FUNGI FORAGERS

No. 18, February 2020

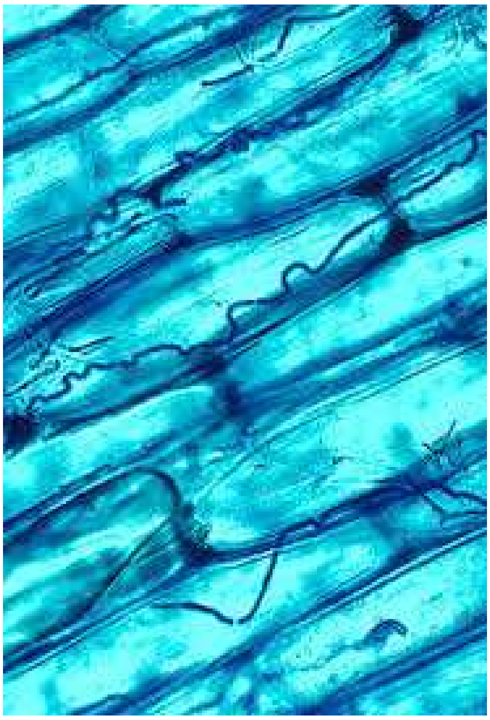
OUR PURPOSE: TO RAISE AWARENESS AND INTEREST IN FUNGI OF THE CAIRNS REGION

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

ENDOPHYTES

In Cairns Fungi Foragers (CFF) Part 13 (February 2019) were two articles: one discussing fungi that use dead plants by decaying their tissues to obtain nutrition for the fungus, and in return release the nutrients in the plants' structure to re-enrich the soil for other plants – that is, they recycle dead plant tissues. The second was about mycorrhizae where fungi use plants to obtain sugars which they cannot manufacture themselves, and, in return, give the plants water and nutrients which the fungus can extract from the soil. But there is a third way that plants and fungi cooperate for the benefit of both. These specialised fungi are called **endophytes** (endo = inside and phytus = plant).



Mycelia of an endophytic fungus growing between and inside plant cells (Internet pic)

An endophytic fungus lives within a plant for at least part of its life without causing disease. Endophytes have been found in all species of plants studied so far, although most of the relationships are not well understood. Many economically important grasses, such as wheat and sweet corn, carry fungal endophytes which may enhance plant growth, improve the plant's ability to tolerate drought, or increase their resistance to insect pests and other animals that eat their foliage.

Endophytic fungi may pass from parent plant to offspring by hyphae living inside the seeds, or between individual plants as windblown or insect-carried spores. A few fungi use both methods. There are also some sneaky ones that are capable of being disease fungi but live quite happily within the plant, assisting it, and only become active and reproduce when their host plants are stressed or begin to die from other causes.

Endophytes may benefit host plants by preventing disease-causing organisms from colonizing them. Colonization of the plant's tissues by endophytes creates a "barrier effect" (antibiotics?), where the local endophytes outcompete and prevent disease-causing viruses, bacteria or damaging fungi from taking hold.

The presence of some fungal endophytes can cause higher rates of water loss in leaves but others help plants survive drought and heat.

A wide range of chemical compounds naturally occurring in plants are not made by the plant itself, but by the endophytic fungi that live within the plant. Many fragrances used to attract pollinators, natural insecticides (e.g. caffeine, nicotine), chemicals we use as drugs (e.g. morphine, ephedrine), anti-cancer drugs (e.g. taxol), are all made by endophytic fungi. Endophytes are also being investigated for use in agriculture and biofuel production. Inoculating crop plants with certain endophytes may provide increased disease or parasite resistance while others may possess processes that convert cellulose and other carbon sources into "myco-diesel". The fungus *Piriformospora indica*, for example, has been shown to increase crop yield for barley, tomato, sweet corn, etc., and provide a measure of protection against root diseases.

It is suggested thousands of endophytes may be useful to humans but there are few scientists working in this field, and because deforestation and biodiversity loss are out of control, many endophytes might be permanently lost before they are even discovered. The effects of climate change on these important endophytic fungi is being investigated because plants grown in different climates, or at increased carbon dioxide levels, have been found to have different endophytic fungi.

While many endophytes are known to colonize multiple species of plants, some are host specific. Endophytic species are very diverse; only a small minority of existing endophytes have been scientifically identified. A single leaf of a plant may harbour many different species of endophytes: bacterial, algal and fungal. Additionally, some endophytic bacteria may live within endophytic fungi themselves. Fungal endophytes discovered so far are generally from the phylum Ascomycota, the sac fungi, though other groups of fungi are represented.

