FUNGI FORAGERS

No. 12, December 2018

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 rather than identification.

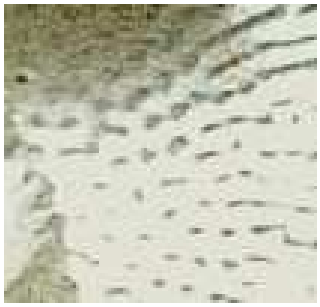
Barry Muir, Editor Jenn Muir

Gills Versus Pores – What's the Difference?

Following our last edition of Cairns Fungi Foragers (CFF) where we wrote about how spores were fired off basidia by merging of water droplets, a question was asked about the connection between gills and pores in fungus evolution. The short answer is that there isn't really a connection. For gilled and pored fungi to produce spores efficiently they need to increase the surface area of the part of the fungus that produces the spores – the more surface they have, the more basidia can be supported and hence the more spores can be produced. There are so-called pored fungi that have gills and so-called gilled fungi that have pores. It's simply a matter of getting as much surface area and as many spores produced as you possibly can. A close look at many **unrelated** fungi will show you all sorts of combinations, even some with convoluted furrows or spines – you name it and some fungus has used it. Here are a few examples:

Simple gills – *Cortinarius*

Complex gills – *Pseudohygrocybe*



Can't quite decide what I want to be – *Filoboletus*

Pores? - *Boletellus*

Other Types of Spore Dispersal

In an earlier CFF newsletter (No. 6 December 2017) we discussed *Pilobolus*, with some excellent photos taken by Ray Palmer. These little guys shoot their spore capsules off the top and they can travel up to 2 m and get stuck to some grass where they can be eaten by animals. The animals then poo the spores out somewhere else. Another group of fungi that uses animals in this way are the truffles (see CFF No. 4, August 2017). Truffles are eaten by wallabies, rats and birds such as the Brush Turkey, and their spores are carried far and wide.

The Bird Nest Fungi disperse their spores by putting them in tiny capsules called peridioles. These peridioles, which look like tiny eggs, form inside a cup-shaped base, the "nest". When a raindrop hits the

side of the cup it flicks the peridioles out of the cup and they fly through the air, eventually sticking to some vegetation or landing on the ground. The peridioles then burst or decay, releasing the spores.

Bird Nest Fungi

Phallus multicolor with flies

Fungi such as *Phallus* produce a gluey foul-smelling goop called the gleba on the tip of the fungus. The bad smell attracts flies and the first thought is that flies walk over the gleba and get it stuck to their feet. However, a scientist in Japan, Nobuka Tuno, has found (Ecological Research 1998 No. 13) that the spores pass through the fly's gut intact and are then deposited in the fly's droppings. The spores rarely stick to the fly's feet.

The tough-skinned puffballs release their spores by just splitting open and disintegrating (e.g. *Scleroderma*) or have thin, papery skins (e.g. *Pisolithus* and *Geaster*) that puff out spores when the thin skins are impacted by raindrops or animal disturbance.

What About Dispersal by Wind?

Some research has shown that the spores of many fungi only travel a metre or so from the "parent" fruitbody and that only about 5% of spores travel further. While 5% dispersal does not seem high, if a single fruitbody successfully released an estimated billion spores, then about 50 million spores could disperse greater than a metre or so downwind. Further, even light winds could carry large spores many tens of metres or even thousands of kilometres and small spores even further; over 44,000 km (Okubo and Levin 1989 quoted in Galante, Horton and Swaney, 2011, Mycologia 103 (6):1175-1183).

Ever Stopped to Think?

As we know from previous articles, fungal hyphae grow by increasing pressure in the tip of the hyphae; up to 1200 pounds per square inch (psi) in some cases. The pressure in your car tyres is around 30 psi and we all know what happens when you get a tyre blowout, so 1200 psi is a LOT of pressure.

So, what happens when we dig into soil with a spade or cut into the hyphae growing in the wood of a tree. Why don't all the contents within the hypha squirt out of the fungus and kill it? The reason is that the hyphae are made up of cells joined end to end, with more cells added as the hypha grows. The cell contents are all joined together by minute holes (called pores) in the wall (called a septum) between each pair of cells. During aging of the hyphae of most fungi these minute holes become glued up with chemical deposits. In some fungal tissues, notably in spore-producing parts, complex structures often develop in the septal pores which are believed to partly close the pore, acting as sieves to permit selective passage of certain molecules and small cell components, whilst regulating or preventing the migration of large cell components.

Thus, as well as the aging process slowly blocking these pores, many fungi can plug these holes very rapidly, in the event of hyphal breakage, using special structures within the cells called Woronin bodies. Some species plug the holes with hexagonal crystals instead; an instant puncture kit!

