FUNGI FORAGERS

No. 16, August 2019

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

WANTED!

Frances (Fran) Guard (you may know her as one of the authors of the "Australian Subtropical Fungi" book) is collecting information on sightings of an undescribed species of *Marasmius* (see three pix this page). It is thought to be quite common in South-east Queensland, and Fran would like to know of any locations where you have seen it further south in New South Wales or up in Far North Queensland. The main features of the fruit-body are its robustness - up to 70-80 mm tall, cap up to ~12 mm wide, with a glossy stem - black at the base and pink at the top, and with 20-30 gills – this is an important character because many of the smaller *Marasmius* have only a few gills. It may be brown, dusky pink or purple; often solitary, but occasionally in families. Fran wants to formally describe it so any records you have are important.

If you think you have found it, please send existing photographs to Fran or take lots of photographs if a new record (both of the cap and underside and stem) and the location where it was seen. Fran's contact is: franguard@icloud.com

DECAY FUNGI

Part 3 - FUNGI THAT ATTACK OTHER FUNGI

Although this may sound surprising, fungi are often parasitic on other fungi. In fact, **mycoparasitism** is common among fungi, with whole groups specialized for this way of life. It is not known when parasitism of fungi on other fungi evolved, though, as we noted in Part 1 of this series (CFF Pt 13 February 2019) the occurrence of mycorrhizae in 460 million-year-old fossils suggests that parasitism may have been occurring at that early time. A piece of amber (fossilised tree resin) from the Early Cretaceous (100 million years ago) contained a mushroom which was a parasite, and which was itself infected by another parasite. These observations show that complex patterns of parasitism were well developed by the Cretaceous.

In nature, decay fungi grow on bacteria, plants, animals and many other fungi – not always as parasites, but just as consumers or in competition. Fungi in the same substrate will compete with one another for control of that nutrient source; and the competition may be so vigorous that the most successfully competitive fungi specialise in being parasitic on other fungi. Many fungi can secrete special enzymes which give them the ability to attack living hyphae of filamentous fungi, causing wall-degradation and consequent breakdown. The common jelly-fungus *Tremella mesenterica* is such a parasite and will remain active as long as the host fungus is alive. However, like most observations in nature (that is what makes nature so interesting) things are rarely that simple. Fungi growing with or on other fungi can have many different sorts of relationships, varying from indifferent, causing decay, mutually beneficial to each other, or a range of intensities of parasitic, and it is not always clear which relationship applies.

Tremella mesenterica Cairns Botanic Gardens

A bolete *Chalciporus piperatus* being consumed by a mould

Some, perhaps many, fungi can parasitise organisms from different kingdoms: for example, there is a fungus called *Arthrobotrys oligospora* (in the Ascomycota or sac fungi) which acts as a parasite on fungi, invades barley roots and also traps and feeds on nematodes (see CFF No. 10 August 2018). Clearly, this species can penetrate the tissues of some life forms of all three kingdoms (fungi, plant and animal). Another example occurs in the genus *Metarhizium* where *Metarhizium acridum* which is an insect pathogen (causes disease and death), also colonises plant roots and may even be mycorrhizal. Genetic studies have shown that *Metarhizium* switches on different genes in the presence of plants and insects, demonstrating that it has specialist genes for each aspect of its complex lifestyle.

There are destructive parasites that directly invade and kill their hosts, those that cause death of the basidia (reproductive structures that carry the spores) without penetrating the hyphae of the host and those where a balanced relationship is established and the parasite grows on the still-living mycelium of the host fungus such as was mentioned with *Tremella.*

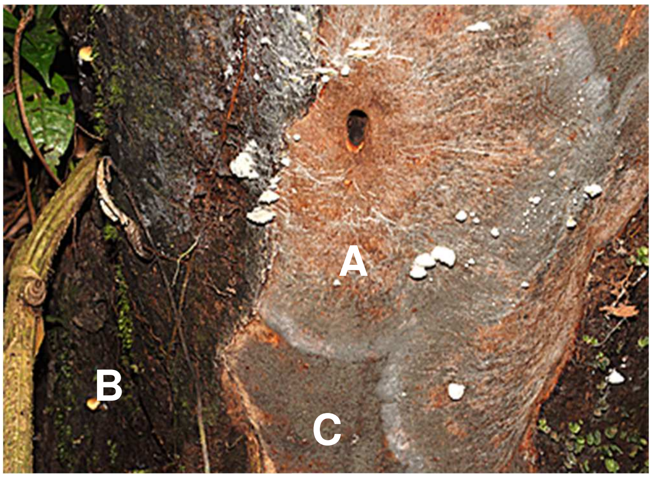
Parasitism may occur through:

- entry of the mycoparasite's hyphae into the host hyphae to absorb nutrients directly from it,
- by formation of root-like structures called haustoria from the parasitic hyphae that penetrate the host, and
- specialised contact cells which accomplish direct continuity with the cells of the host through fine pores in the hyphal walls.

