FUNGI FORAGERS

No. 20, June 2020

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

This newsletter is not associated with any club or organisation and 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

A CALL FOR HELP AND A CHANCE TO BE INVOLVED IN A GLOBAL FUNGI PROJECT

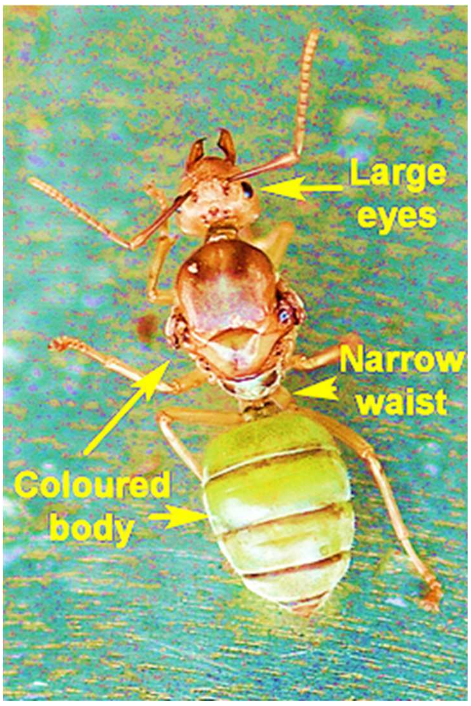
Estonian mycologist Leho Tedersoo is looking for more participants for their citizen science global fungus project. They are after samples from household dust and plant leaves to sequence for fungal DNA.

The instructions are easy and not much cost is involved, so take a look and see if you can help. They are after samples particularly from Eastern and Northern Australia and especially Darwin, so if you know anyone in Darwin who might like to help please pass this on. You will find the instructions in the following links: https://sisu.ut.ee/funhome/avaleht and https://sisu.ut.ee/funleaf/about

FUNGI ASSOCIATED WITH ANTS AND TERMITES

In the previous (April 2020) Cairns Fungi Foragers (CFF) newsletter we mentioned ants and other insects using fungi. We will now expand this further.

Firstly, what do we mean by "ants"? True ants are a highly evolved group of insects related to bees and wasps. Examples are the pesky Green Tree Ants that sometimes interrupt our gardening experience, and Bulldog Ants that make large nests at ground level and which are usually discovered by standing on the nest until they let you know they are there. These are in the insect order Hymenoptera (*hymen* = membrane, *ptera* = wing). The workers are generally coloured, have large eyes, and a thin, articulating "waist" between chest and abdomen. They tend to live in specially constructed nests such as that of the Green Tree Ant, or in pre-existing holes, or they dig burrows. Most are meat-eating or sugar-feeders and do not generally consume wood.



A typical ant

The second group, often wrongly called “white ants”, are not ants at all: they are termites, a primitive group of insects more closely related to the cockroaches than to bees and wasps. Termites are in the insect Order Isoptera, meaning “same wings” because the flying reproductive adults have two pairs of long, almost identical wings. The workers are usually pale coloured or white and have no eyes or articulating “waist”. Nearly all species live in specially constructed nests made in wood or soil and eat plant debris and wood.

A typical termite

These distinctions are important if we are looking at fungi as there are different suites of fungi associated with each order of insects. There are two types of fungi – those we don’t see and those we do! Those we don’t see are the mycelia and minute fruiting bodies of fungi that live within the nests and are used as food by the ants or termites. Probably the best known of the fungi-growing ants are the Leafcutters from USA down to Argentina in South America. They cut grasses and leaves, carrying them to their colonies' nests, and grow nutritious fungi on them on which they later feed. They also feed it to their brood. They really do farm their fungi; planting them on freshly chewed leaves and using antibiotic-producing bacteria to keep other less nutritious fungal competitors at bay. When young queens leave their nest to found new colonies, they take with them both the farmed fungi and the antibiotic bacteria. The fungi they grow are almost entirely related to Leucocoprinaceae and the Agaricaceae.

I have been unable to find evidence that ants in Australia cultivate fungi to eat, except for the ants that live in “ant plants”. Inside the bulbous ant plant are many chambers: some with golden interiors, others with black interiors. The ants live mainly in the golden chambers and put their rubbish such as ant corpses, food debris and poo in the black chambers. This rubbish has fungus growing on it which extracts the nutrients that the plant uses. It is also possible that the ants feed on the fungus, at least occasionally, perhaps when times are tough, and they may actually “farm” it, as they have been observed carrying fungus about (M. Greenfield, pers. comm.)

Section through an ant plant showing black chambers on the left and golden chambers at the middle-bottom.