YOU CAN DO RESEARCH ON FUNGUS ECOLOGY

Cairns Fungi Foragers newsletter, as you will have noticed, has a bias towards the ecology of fungi rather than identification. This is for several reasons:

1. most of us have access to only a couple of popular books on fungi (e.g. Fuhrer or Young) – mostly relating to fungi of southern States, not Queensland. These are sometimes of limited use in identification of local Far North Queensland species. The more technical literature is difficult to obtain in Cairns and is also hard to understand without training;
2. we do not have access to high-powered microscopes, making it very difficult to identify fungi even if we did have the literature;
3. even if we had access to the equipment and the literature, many species of fungi we find up here are not scientifically described; or
4. many we find are extensions of their known ranges where one cannot be entirely certain whether they are the same as southern species or not.

There is, however, something we can all do that requires almost no equipment and which, for the most part is ORIGINAL RESEARCH! That is to look at fungal ecology and make detailed observations. If those observations relate to particular species (being very careful to make sure that our observations are on only ONE species if it is that type of study) we can then collect and preserve those species and send them off for identification. Once a name is obtained from the experts (this may take weeks, as they are few in number and they're hugely overworked) the observations can then be written up as scientific papers.

You do not have to be a scientist to publish "scientific" papers – we have seen excellent papers written by high-school students and citizen scientists and that contribute enormously to our knowledge. They can be published in Naturalist Magazines, in fungus society newsletters, or on-line sites like Facebook. iNaturalist is an excellent example of where photographs of fungi can be published. If enough people lodge photographs, experts can begin to analyse the information for time of fruiting, distribution, soil type and other information not available otherwise.

Some possible topics for amateur research on fungi are: growth rates of fruiting bodies; succession of fungal types over time in certain locations or as food resources change; behaviour such as phototropism (being attracted to or repelled by light – see the paper attached to this newsletter); recording host plants and substrates; associations with certain green plants; associations with unusual rainfall events; or information on fruit-body predation and predators. If you have any suggestions for other studies, please send them to me and I will pass the ideas on to others through this newsletter. If you feel nervous about sending a paper or report to be published, feel free to send it to Jenn and me and we will have a look at it. Jenn is also an excellent editor and is great at polishing up a paper into something more presentable – you ought to see some of my articles before Jenn gets at them!

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WE WISH YOU ALL THE VERY BEST OF HEALTH AND A PROSPEROUS 2019

PHOTOTROPISM *IN LEUCOCOPRINUS BIRNBAUMII*

Barry Muir

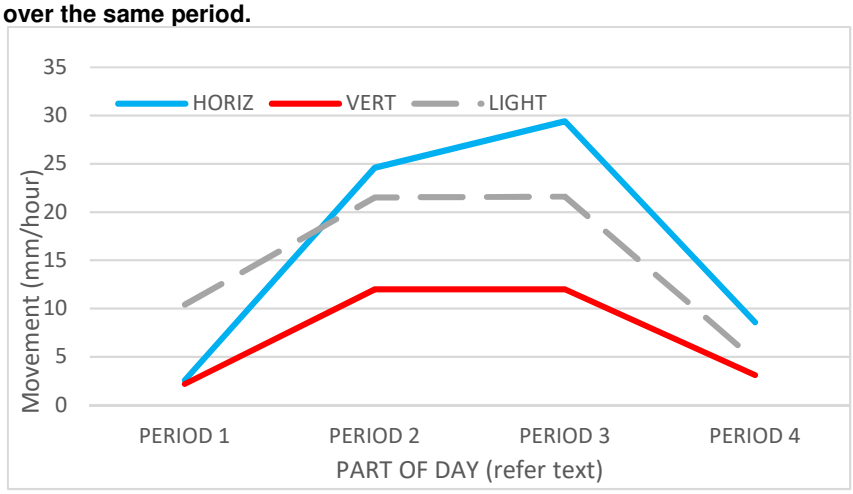
It has been known for many years that fungi can perceive light with the same light-sensitive molecules that plants and animals use. These are proteins that change their structure when capturing light of a certain wavelength. For example, blue light is detected by flavin-containing proteins, green light by opsin (which also detects light in the human eye), and red light is detected by phytochromes, which were initially discovered in plants where their role is to regulate light-dependent growth (BioRegion Freiburg 2010). The yellow colour of *Leucocoprinus birnbaumii* mushrooms is caused by alkaloids known as birnbaumins but it is not known if these are implicated in light-trapping or whether they are purely protective, probably being the compounds implicated in the toxicity of the fungus (Bartsch *et al*. 2005).

In the late afternoon of 31 November 2017 (herein referred to as Day 1) a sudden flush of tiny *L. birnbaumii* were observed in a flower pot located inside a brick alcove such that light only impinged on the pot from one direction. Almost all the "buttons" were leaning slightly toward the light. By the following morning (Day 2), the three larger fungi in the group (which were all about the same size) were observed to be leaning even more toward the light. To determine if this was a true phototropic response, at 1200 hrs the pot was rotated 180 degrees, and the location of the caps was marked using toothpicks and drinking straws to indicate the horizontal positions of the caps. The height of the caps above the surface of the soil was also estimated using a small ruler. As the three mushrooms were all about the same size it was assumed that growth rate (compared to movement rate), were somewhat comparable.

Four hours later, the three larger caps had responded by redirecting growth toward the light. The smaller caps had not moved. The measurements do not take into consideration the distortion caused by the changes in direction of growth, and it is fully understood that some of the movement was caused by reorientation and some by pileus expansion and stipe growth. The three caps had moved an average of about 15 mm horizontally and 9 mm vertically in the four-hour period.