Cladobotryum mould growing on a *Phellinus* polypore bracket-fungus (Mossman Gorge)

This antagonism between species sometimes creates "contact zones" between opposing mycelia that are visible in infected timber. In **neutral interactions** the hyphae intermingle without any apparent reaction to one another; in **mutual interactions** both individuals derive some benefit, which increases the survival value of both; and **competitive inter-actions** are detrimental to both species because the antagonism weakens them both. Competitive interactions generally result in one of the competing fungi proving to be more aggressive than the other, and the more aggressive fungus captures more nutrients than the less aggressive.

The most aggressive parasitic fungi are the true mycoparasites that are divided into two Groups: one where the parasite is so strongly aggressive that it dominates and ultimately kills its partner/host. Close direct contact between parasite and host, often with the parasite's hyphae coiled around hyphae of the host helps exchange of nutrients without losing the nutrients to competing bacteria. The other type of parasites are more balanced; the parasite being highly adapted to coexisting with the host for extended periods of time, and often forming specialised host-parasite structures.



Three species of mould competing for food resources on the cut end of a log. Species A is parasitising species C and species B is consuming species C and fighting with species A.

Mycoparasites are probably very significant in the natural environment because fungi are major contributors to natural communities, and these relationships between fungi must play an important role in development of community structure. They certainly affect the fruit bodies of the infected fungus, reducing or stopping spore production.

Ganoderma borninensis as it is supposed to look. (Internet picture)

The same species (supposedly) where it has been attacked by *Cladobotryum*

The extent of the symptoms depends on the stage of development reached at the time of infection: the earlier the infection occurs, the greater the deformity caused. The most extreme effect is for a shapeless mass of tissue to be formed rather than a mushroom. Infection at later stages of development causes deformities, including bulbous stems with unformed caps and fruit bodies in which the tissues disintegrate. Other impacts may be abnormal enlargement of the gills as they become covered by the parasite. Internally, the mushroom may become wet and develop a foul odour probably caused by bacterial rot, and it may weep drops of clear amber-coloured liquid.

Large fungi in the wild, particularly field mushrooms, are commonly parasitised by members of the genus *Cladobotryum* (Ascomycota), and *C. dendroides* is also a common disease-causing fungus of cultivated mushrooms. It is for this reason that great care is needed in collecting and eating mushrooms in the wild because they may be invisibly infected by other species of fungus, some of which are very poisonous.

A close-up of part of the fertile surface of a *Hexagonia tenuis* collected at Goomboora Park near Cairns. Examination of thin sections through the peculiar raised structures showed the presence of hyphae that were not those of the *Hexagonia*. They are presumably a parasitic fungus that had penetrated the *Hexagonia* and caused distortion of growth. One finds peculiar misshapen fungi from time to time and these may be the result of parasitism.

Parasitic fungi in whatever form are common and widespread. Many fungi occur in nature in interdependent relationships just as mycorrhizae do with green plants. It is difficult to establish the exact number of fungi known to grow on other fungi, but there is a published estimate of 1,100 species of fungi parasitising 2,500 other species of fungi, with probably at least a further 2,000 species of fungi, of all groups, growing parasitically on lichens[1]. Although widespread, their parasitic nature may not be obvious. If two fungi are found growing together there is a great likelihood that one of them is a parasite. However, it requires careful experimentation to demonstrate parasitism in fungi and much work has yet to be done before scientists have a clear understanding of its extent. *Trichoderma*, the most frequently studied mycoparasite occurs in soils, rotting wood, old mushrooms and many other environments. When it grows over another fungus it simply dissolves its host's hyphae with enzymes. *Trichoderma* species are not usually very particular about what fungi they consume. This lack of host-specificity has made them useful as agents of biological control for plant parasites, especially those attacking plant roots. On the other hand, these same fungi can be highly destructive if they get into commercial mushroom beds.

