FUNGI FORAGERS

No.32: October 2022

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)

COMMUNICATING BY CHEMICALS

Plants, animals and fungi “talk” to each other using chemicals called pheromones. Some pheromones we are very familiar with: flower fragrances to attract pollinators, perfumes we dab on ourselves to enhance our own body pheromones to attract a mate! These chemical signals trigger a response in another organism which is equipped to receive and interpret the signal.

***Brugmansia suaveolens*, or ‘Angel’s Trumpet’ produces a perfume that can cause mental illness in humans.**

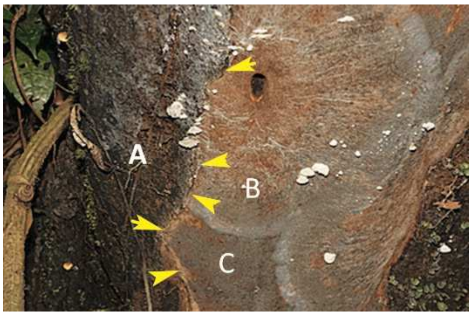
There are several types of pheromones:

- aggregation pheromones function in finding a mate; in the case of fungi, attracting mycelia of a different mating type so they can join and combine their genetic material in order to produce a fruit body;
- pheromones can overcome host resistance such as a pathogenic fungus attracting other individuals of the same species to form a united attack on their target;
- uniting in defence against predators (several mycelia of the same species uniting forces against a pathogen or parasite attacking them);
- certain plants use endophyte fungi to emit alarm pheromones when grazed upon by animals, resulting in tannin production in neighbouring plants. These tannins make the plants less appetizing for the herbivore, so they move on. That is why sheep and cattle constantly move while grazing – to get to tastier grass! It is not known if this mechanism also occurs in fungi. It is possible, for example, that a group of mycelia or fungal fruit bodies attacked by mammals, birds or insects might “notify” other fruit bodies in the group, causing them to become more distasteful or even more toxic. This area requires research.
- pheromones can be used to inform a competitor that a site is “occupied” and that a competitor should go elsewhere. The magnificent Cairns Birdwing butterfly uses this trick. Their eggs and

caterpillars emit pheromones that tell female butterflies that the host plant is already “taken” and that they should go away.

The Cairns Birdwing caterpillar emits warning perfumes and can even protrude special perfume structures from its head if disturbed.

We know there is competition between fungal mycelia for resources such as decaying wood. Do fungi that are occupying part of a log, for example, produce substances in the wood to encourage other fungi to move away from where they are to other parts of the log? We don't know, but field observations suggest that some occupied parts of logs appear to become less favourable to other fungi trying to become established. This could be seen as the occupying mycelium setting up a “territory” to protect its resources;



Three species of fungal hyphae fighting for dominance in a decaying log. The ‘fronts’ of conflict are shown by arrows.

- primer pheromones develop slowly and last a long time. The “dog poo” smell of some stinkhorns is caused by pheromones designed to attract flies and other insects to disperse the spores;
- primer pheromones trigger a change of development (in which they differ from all the other pheromones, which trigger a change in behaviour). An example might be where a large and widespread growth of mycelium might be triggered to all produce fruit bodies at the same time perhaps to spread animal predation over a larger area. Whether such events are caused by transmission of signals through the mycelium (like hormones passing along veins) or whether they are triggered by gaseous pheromones is unclear.

Several pheromones have been identified in fungi, including a substance called sirenin which attracts mobile cells from other fungi, farnesol (a type of alcohol), specialised fatty materials called oxylipins and even ammonia and carbon dioxide are used as “messengers”. How they work largely remains a mystery.

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CUP FUNGI

‘Cup fungi’ is a general term to include a whole suite of fungi shaped more or less like cups, saucers, or goblets. They all belong in families and genera within the Ascomycota or ‘sac’ fungi – those that produce their spores in elongated sacs and squirt them out under pressure.

Some species are easily identified, but others are extremely difficult because they have so few features, even under the microscope.

***Cookeina sulcipes*, a very common cup fungus in North Queensland.**

It was always thought that cup fungi were all decomposer/recyclers, but some research undertaken in 2006 suggested the possibility that some cup fungi are actually mycorrhizal symbionts with trees.

