A Mycolegium of Literature

Fruitbodies – a selection of the mycological literature

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This anthology of the mycological literature represents a collection of articles focusing on fruitbodies – how do the fungi form them, why are some big, and some small, and why are they now in many places not fruiting at the same time as they used to. As always, a personal choice, with too many interesting articles left behind; this is only an inspiration for exploration of the literature that you can find online.

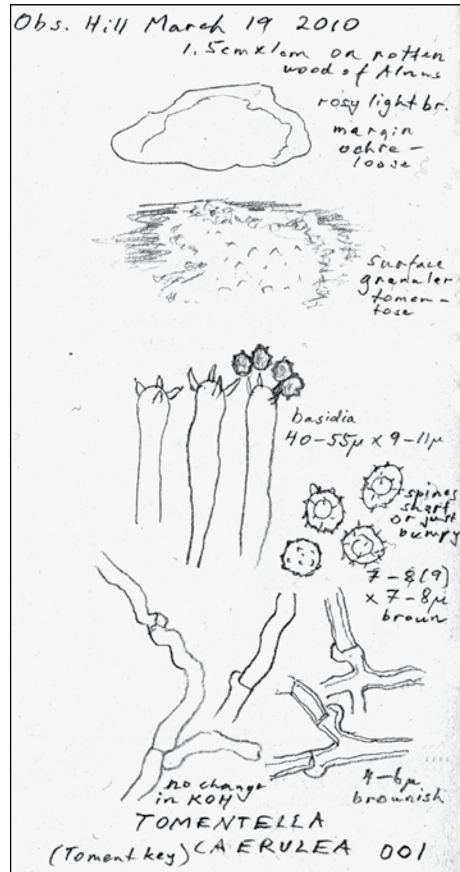
Tomentella caerulea, photo by Adolf Ceska.

Fruitbodies

Fungal fruitbodies serve only one purpose: production of offspring in the form of spores and getting these spores into the world. Every fruitbody is tailored to that, and the fungus uses a lot of energy to do so. How it is done is one of the open questions in mycology. Ectomycorrhizal fungi get the necessary carbs (carbohydrates in the form of sugars) for this enterprise from the tree they are associating with, but how they get the nitrogen that is necessary to make proteins is another question. For one medium-sized *Boletus edulis* a bit under one gram of nitrogen is needed. If we assume that the hyphae that grow around the tree roots (the root tips) are used for nitrogen storage, millions of root tips are needed for the production of that one porcino; this translates into a single individual covering 1-2 square meters of forest floor with one fruitbody on top. Storing nitrogen inside the hyphae is another option, but very many hyphae are needed, and on top of that it would make these fungal structures an easy target for fungivores. Of course, fungi have the same idea as humans, and they can provide their hyphal walls with the fungal equivalent of glass shards to fend off soil-dwelling fungus eating invertebrates. Both scenarios of N-storage are not very likely, and the fungus must be able to mobilize and organize the necessary building blocks very quickly; how that is done is still an open question.

We all know that there is huge variation in fruitbody size, and that some of the ectomycorrhizal species are very hard to find on tree roots, despite the fact that they form many large fruitbodies. Other species show the opposite pattern: they are very commonly found on the root tips, but the fruitbodies are hard to find. *Tomentella* species are a perfect example of this group – they grow in every forest type from the arctic to the tropics, in conifer forests and in deciduous woods. Finding the fruitbodies is a challenge, as they are just a brown to lilac-brown slightly fuzzy layer (the word crust which is usually used to described such fungi evokes a much more substantial entity) often on the underside of branches that lie on the forest floor. Hard to find, hard to recognize, BUT, ubiquitous, and big players in the ectomycorrhizal community. More conspicuous in the soil is *Piloderma fallax*, with its bright yellow rhizomorphs that stand out, but again the fruitbodies are just a crust. Another group that forms these fuzzy "crustose" fruitbodies are *Clavulina* relatives accommodated in the genus *Membranomyces*. Again: widespread, common, easily found on root tips, but hard to find fruiting. These are all fungi that do not invest heavily in fruitbodies, but still are very successful.

The spores of these humble low lying species get around by hitching rides from insects and other small invertebrates. Mites mow the *Tomentella* surface, gorging on the spores and getting covered by them; the thick-walled pigmented *Tomentella* spores are adapted to this and easily survive the passage through the animal's digestive tract.



Tomentella caerulea, illustration by Oluna Ceska.

Fruiting patterns

There still are many mysteries around the ways fungi make their fruitbodies. The triggers for making them are also not very well known. Why were there porcini everywhere in 2011, and hardly any in 2012? We do not have the specific answers for each species, but we all know that water and temperature are factors of importance – in years of drought, mushrooms are very scarce to absent, and fleshy mushrooms are nowhere to be seen when there is a foot of snow on the ground.

Correlations with weather patterns are, however, still not easy to show. A long-term study in a small forest plot in Switzerland shows that. For over 20 years fungal fruitbodies were counted from May to December, during weekly surveys. Around three weeks after rain, fruitbodies would appear. In the driest year on record, only a meager 18 species were found (and that was during that 6-month survey period), whereas the highest number of species recorded during any year (but not in the wettest year) was 194. Of the more than 400 species found during the study, only eight species were found every year. This data set was also used in a recent study to detect general trends in fruiting patterns throughout the years.

It was already known from studies in Saarland (an area in western Germany), that individual species' fruiting patterns had changed in the period from 1970–1989, with many species having shorter fruiting seasons, and a third of the investigated species fruiting longer, without being more abundant.

A recently published study by Kauserud and co-workers analyzed almost 750,000 records for 486 autumnal species from the UK, Norway, Switzerland and Austria over the years 1970-2007; much longer than for the Saarland study, and including the Swiss data set discussed above. Modern sophisticated statistical methods are used to analyze the data. The weather patterns in these four different places are different to start with, and have changed in different ways as well, and this shows also in the fungal records. In the UK the changes in fruiting are the most obvious – many species are now fruiting much later in the year than in the past, because of the milder winters, and also start to fruit earlier in the summer than they used to. In all countries the average day of fruiting for the average mushroom is now later in the year than in the early 70s. One other interesting finding is that in general the fruiting period of mycorrhizal fungi is more compressed than that of saprotrophs, despite the fact that the vegetation season, the time the plants are active, also has expanded over the years.

Changes in weather and in the environment are not restricted to Europe. But, for the USA the data do show changes in fruiting patterns are nonexistent. We can remedy that by making lists for club forays, or even better by keeping specimens from local, regional, and national meetings. Right now, existing fungal herbarium data going back to the mid 19th century are entered into a central database so we will have easy access to historical records to compare the present-day data. Herbarium records of plants through the years clearly show changes in flowering time and in distribution and occurrence of certain species in the northeastern USA.

Think about all these issues next year, when you eagerly wait for the first morels to appear after the long winter. Imagine the machinery springing into action after that long dormant period, and realize what it means for the forest as a whole that the fungi are active for longer periods than they used to be 40 years ago.

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