Parasitic fungi occur in all habitats and it is probable that mycoparasitism occurs more widely than currently imagined. After all, because fungi are such common, even dominant, members of natural populations in all habitats, the ability of a species to harvest nutrients from either living or dead hyphae of another species must have advantages.

Extracted partly from Moore, D, Robson, GD and Trinci, APJ (undated), *21st Century Guidebook to Fungi,* ed. 2.
http://www.davidmoore.org.uk/21st_Century_Guidebook_to_Fungi_PLATINUM/Ch16_15.htm

[1] Lichens, of course, are a cooperative 'agreement' between a fungus and an algae – like mycorrhiza in a way, but with an alga rather than a tree or shrub.

Ever Stop to Think?

The insides of living cells, including fungi, are continually changing: old materials are broken down and new ones formed. When proteins and other nitrogen-containing compounds are broken down, either as part of cell processes or as supplied nutrients, the carbon can be disposed of as carbon dioxide, hydrogen as water, and nitrogen either as ammonium or as urea. Experiments with the common mushroom *Agaricus bisporus* and with the toadstools *Coprinopsis cinerea* and *Volvariella volvacea* have shown that one third to one half of the nitrogen from the protein is excreted as ammonium into the material on which the fungus is growing.

Ultimately, all nitrogen in living organisms is derived from the air. Each year an amount between 100 and 200 million tonnes of nitrogen is made into ammonium by bacteria and algae, but, from what we understand, it is unlikely that any fungi are able to do this.

The sugar-alcohol called mannitol, and the sugar trehalose, are almost always found among the carbohydrates in fungi; trehalose being the most common sugar. Mannitol and trehalose seem to serve as storage compounds in the same way glucose does in us. In the common supermarket mushroom *Agaricus bisporus*, up to 50% of the total dry weight (yes, that's right, half of the cultivated mushroom on your plate is mannitol sugar). However, mannitol increases blood glucose to a lesser extent than cane sugar (sucrose), so is used as a sweetener for people with diabetes, and in chewing gums. hard candies and dried fruits.

FUNGAL RESPONSE TO MOISTURE AND HEAT

Fungi readily dehydrate. There is thus a humidity threshold above which many fungi thrive and below which they either die or become dormant. In the very still conditions that occur on ***flat*** rainforest floor most of the time there is a measurable humidity boundary layer just above where the soil meets the air. In my study areas this boundary layer is usually about 8–10 cm above the soil surface and can be as much as 2°C warmer and 10-15% more humid than the cooler, drier air above the boundary. The warmth and moisture from the soil makes the zone beneath the boundary more hospitable for fungi[2]. If you carefully study a flat area within the rainforest that has a proliferation of ground fungi, you will find the fungi fall into two categories: short ones that are entirely below the boundary and within the boundary zone; and much taller ones where the caps are above the boundary layer. In some cases, those which are above the boundary may have unusually elongated stems to raise them up. *Leucocoprinus fragillisimus* and some *Psathyrella* are particularly good at this in my study areas. Many will be short, often less than, say, 80 mm tall while others may be 120 mm or more tall to raise them above the boundary layer. On sloping surfaces such as hillsides or even low mounds, the boundary layer cannot form because, if cooler, it flows downhill and, if warmer, it just disperses. Even the slightest breeze, such as walking through the forest, can disrupt the boundary layer.