FUNGI – LIFE-SAVERS AFTER FIRE

This article has been published before in CFF No. 20, June 2020, but I think is worth repeating as the inland, southern and western parts of Australia head into summer. Fire is less of an issue here in Tropical North Queensland in summer because that is when we get our rain but is still important in the grasslands of the Northern Territory, despite the rain.

In the few months before Christmas, wildfires devastate forests, bushland, grasslands, towns and communities in almost every State. The biological impact of these fires on fire-intolerant fauna and flora (and Australia has many of both, contrary to popular opinion) is enormous and some, once burned, will take hundreds of years to re-establish, if at all, considering the added impacts of agricultural clearing, roads and corridors preventing animal and seed recruitment, and increased weed and pest encroachment.

One week after a fire – Cape Arid National Park (Western Australia) December 2008. Plants have commenced sprouting and pyrophilous fungi can be found

Fire management best practice involves fire mosaics which include not only a variety of fire ages, but also highly valuable areas of native bush which are left unburned for many years. These unburned areas provide both a benchmark for measuring the impacts of fire and as refugia for all manner of native species. Areas which remain in a pristine state are not only rare but are of inestimable value. Nonetheless, small wildfires are important disturbance events that reshape forest and grasslands through the combustion of stored carbon and that they alter the composition and structure of plant communities, increase local diversity and alter soil bacterial and fungal communities.

Thus, although severe wildfires are detrimental to many animal, plant and fungal species, some fungi have adapted by forming reproductive fruit bodies only after a wildfire. Studies have shown that during the first month after the fire many algae and fungi (mostly Ascomycetes – the sac fungi) appear. This is followed by further stages characterized by the presence of mosses and liverworts, and finally by the colonization of plants that like high nitrogen concentrations in the soil. In those early stages many fire-loving (pyrophilous: Greek pyro = fire, philous = love) fungi appear. Some of these are observed only after a fire while others do not require a fire in order to fruit but fruit more enthusiastically after fire.

It is believed that some pyrophilous fungi normally occur as endophytes (see CFF No. 18 February 2020 for some information on endophytes) before a fire disturbance, others as mycorrhiza, root pathogens, or soil saprobes, but for many their normal ecological niche is still unknown. The high temperature during a fire either breaks spore dormancy or stimulates a sclerotium (a below-ground root-like structure), prompting it to fruit. Further, the increase in soil alkalinity that follows fire favours some fungi and the intense heat kills most of the other soil microorganisms, presumably reducing competition near the soil surface.

These pyrophilous fungi have a major role in re-establishing the local fauna that survive the fire. In south-east Australia and inland Queensland *Pyronema* species can form paint-like coatings of orange-red on burned soils and stumps within 48 hours. In Western Australia, *Hypomyces rosellus,* another paint-like fungus, is similar and quickly springs up on burned wood. These fungi are grazed by surviving snails, possums and wallabies and soon attract insects which then feed spiders, birds and lizards.

Laccocephalum mylittae (Bush-tucker Bread) can appear in three or four days and is eaten by wallabies, bandicoots and possums. *Cortinarius sublargus* is a gilled fungus quick to spring up after fire and its fruit bodies can weigh up to a kilogram, providing a lot of food very quickly. Of course, they also attract slugs, snails, tiny soil critters and insects that, in turn feed larger animals.

Wildfires can be very intense – generating temperatures up to 1,600 ºC, yet subsoil temperatures may be low

Not to be ignored, although rarely seen, are the truffles. Truffles are not a specific fungal group in themselves but are highly specialised underground fruiting bodies that have evolved in several fungus families, including *Russula* (Brittle-gill Mushrooms), *Cortinarius* (Web-cap Mushrooms), the bolete fungi (mushrooms with pores rather than gills under the cap), the Stinkhorns, and the Sac Fungi (Ascomycetes). It is believed there are about 2000 species of truffles in Australia, of which only about 300 have been described scientifically.

