Edible and Poisonous Fungi

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This anthology of mycological literature focuses on species that are gathered in the wild for their edibility, and on species that are shunned because of their toxins.

As always, the selection is personal, not exhaustive, and meant to give you a handle to find more information. Many journals post abstracts of their articles online—just use the name of the journal in a search engine to start exploring. Some journals now allow free online access to the whole article, either immediately or after a modest delay.

Matsutake


Prized in Japanese cuisine, and native to a wide area, Matsutakes (note the plural) are the subject of many different studies, some focused on characterizing what they are, others looking at their ecology and life style, and the effects of picking, forest management etc. on production. In general, such studies are rare, and this makes Matsutakes one of the better researched species of mushrooms.

So what exactly are Matsutakes, where do they occur and how are they related to other species in the genus *Tricholoma*?

Matsutake in the Japanese sense is *Tricholoma matsutake*, which can be found throughout Europe and Asia as far east as Japan, growing with conifers. It also occurs in the eastern U.S.A. In Europe what was known as *T. nauseosum*, is the same species. However, similar-looking species on the American west coast (*T. magnivelare*), and in Mexico are different. What has been called *T. caligatum* in several places, e.g. the darker species in western North America, is not the same as the European species of that name, and therefore is still without a valid name in these places.

Matsutakes, both the Eurasian and the American species, form extensive mycelial mats or fairy rings, called “shiro” in Japan. In grassland fungi we expect that one individual grows out of a central point and that all the fruitbodies it subsequently forms over the course of many years will still be part of the same individual. Matsutakes do not necessarily follow this pattern. One shiro may indeed be made up of one individual, but shiros may also occur with contributions from up to four genetically different organisms. Mycorrhizal root tips are only found below the shiros. But, one matsutake individual can form mycorrhiza with different individual pine trees.
It has been shown that the Matsutakes are good competitors, but other species make a comeback as soon as the shiro has moved through the forest.

In two studies focusing on southwestern China, the genetic make up of Matsutake in forests of different ages and in different places was compared. The genetic diversity in the old-growth forests was greater than in the 50-year-old plantations. Both studies concluded that spores play a very important role in the establishment of new individuals. This may be translated into a warning against the systematic picking of the unopened fruitbodies! As the authors note: “At present, in order to satisfy consumer demands in Japan, virtually all *T. matsutake* mushrooms are picked prematurely before the veins of the mushrooms are ruptured to release spores.” By the way, raking which leaves the mycelium exposed is very bad practice—fruitbody production is severely disrupted and is slow to recover.

The research summed up here in a few sentences is actually very labor intensive. To show that specimens are genetically diverse, characters which reflect the difference have to be found, and that is not too easy in fungi. The genome of fungi lacks frills and fringes; selection works harder on the genes themselves than on the non-coding parts of the genome, so variation is harder to find. And then, the material has to be collected in difficult terrain, like the steep mountainous areas of Yunnan.

*Tricholoma maquinivale* is host to one of the so-called ghost plants, i.e. plants without chlorophyll that parasitize fungi on their roots to provide them with the carbohydrates the fungi receive from a tree species. Commercial matsutake pickers use the presence of the candy-stick, *Allo tropha virgata*, as an indication for the presence of western Matsutakes. A Japanese counterpart of *Allo tropha virgata* similarly marks the presence of Japanese Matsutakes.

**Boletes**


I always warn people that they have to be positive about their mushroom identification and make sure that every mushroom they want to eat is edible. This is impossible when there is no name to which an edibility report can be attached. We can rejoice then that certain hitherto nameless but well-known species have joined the ranks of the officially and scientifically described. That means that there is now an official name with a description, a diagnosis in Latin, and a type collection (which is a representative collection, preserved in an official herbarium), and the description and diagnosis are published in a journal that gets distributed to institutions (and in the ideal world also to interested people).