I have also found mycelia growing in parts of Harvester Ants nests in south-west Western Australia. These ants collect small sticks (see picture at right) to build their nests, but whether or not this is to grow fungus I don’t know.

Of the fungi we do see, most are associated with termites rather than ants. I suspect this is partly because termite nests are more conducive to growing large fungi on their surface, and partly because any external fungus that grows on an ant nest is most likely quickly eaten or removed.

The most common large fungus on termite mounds in the Cairns region is *Podaxis beringamensis*: a large, distinctive mushroom-like fungus (it is actually a **puffball**) that grows in drier country on termite mounds, or on sandy soil with termite nests beneath.

This one was photographed in the central Pilbara of Western Australia: but they have been observed on termite mounds along the road from Kuranda to Mareeba, west of Cairns, and have been recorded from the Cape York Peninsula. The fungus' black spore mass was used by desert Indigenous people to darken white hair in the elderly men's whiskers, as well as for body painting and as a fly repellent (www.aubg.gov.au/fungi/aboriginal.html).

FUNGI – LIFE-SAVERS AFTER FIRE

In the few months before Christmas 2019 and into early 2020, wildfires devastated forests, bushland, towns, homes, and communities in almost every Australian 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 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.

Modern fire management is based on a false belief that fire intensity is directly related to time since the last fire. This has been proven incorrect (in fact the opposite is true), but, nonetheless, fire management still involves creating fire mosaics which include a variety of fire ages. Occasionally, usually by accident, areas of native bush are left unburned for many years, and these provide a benchmark for measuring the impacts of fire and as refugia for all manner of native species. Areas such as this which remain in a near-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 alter the composition and structure of plant communities, increase local diversity, and alter soil bacterial and fungal communities.

Although severe wildfires are detrimental to most animal, plant and fungal species, some fungi have adapted by forming reproductive fruit bodies only after a fire. 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 prefer 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 a discussion on endophytes) of mosses or lichens before a fire disturbance, others as mycorrhizas, root pathogens or recyclers, 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.

These pyrophilous fungi have a major role in re-establishing local fauna that survived the fire. In south-east and south-west Australia and inland Queensland, *Pyronema* species can form mycelial paint-like coatings of orange-red on burned soils and stumps within 48 hours. In Western Australia, another paint-like fungus, *Hypomyces rosellus,* is similar and quickly springs up on burned wood.

Pyronema omphalodes
Morwell National Park after fire – Internet Image

These fungi are grazed upon by surviving snails, possums and wallabies, and soon attract insects on which spiders, birds and lizards then feed. *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.

Laccocephalum tumulosum or Stone-maker Fungus
occurs in south-west Western Australia after fire.
Note the "stone" - a large tuber-like buried sclerotium.

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 2,000 species of truffles in Australia, of which only about 300 have been described scientifically.