Truffles are specifically the fruiting bodies of mycorrhizal fungi. Because they fruit underground, they can save energy by not developing proper stalks and caps. The downside is that they cannot disperse their spores by letting them blow in the wind. Instead, they depend on small mammals to dig them up and eat them. To attract the animals, they produce distinctive odours which then seep through the soil and are easily sensed by Australian native truffle-eaters. Several native animals depend on these truffles, especially the Potoroos and Bettongs and the Northern Bandicoot and, on the edges of rainforest adjacent to burned areas, Orange-footed Scrub-fowl and Brush Turkey. Digging for truffles after fire is vitally important in the Australian eucalyptus forests as it breaks up the surface soil, helping rainfall to penetrate the soil rather than run off and cause erosion, a big problem after fire. It has been estimated that one species, the Western Potoroo of south-west Western Australia, can move up to four tonnes of soil per animal per year, by digging up to 100 truffles per night.

For more information on fire and fungi I recommend McMullan-Fisher, SJM, May, TW, Robinson, RM, Bell, TL, Lebel, T, Catcheside, .P & York, A. (2011). Fungi and fire in Australian ecosystems: a review of current knowledge, management implications and future directions. Aust. J. Botany 59: 70–90.

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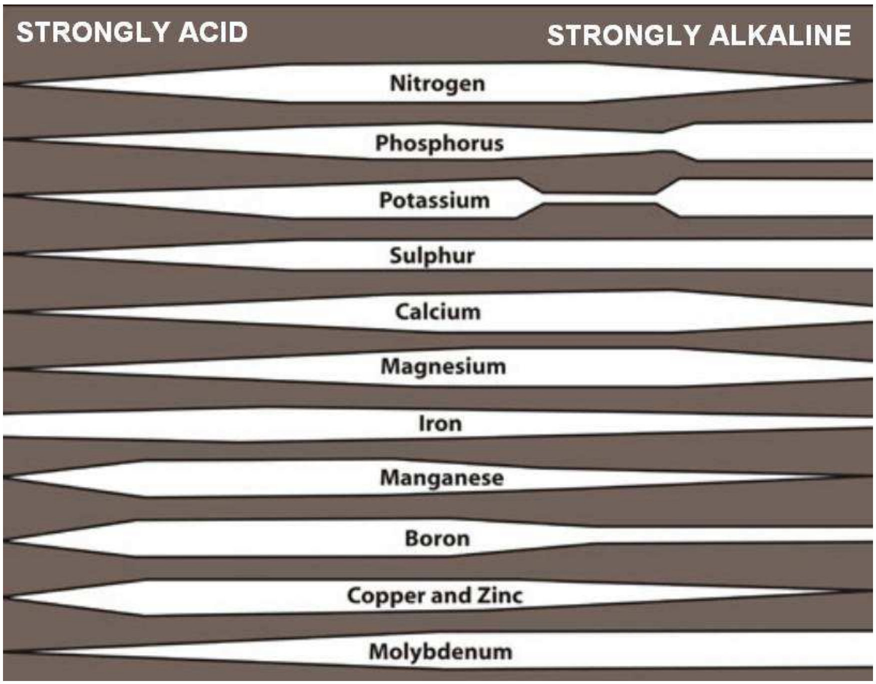
TRACE ELEMENTS – THE ROLE OF FUNGI

Any of us who are keen gardeners know that trace elements are vital to the successful growth, productivity of fruit and seed set of our decorative plants and home-garden crops of fruit and vegetables. We probably also know that mycorrhizal fungi are key to the successful extraction of those trace elements out of the soil and passing them to the plants. In general, most plants cannot extract these minerals themselves but require the amazing assemblage of enzymes and chemical processes of the fungi as mediators.

The main elements needed in large quantities by plants are nitrogen (N), phosphorous (P) and potassium (K – the Latin name for potassium is kalium). Hence the importance of so-called NPK fertilisers. OK, but what are trace elements and where do they fit in?

Trace elements are required by plants only in very small quantities – traces, in fact. Some such as boron, copper, iron, manganese, molybdenum, silicon, vanadium and zinc are specifically required by plants. Animals require copper, cobalt, iodine, iron, manganese, molybdenum, selenium and zinc for their life-processes but they can only obtain these elements by feeding on plants that contain them. There are also essential but minor roles for arsenic, fluorine, nickel, silicon, tin, chlorine and vanadium in both plant and animal nutrition although some can become toxic in large amounts.