SOME THOUGHTS ON SPORE SIZE

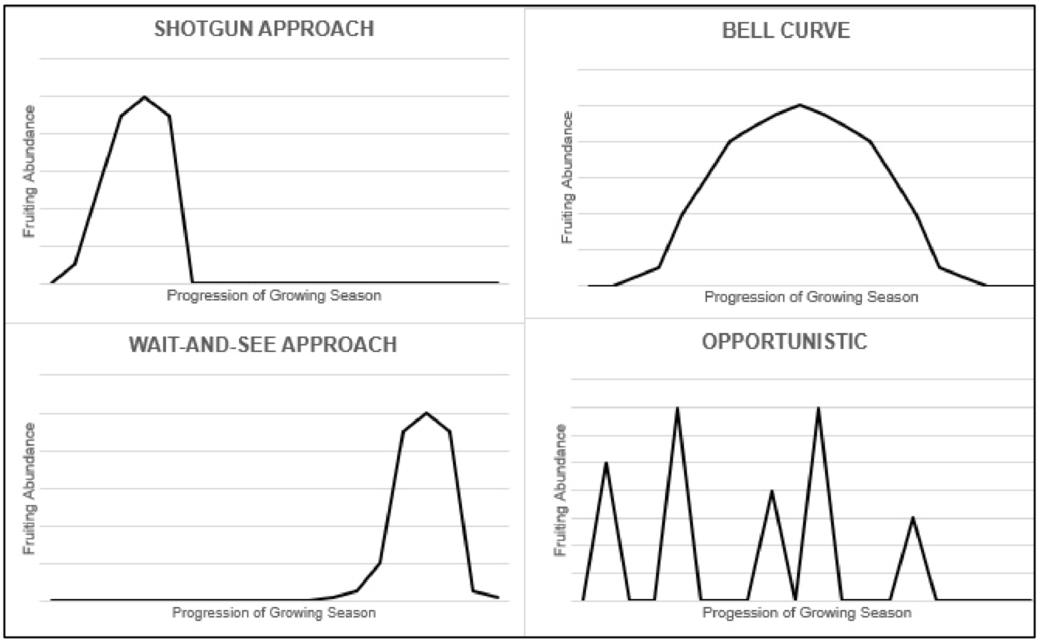
Abstract from Kauserud, H., Colman V E., & Ryvarden, L. (2008). Relationship between basidiospore size, shape and life history characteristics: a comparison of polypores. Elsevier Ltd.

Although spore dispersal is the predominant mode of spread in fungi, the functional ecology of offspring (spore) size and shape has received little attention. We investigated the relationship between spore size (volume) and shape and various life history parameters among 303 European polypore species. In an analysis of variance, basidiocarp [fruit-body] size, nutritional mode (parasitic vs. saprotrophic [decay species]) and host (conifer vs. deciduous) accounted for a significant part of the variation in spore size. Species producing large basidiocarps also produce large spores, parasites produce larger spores than saprotrophs, and species colonizing deciduous trees generally produce larger spores than those colonizing conifers. There was a correlation between spore size and shape, with larger spores being more spherical. The most important factors accounting for variation in spore shape were rot type (white rot vs. brown rot**) and nutritional mode, with white rot species and parasites having more spherical spores compared with brown rotters and saprotrophs.

** See CFF No. 13 page 6

WHY DO FUNGI APPEAR UNPREDICTABLY?

In CFF No. 16 page 5, there was an article entitled “Fungal Response to Moisture and Heat”. The article described how there is a zone of fungal “comfort” within which many species fruit, and outside of which they do not fruit. There also appears to be four basic fruit occurrence “types”, depending on when certain species first appear after commencement of rainfall, and how long they persist, provided conditions are suitable. In the “Shotgun Approach”, almost all the fungi fruit-bodies appear within the first 24-48 hours of suitable conditions and never or rarely appear again, until, perhaps, the following wet season. This group includes many of the species that are seen only once or twice a year (Figure 1).