On Day 3 at 0600 hrs, the flowerpot was again rotated 180 degrees. Light was also measured hourly using a Ross Photographic Light Meter. During early morning (period 1) the three caps averaged 2.6 mm in horizontal movement and 2.2 mm in vertical movement. During mid to late morning (period 2) movement was 24.6 mm horizontally and 12 mm vertically. Movement during the afternoon (period 3) was 29.4 mm horizontally and 12 mm vertically and during late afternoon and evening (period 4) 8.6 mm horizontally and 3.1 mm vertically. Spores were shed that night. Results in Figure 1.

Figure 1. Graph of mean horizontal and vertical movement of three *L. birnbaumii* caps of comparable size over the course of a day, and light level over the same period.



On Day 4 the caps collapsed and there was no growth. On Day 6 the collapsed caps were removed from the pot and late that afternoon new buttons had begun to grow. By Day 7 the buttons were larger but crowded and very variable in size, making measurement of movements difficult so this was not repeated. However, a sheet of blue cellophane was taped over the alcove at 1000 hrs so that predominantly blue light impinged on the fungi during the brightest part of the day. By 1600 hrs all had grown in both height and length and the

caps had begun to fill out, suggesting that the dominance of blue light had not particularly diminished movement or growth.

On Day 8 the pot was rotated 180 degrees. In the previous experiment this had resulted in a rapid reversal of movement direction to again head towards the light. The blue cellophane was replaced with pale red cellophane, which, it was assumed, would filter out most of the blue light. This was done about 0730 hrs, before there was much opportunity for the fungi to become reoriented to the rotation of the pot. By 1130 hrs, the mushrooms had not responded and appeared to be dying. The red cellophane was removed. There were no responses by 1500 hrs and the mushrooms had collapsed. No spores had been shed.

I suggest that red light not only reduced or prevented a phototrophic response, but the absence of blue light may have led to the early collapse of the second flush of mushrooms. It is possible that they required blue light not only to orientate themselves but there was some physiological need to maintain pileus health and to produce spores. Blue light is known to be a fungal initiator (Idnurm *et al.* 2010, Schwerdtfeger and Linden 2001). In green plants it is recognised that blue light is predominantly absorbed by red/yellow pigments (BioRegion Freiburg 2010). Perhaps the yellow pigment of *L. birnbaumii* is, in some way, acting as a light-trapping pigment although it is an alkaloid rather than a known light-trapping pigment such as flavin (Heintzen 2012). It is noted, however that Bartsch *et al*. (2005) considered the *L. birnbaumii* pigment chemistry "unusual", but do not speculate further. Alternatively, its colour may coincidentally be masking light-trapping pigments that are also present.

Summary

The following conclusions may be drawn from the observations:

1. there is clear evidence that *Leucocoprinus birnbaumii* is positively phototrophic, being attracted to light and responding rapidly by changes in direction of growth.
2. movement responses peaked during the middle part of the day when light was brightest and were slower in the early morning and late afternoon/evening. This may suggest that movement rate was directly related to light intensity.
3. the buttons that appeared dormant during the first flush of mushrooms did not begin to develop until the second day after the first flush had collapsed. This raises the question of whether they were, in some way, inhibited from development while the first flush was still growing.
4. it appears that blue light did not alter, or enhance, the phototrophic response, whereas red light not only reduced or prevented a response but may have led to the early collapse of the second flush of fruiting bodies.
5. there are indications that blue light may be required to initiate or allow sporulation, as its absence led to collapse of the mushrooms before they had set spores.
6. it is suggested that the unusual yellow alkaloid pigment birnbaumin may have a role as a light-harvesting pigment. This is unlikely, but worthy of further investigation.

REFERENCES

Bartsch, A, Bross, M, Spiteller P, Spiteller, M and Steglich, W. (2005). Birnbaumin A and B: Two Unusual 1-Hydroxyindole Pigments from the "Flower Pot Parasol "Leucocoprinus birnbaumii. Angew Chem Int Ed Engl. ***44*** *(19): 2957–2959. doi:10.1002/anie.200500082. PMID 15818629*

BioRegion Freiburg (2010). *A Ray of Light for Fungi*. https://www.gesundheitsindustrie-bw.de/en/article/news/a-ray-of-light-for-fungi/ BIOPRO Baden-Württemberg GmbH

Heintzen, C. (2012). Plant and fungal photopigments**.** *WIREs Membr Transp Signal* 2012, 1:411–432. doi: 10.1002/wmts.36

Idnurm, A, Verma, S, and Corrochano, LM. (2010) A glimpse into the basis of vision in the kingdom Mycota. *Fungal Genetics and Biology.* **47**: 881–892.

Schwerdtfeger, C. and Linden, H. (2001) Blue light adaptation and desensitization of light signal transduction in *Neurospora crassa*. *Mol. Microbiol.* **39**, 1080–1087. CrossRefMedlineWeb of ScienceGoogle Scholar