Boron, for example, is associated with development of the growing point of plants, manufacture of growth hormones, development of cell walls and protein metabolism, maintaining correct water relations within the plant, sugar transfer from place to place and fruiting processes. Chlorine in the form of chloride tends to maintain a higher moisture content in plant leaves and appears to endow plants with a greater resistance to drought. Cobalt is required by nitrogen-fixing bacteria and thus indirectly by leguminous plants such as lucerne, soybeans, clover, beans and peas.



How available trace elements are depends on the acidity/alkalinity of the soil

Copper occurs in soils principally adsorbed (attached to the surface) by clay minerals or tied up by organic matter. Copper plays a role in plant growth as an enzyme activator or as a part of many enzymes which function in respiration. Copper is also important in protein metabolism and chlorophyll manufacture. Iodine is important in the health of animals more than plants and is therefore vital for grazing and foraging animals that obtain iodine from their food. Iron is an essential component of chlorophyll manufacture and a low oxygen content of soils has been found in some cases to be related to iron deficiency. Iron is also a tightly bound component in a wide group of proteins, which include haemoglobin (the red blood colour) in animals. Deficiency of iron suppresses cell division and leaf development in plants.

Manganese is essential in photosynthesis and acts as a catalyst in nitrate reduction (nitrogen-fixing). It is a constituent of some enzymes involved in respiration and of some enzymes responsible for manufacturing proteins. Manganese also activates some specialised enzyme systems and is involved in processing of carbohydrates.

Molybdenum is essential to nitrogen-fixing nodule bacteria but is toxic to animals, but selenium is an essential element for animals, and a deficiency of which produces muscular dystrophy and allied diseases. Zinc functions in plants largely as a metal activator of enzymes and deficiency of zinc produces changes in leaf and cell structure.

But what about trace elements required by fungi? The concentrations of ten trace elements, arsenic, bromine, cadmium, copper, mercury, iodine, manganese, selenium, zinc and vanadium, have been determined in up to 27 species of higher fungi from several sites in Slovenia, Yugoslavia. High levels of mercury have been found in many fungi species, along with cadmium. The genus Amanita seems to be good at accumulating bromine, and selenium by the edible Boletes.

We rarely stop to think why we add trace elements to soils, but clearly this considerable variety of elements have vital roles to play, despite the tiny amounts needed. It is worth remembering that these trace elements are mobilised almost entirely by the activity of mycorrhizal fungi and without those fungal activities plants and animals would be unable to survive.

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FOOD FOR THOUGHT – TRIGGERS TO FRUITING

Several researchers have found a strong relationship between spore size and time of fruiting: on average a doubling of spore size (volume) corresponded to three days earlier fruiting at the genus level. They also found that small-spored species dominated in the coastal parts of Norway whereas larger-spored species were more typical of inland parts. Does this apply in Australia? Are the fungi of our coastal forest more likely to be small spored than those of the inland forests? It was also suggested that species with smaller spores may be more prevalent in areas with a moister climate than species with larger spores.

Researchers observed significant correlations between spore size and climatic factors (rainfall and temperature) and suggested that this relates to water storage in spores as a critical factor for successful germination. This particularly applied in the drier micro-environments found earlier in the fruiting season and in inland climatic zones rather than coastal zones. It was also found that, ignoring geography, large-spored species were related to higher temperatures, but this effect was less pronounced when rainfall was higher. At higher temperatures, spore size decreased with increasing rainfall.

Spore size seemed to be related to the water requirements of the germinating mycelium. So, which has the largest spores – wood fungi or soil fungi - and which substrate has the most water during any particular fruiting event? What about fungi that grow on both clayey and sandy soils. The clay soils hold more water for longer than sandy soils, so does the fungus growing on sand have larger spores?

The researchers suggested that for both mushrooms and polypores that spore size is related to fruit body size. Is that the case in Australia? Here is an interesting field for research.

References: Kauserud, H., Colman, J. E., & Ryvarden, L. (2008). Relationship between basidiospore size, shape and life history characteristics: a comparison of polypores. Fungal Ecology 1:19-23. (doi:10.1016/j.funeco.2007.12.001)

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Meerts, P. (1999). The evolution of spore size in Agarics: do big mushrooms have big spores? J. Evolutionary Biology 12:161-165

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