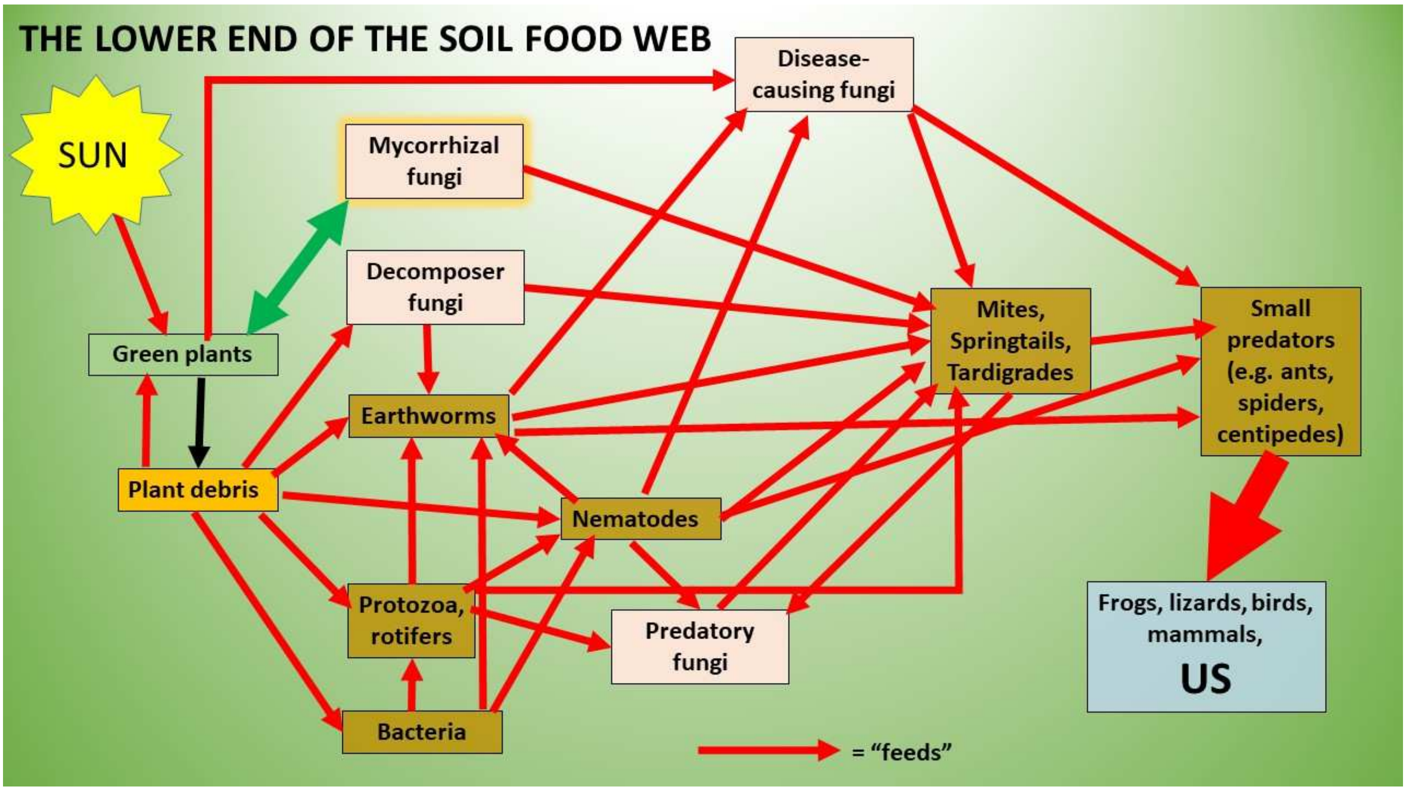
Truffles are specifically the fruiting bodies of mycorrhizal fungi. Because they fruit underground, they can save energy by not developing proper stalks and caps. The downside is that they cannot disperse their spores by letting them blow in the wind. Instead they depend on small mammals to dig them up, eat them, then poop the spores out elsewhere. To attract the animals, they produce distinctive odours which then seep through the soil and are easily sensed by Australian truffle-munchers. Several native animals depend on these truffles, especially the Potoroos, Bettongs and the Northern Bandicoot, and, on the edges of rainforest adjacent to burned areas Orange-footed Scrubfowl and Australian 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.

The quick appearance of fungi after fire is vital to the survival of many animals that would otherwise starve.

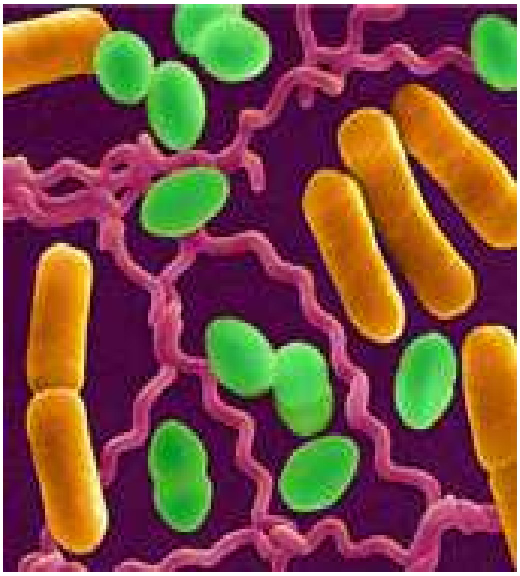
FUNGUS THE BOGEYMAN'S NEIGHBOURS - BACTERIA

As we all know, fungi are a major and vital part of our world, but they are not alone. Their neighbours in soil comprise a whole range of beasties from bacteria to bugs. About 90% of the living organisms in soil are fungi and they set about quietly and unobtrusively decomposing and recycling, predating on nematode worms, working symbiotically with plants to provide nutrients, producing glomalin to stick soil together, causing and preventing disease, and a host of other activities. In fact, they are just part of an extraordinarily complex interrelationship between organisms called a food web. The "lower end" of such a web is illustrated below. The "upper end" of the food web is the larger critters like frogs, lizards, birds, mammals, and us.



This diagram is grossly oversimplified, but if you have a look on the Internet for illustrations of food webs you will find a few that will do your head in.

I said above that fungi make up about 90% of the soils living organisms. The other 10% is made up of bacteria, protozoa and a host of tiny animals and some larger animals such as earthworms, insects and so on. Firstly, let's look at bacteria.