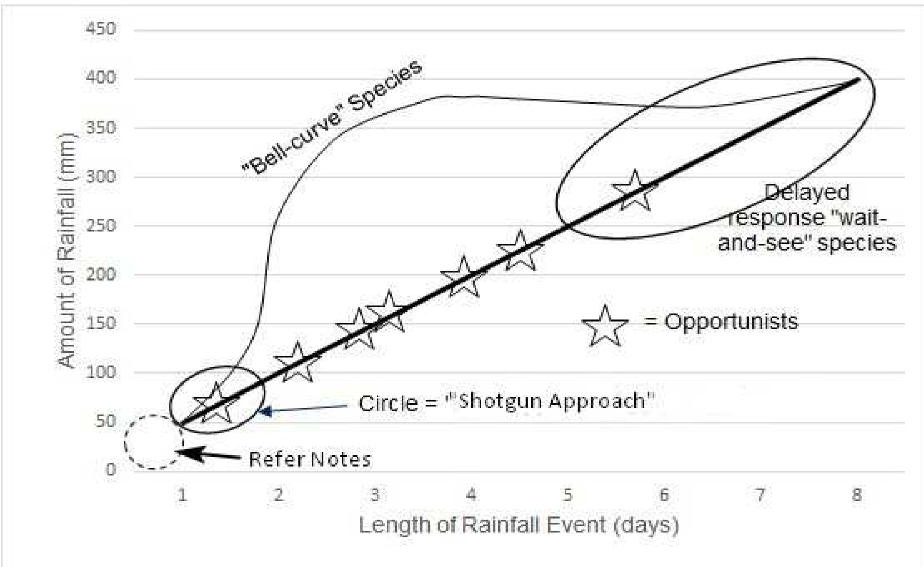


With the "Bell-curve" fungi, a few appear quite early after rains commence, gradually increase in numbers over the wet period or season, eventually reaching a peak in abundance, then gradually decline in numbers until only one or two new specimens appear, despite the continuance of suitable weather.

The "Wait and See" approach, seems to be popular with some coral fungi like *Ramaria*. Only after a lot of rain over an extended period do they appear, and if the wet period does not last long enough, or is punctuated with several dry days, they simply fail to appear at all. This does not seem to relate to degree of saturation of the soil or wood on which they grow. They just take their time getting up the enthusiasm. Exactly what triggers individual species to fruit is yet to be determined but probably relates to the availability of nutrients as well as the genetic makeup of the species.

Finally, there are the "Opportunistic species" like *Tremella*. These fungi pop up almost every time there is a shower of rain, almost regardless of quantity of rain or duration. *Tremella* (a jelly fungus that is a parasite on other fungi) and *Phallus indusiatus,* the Crinoline Stinkhorn, seem to follow this pattern.

In the Cairns region these fruiting types fall in a pattern with respect to amount of rainfall, as shown on Figure 2 below. In the example, the fictitious rainfall "event" is 400 mm of rainfall over eight days. A similar pattern occurred in Cairns from mid-December 2018 to mid-February 2019, when 1,760 mm of rain fell over 50 days almost without a break.



On Figure 2 there is a small circle on the bottom left (labelled "Refer Notes"). These fungal species *precede* the commencement of rains, although a light shower or two may occur. Some fungi, such as *Calvatia*, may begin to grow although there has been no or very little rain. My observations indicate these events are always preceded by a sudden and rapid drop in air pressure, heralding the rains yet to come. If the drop in air pressure is slow, over two or more days, they are not triggered to fruit, but a sudden drop such as an impending storm can elicit rapid growth. These are probably the species observers think of when they say some fungi "seem to know" when rain is coming – quite simply, they probably do! Many animals use a similar pressure-sense, such as bees that change their behaviour or ants that undertake mating swarms just before rainfall.

WHAT IS GONDWANA AND WHAT DOES IT MEAN FOR FUNGI?

Once upon a seriously long time ago (about 400 million years), all the Earth's continents were joined together in one big mass scientists call Pangaea. However, the Earth's surface does not consist of a motionless crust but rather of large plates which move and jostle against each other like leaves on a pond. There are seven large plates and many smaller plates that drift around the Earth's surface.

Figure 1: diagrammatic representation of Pangaea (from Internet)

About 200 or so million years ago the Pangaea mass split pretty much in two; the northern bit was named Laurasia, and consisted mostly of North America, Europe and Asia, still glued together, and a southern bit called Gondwana. The jostling continued and the plates moved apart and, in some places, even re-joined then moved apart again.