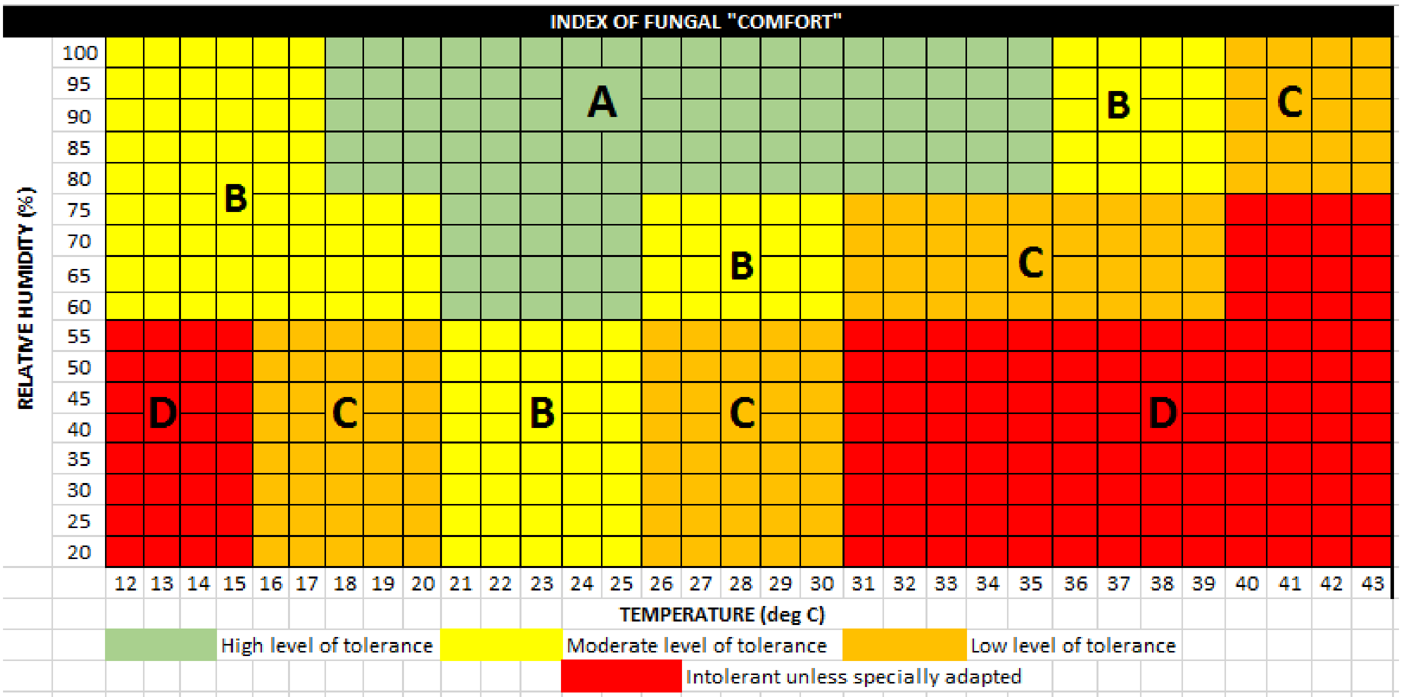
Tall, robust fungus fruit bodies such as some *Amanita* have their caps raised above the soil/air boundary layer but even then, 95% of spores fall within about 1 m of the cap. Dispersal distance increases with increasing cap height and decreasing spore size. The smaller delicate fungi that grow on soil are, of course, entirely within that boundary layer and thus are less prone to drying. Fungi that grow above the ground, such as those on fallen wood and tree trunks, appear to be controlled more by other features such as state of decay of the wood and overall humidity.

The effects of heat on fungi are related to the chemical reactions within the fungal cells. For best growth, temperatures must be in a range that allows the most efficient chemical reactions. With cold tolerant and high heat tolerant fungi, growth can occur at either lower or higher temperatures respectively, but growth is

[2] This only applies on flat soil surfaces. On gently sloping surfaces, the boundary zone tends to flow downhill, making the high humidity zone deeper in depressions. Clearly the high humidity makes this air denser so it flows *downhill* otherwise the warmth from the soil would tend to make the zone break up and dissipate.

not at its best. Some mid-range-temperature fungi may be able to grow, or at least survive, at either lower or higher temperatures, depending on the genetics of the fungus and other environmental conditions. Another form of temperature tolerance lies in the spores, which can often withstand temperature extremes, and germinate when conditions return to normal. Finally, some fungi that have normally mid-range temperature preferences have spores that require heat to stimulate germination. Temperature tolerance of spores is strongly tied to the amount of water available, so that wet heat can be effective at damaging spores but can also favour their germination.

Below is a simple diagram showing fungal "comfort". When humidity is high, and temperature is in the mid-range (the green zone), many fungi are "comfortable" and readily fruit and set spores. At low humidity and very low or very high temperatures (the red zones) the fungal fruit-bodies are stressed and may die without setting spores.



Next time you find some fungi in the rainforest look carefully at exactly where the fungus is growing. Take note of whether a boundary zone is likely to exist. Note whether or not there is any likelihood of competition with other fungi; the amount of light to which the fungi are exposed (e.g. forest density); availability of water at a very small scale, such as being trapped in cracks in wood or tiny depressions in the soil; and things that may affect humidity (e.g. protection from wind by a nearby log or wall) or temperature (such as nearby roadways or clearings). This will help you explain why some fungi occur where they do and not elsewhere and will increase your enjoyment of fungal foraging. If you find something particularly interesting let me know.

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