while the hemicellulose and cellulose is removed. Brown rots have a preference for pines and other conifers but also occur in many hardwoods such as eucalypts. Brown rot fungi include *Serpula lacrymans* (true dry rot), and several less well-known fungi.

Brown cubical rot



Serpula lacrymans (dry rot) in a fallen log.

Soft rots are Ascomycetes (the cup or sac fungi), not Basidiomycetes, but behave in a similar way as do white rot fungi, destroying hemicellulose, then cellulose and finally the lignin, leaving white, crumbly sawdust-like material. When we observe white-rotted wood, we do not know whether it was caused by white rot or soft rot fungi unless we see the fruiting bodies. Soft rot prefers wood of high water and high nitrogen content. They arer common decomposers of cellulose in the soil and are the least specialised of the wood-rot fungi.

The following table compares the features of white rot and brown rot:

ROT TYPE	CHEMISTRY	COLOUR OF ROT	TEXTURE
White rot	All wood components removed at the same time or lignin first	Usualy white, sometimes yellowish or reddish-brown with black specks	Spongy, stringy, crumbly
Brown rot	Cellulose and hemicellulose decay, brown lignin remains	Brown blocks, sometimes with shiny surfaces and white hyphae in the cracks	Cubical blocks which may be crumbly


A massive white rot *Ganoderma australe* (Artist's Conk) growing on a Sheoak (*Allocasuarina*) in Rockhampton Botanic Garden


Fomitopsis, a brown rot fungus growing on a fallen log, near Lake Eacham

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