Title: 'The uninvited'

Description: Fly agaric (*Amanita muscaria*) with foraging mouse

Photographer's name: Noelle Bennett

Where and when: Chain Hills. Dunedin, April 2015.

Sustainability: Two important uninvited species are featured in this composite photograph – the fly agaric "toadstool" which is the fruiting body of a fungus - and a common house mouse. Both were introduced accidentally and are now permanent features of the ecology of many of our forests.

One of the most instantly recognisable of these introduced fungi is the "fly agaric" – that classic red speckled toadstool that is featured in books and cards. It is commonly associated with pine trees and birch trees, so that is its most likely route of introduction to New Zealand.

When it first emerges from the soil, the fruiting body of fly agaric looks like a white egg and the cap is covered with numerous small white or yellowish pyramid-shaped warts. These are remnants of the "universal veil", a membrane that encloses the entire mushroom when it is still very young. As the fungus grows, that signature red colour appears through the broken veil and the warts become less prominent. The warts do not actually change in size, but simply seem smaller courtesy of the expanding skin around them. As the fruiting body grows, the cap goes through a variety of shape changes until it finally becomes plate-like and flat in mature specimens. Fully grown, the bright red cap is usually between 8 and 20 cm in diameter, although larger specimens have been found.

So, as an introduced species, are fly agaric fungi a threat to our native and endemic species of fungi? Fly agaric are "ectomycorrhyzal fungi" (from the Greek *ektos* meaning outside, *mýkēs* meaning fungi and *rhyza* meaning root). This means that the fungi (in the soli) and tree form a symbiotic association (mutually beneficial connection) - the feeder roots of trees can absorb more nutrients from the soil because of the fungi, and the fungi gets food and nutrients from the tree.

A potential downside to this new ectomycorrhyzal invader is that they might displace the native ectomycorrhyzal fungi that also compete with each other for access to the plant host's roots, carbon and mineral nutrients in the soil.

Fly agaric frequently produces a high density of fruiting bodies (mushrooms, toadstools) so it is logical that it is also capturing a significant portion of available resources in the soil and from the plant, which, in turn, could threaten native fungi. This is a particular worry now that fly agaric has started to colonise our native *Nothofagus* (beech) forest. Seeing the fruiting bodies of this invasive species above ground doesn't give an accurate impression of the actual size of the individual fungus. What we see is just a small fraction of the true expanse of the fungus underground which may well extend for many metres through the soil. If a fly agaric fungus is indeed capturing a significant portion of available resources, they could seriously impinge on native fungi, including those nationally critical species.

So, what about that cute mouse? Is it also a threat to our biodiversity? Absolutely! They eat seeds and fruits and so are probably changing forest regeneration patterns and eventual forest composition. But it's their predation of insects that is likely to be the most far reaching impact. Mice have a keen sense of smell and sharp hearing - many of our native insects smell and make a lot of noise, so they are sitting targets for hungry mice. Mice climb, so they forage throughout the tree canopy. They are so small that they can get into small cervices in trees and amongst the fallen debris in this photo where insects used to find safe shelter. On offshore islands without mice, you find way more insects, especially the really big ones, and they are often sheltering in exposed places that a mouse can find and clean-out in no time. Mice, like all mammals, run a high-energy lifestyle - maintaining a high body heat, fast reproduction and lactating (when rearing young) makes them hungry beasts.

In New Zealand there are relatively few predators of mice (just mainly stoats, cats and moreporks), so they can reach enormous abundance. They are also habitat generalists that can prosper in all of New Zealand's main terrestrial habitats, including our towns and built environments.

All this makes for a hungry mouse hoard that is impacting on the base of the forest ecosystem food webs. Therefore, mice and rats together are probably having a huge and less obvious impact on the forests than the more recognised threat from rats and stoats destroying eggs, nestlings and adult birds. Before they arrived in New Zealand there would have been way more stick insects (probably our main forest leaf browsers), weta, beetles, native snails … the base workers that kept the forest ecosystem cycles going. Now many of those bigger insects are rare or have been eliminated altogether by mice, rats, stoats, hedgehogs and, in some beech forests, by introduced social wasps. These are indeed uninvited and unwelcome guests.

Photographer's notes: I suspect that the fly agaric is one fungus that most people would recognise. It seems to represent people's archetypal view of the classic 'toadstool' and it has to be admitted that it does make for a rather interesting photographic subject. I'd seen the mouse messing about in some decaying logs nearby and thought my chances of being able to get an image of him were just about nil. He was very fidgety at first. But eventually he started to ignore me which was awesome. That's often the photographers' challenge – be boring and patient until you are ignored by the star attraction … rewards will follow. The mouse wasn't actually under the mushroom, so I gave him or her a digital transportation to make the composition fit better.

Photo specs: This image is a composite that was produced from two images but one of them has been used multiple times with differing effects applied to each iteration to produce a desired end result. Technical specs: The main image (the fly agaric) was taken using a Panasonic DMC-GH4 camera and a Panasonic Leica DG Macro-Elmarit 45mm f/2.8 macro lens. Exposure details - 1/160 sec at f12 with an ISO of 200 and a focal length of 45mm (90mm full frame equivalent).

Digital specs: 4176 x 3523 pixels (14.71MP) @ 300dpi

Key words: fungi, fungus, mushroom, fly agaric, amanita muscaria, saprobe, mycorrhyzal, ectomycorrhyzal, hyphae, Chain Hills, Dunedin, competition, Noelle Bennett, Ecosystems Photography, sustainability.

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Noelle Bennett
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