This Gondwanan super-continent consisted of present-day Africa, South America, India, Madagascar, Australia and New Zealand. Then the Gondwanan landmass started to break up and disperse about 170 - 180 million years ago. The bits all separated at different times (Figure 2)

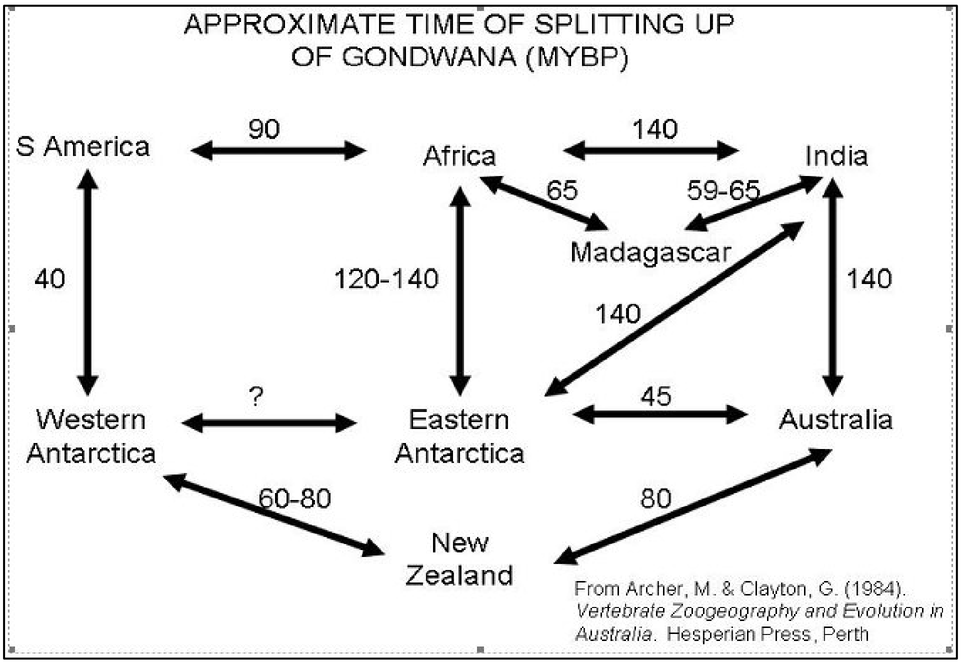


Figure 2: Estimated times of today's continents splitting from the Gondwana supercontinent (from various sources).

The significance for this for fungi is obvious. The ancestors of fungi that evolved when Pangea existed will have split earliest when Laurasia and Gondwana separated. That may be why so many fungi in the Northern Hemisphere are so different to those in the Southern Hemisphere – the two groups partly evolved in isolation from one another. Gondwana, when it was still all joined together would have then evolved its own suite of fungi which, in turn, split apart when Gondwana broke up, again causing what we call "speciation" to occur on the now-separated bits. Figure 2 shows how, for example, fungi in Australia would differ more from species in India because those areas split about 140 million years ago, whereas species in New Zealand and Australia might be more alike because they only split 80 million years ago. That is exactly what we find if we look at the genetics and taxonomy of fungi of these three countries.

Of course, it’s not as simple as that: fungj have tiny spores, easily transported by the wind or on the fur, feathers, skin or in the gut of animals. Wind currents and the migrating creatures would have transported spores between Laurasia and Gondwana and between the component continents. This would have “diluted” the process of speciation and could also have led to hybrids between species. Remember that the fungus is the mycelia, not the fruiting body. If the mycelium of one fungus “mated” or joined with the mycelium of another species, a hybrid could result.

Once humans came along, the transfer of fungal species from one continent to another got completely out of control. We have carried fungi (deliberately, as food or medicine, or accidently) for thousands of years throughout the globe, initially probably randomly and later along trade routes. Human migrations from Africa may have commenced as long ago as 170,000 years before present so there has been plenty of time to mix and distribute fungal populations. In the last 200 years this process has sped up enormously, and spores are probably transported by their millions across the globe every day. Fungi from the same geographical area often exhibit strong genetic barriers to hybridization. Such barriers might not exist, or might be weaker, between fungi that have remained geographically isolated. So — in theory — there is a greater possibility of hybridization when fungi spread beyond their normal geographical ranges. Hybridisation is well-recognised amongst disease-causing fungi but we know almost nothing about hybridisation amongst other fungi.

JUST FOR FUN

In 2011 a fungus from Borneo was named *Spongiforma squarepantsii* in honour of the cartoon character Spongebob Squarepants. It’s a member of the Boletaceae, the Bolete family: those with fleshy tops, stalks like mushrooms and pores under the caps instead of gills. Ref. Lees, S. (2019). Sponge Bob’s cousin found in Singapore. Gardenwise (Singapore Botanic Garden) v 52: pp28-29.

CURIOUS PIC

These cute little girls (fungal fruit bodies are what produce the offspring, so by our definition all fruit bodies are female 😊), are *Xylaria ianthina-velutina*. This strange fungus occurs around the world in tropical climates, usually on the seed pods of trees of the family Fabaceae, the pea and bean family. These are on the pod of the Queensland Black Bean, *Castanospermum australe.*

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