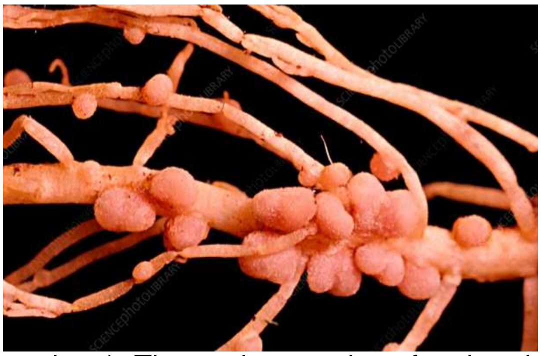
Soil bacteria and soil fungi are the bottom of the food web that supports the functioning of a healthy soil which, in turn, supports all our fruits, vegetables, timber and pasture plants, and, indirectly, all our livestock. Bacteria are single celled, and there may be trillions of bacteria in a single teaspoon of healthy soil. Populations of bacteria can boom or bust in the space of a few days in response to changes in soil moisture, soil temperature or carbon availability. Some bacteria species are very fragile and may be killed by slight changes in the soil environment. Others are extremely tough, able to withstand severe heat, cold or drying. Some bacteria are dependent on specific plant species in the same way as are mycorrhizal fungi.

Soil bacteria occur in many forms such as rods, spheres and spirals (Mammoth Microbes Internet picture).

Just like with fungi, there are several types of soil bacteria:

- **Decomposer/recyclers:** play an important role in the early stages of breaking down organic materials (in the later stages fungi tend to take over);
- **nitrogen fixers:** extract nitrogen gas from the air and convert it into forms that plants can use. They can add the equivalent of more than 100 kg/ha per year of nitrogen to the soil. These specialised bacteria usually live in special nodules on the roots of their host plant. Examples of plants with nitrogen-fixing bacteria include soybeans, peanuts, peas and beans, and many wattle species and rainforest trees. So far, no nitrogen-fixing fungi have been found, so it appears the bacteria are vital in this role;
- **disease suppressors:** release antibiotic substances, similar to those made by fungi, to suppress competitor bacteria. A number of bacteria have been commercialised to produce antibiotics for disease suppression in humans, animals and plants. Streptomycin and Tetracycline are examples of bacterial rather than fungal antibiotics;
- **Actinobacteria:** specialists that help to break down humus in soils. They prefer non-acidic soils, i.e. neutral to slightly alkaline. These bacteria can be encouraged by the addition of garden lime if the soil gets too acid – a condition that sometimes happens during the wet season when soils are water-logged or too much non-composted (green) mulch has been added;
- **sulphur oxidisers:** specialised bacteria that can covert sulphides (common in soil minerals but largely unavailable to plants) into sulphates, a form plants can use; and
- **aerobes and anaerobes:** aerobic bacteria need oxygen and dominate in well-drained soil. They comprise a whole suite of bacteria doing a thousand useful things. Anaerobic bacteria, in contrast, do not need oxygen, and favour wet, poorly drained soils. They can produce toxic compounds that limit root growth, predispose plants to root diseases and give the soil a sour smell. They are probably instrumental in preventing fungal fruiting during very wet conditions (see CFF No. 10, August 2018 pp 4-6).

Though largely unaffected by cultivation and gardening, bacteria populations are depressed by dry conditions, acidity, salt build-up, soil compaction and lack of organic matter in exactly the same way as are fungi. If populations of soil bacteria are too low, it is probably because conditions are unfavourable. Effective approaches to support healthy soil bacteria are to address problems of acidity (by adding lime if necessary), reducing compaction by not walking on garden beds, ensuring good ground cover, and building organic matter content by adding well-rotted mulch, exactly the same as for fungi.



Nitrogen-fixing root nodules on peanut roots
(Internet image b2380064-800px-wm Science Photo Library.

As I have discussed before, you can encourage beneficial soil bacteria and fungi in your soil by providing food (organic matter), water, and minimal disturbance of the soil. Growing garden plants or vegetables that support mycorrhizal fungi allow fungi <u>and</u> beneficial bacteria to increase in the soil. Examples of plant groups that do not form associations with mycorrhizal fungi and are not nitrogen fixers are the crucifer family (e.g. mustard, cabbages, broccoli), and the spinach family (e.g. spinach, beetroot, quinoa). These plants <u>reduce</u> fungi and bacteria in the soil. Tillage (turning the soil) also has a disastrous effect on bacteria by drying them out and on fungi by physically breaking the mycelium. Broad-spectrum fungicides and pesticides are toxic to most fungi and damage beneficial soil bacteria - and result in a decline in both.

Editorial Contact:

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