We are referring to two big conspicuous California Boletes which now carry the names *Boletus rex-veris*, the Sierra Nevada King Bolete, and *Boletus regineus*, the Queen Bolete, which had been masquerading as *B. aereus*, a European species. A big variant of the King Bolete with a brown to cinnamon pore surface when mature is given the name *Boletus edulis* var. *grandedulis*. It is amazing that some of our big conspicuous mushroom species went unnamed for so long!

The King Boletes have been studied in Europe to determine the number of species there. Four species emerge from the molecular-phylogenetic study: *Boletus edulis* s. *str.*, *B. aereus*: the real “aereus,” *B. reticulatus* and *B. pinophilus*. Several other names are sent off to the realm of synonymy.

An ecological study looked at the mycelia of the same four species in the soil. It remains a puzzle how fungi in general—and these in particular—are able to mobilize so many resources to make big fruitbodies. There are no hidden storage areas for nitrogen, sugars etc., and even the number of mycorrhizal root tips is small, and the tips are found only directly below a bolete fruitbody. As had been shown before, there is no correlation between the size and number of fruitbodies and the amount of mycelium or the number of root tips in the soil. Inconspicuous species can be everywhere on the roots, while the species that form big fruitbodies are hard to find on the roots. We can only conclude that some species are very good at getting sugars from the trees with which they form ectomycorrhizae, but how they get the necessary nitrogen for their mushrooms is still a mystery.

**Ectomycorrhizal fungi in culture**


The dream of every mushroom hunter is of course a plantation of her choice edible—imagine a plantation of King Boletes (Porcini), or an oak grove where you are guaranteed to find chanterelles, year after year …

Such dreams have come true in the truffle orchards where oak and hazelnut trees are planted with 

*Tuber* on the roots. Now a Spanish research group is working hard to make the dreams real for edible milk caps. They began by developing techniques to culture the fungi in the lab, then methods to track the fungi in the field. Next, they wanted to know how their focus species, *Lactarius deliciosus*, was doing in competition with two *Rhizopogon* species. Who was stronger—the false truffle or the milk cap or did they live happily together? *Rhizopogon luteolus* and *Lactarius* ignored each other, but the other combination, *Rh. roseolus and L. deliciosus*, competed for root space, with the *Rhizopogon* proving the stronger. After that, it was the great outdoors for the milk cap: Stone Pines were planted and inoculated with *Lactarius deliciosus*. Would the fungal species persist as mycelium on the roots of the trees and in the soil, or would the local fungi that were already present in the soil take over the new root space? The outcome was that the trees flourished on sandy soil, but the milk cap rapidly disappeared from the roots. However, in a site with clayey soil, the trees grew more slowly and the *Lactarius* was able to hang on; it had not been replaced by the other players in the field at the time of publication. One step at a time we get closer to a milk cap orchard!

**Chanterelles**


You would suppose that the chanterelles of the U.S.A. would be well known, and well studied. Yet the big, common Californian *Cantharellus* species, growing under coastal live oaks, was described only in November 2008, and is now known as *Cantharellus californicus*. Six years ago *Cantharellus cascadensis*, a species from the Cascade Mountains in Oregon, was also described as new. That species looks rather similar to the other local species, *C. formosus* and *C. subalbidus*, but differs enormously in its genetic make-up. Furthermore, the three species do not occur in the same habitat—the new species prefers lower elevations, *C. subalbidus* can be found in old-growth forests at higher elevations, while *C. formosus* is more abundant in second-growth forests.

How do forest practices influence the production of chanterelle fruitbodies? When thinning of fifty-year-old Douglas fir plantations in Oregon was scheduled, the effects on the chanterelles was followed over a period of 6 years. Thinning is more or less an euphemism for logging. The more trees logged, the fewer chanterelles, but over time, with new growth, and continued growth of the trees that were left behind, the chanterelle production bounced back. Of course, the impact of the logging on the soil, and the composition of the forest after the thinning are important factors—clearly if all ectomycorrhizal trees, and all chanterelle host trees are logged, there will be no chanterelle to be harvested, even if the forest closes up again.

The people in the western parts of the U.S.A. are lucky to have such big fleshy chanterelles growing in their forests. The locals of the Guyana highlands in northern South America, have to make do with small (less than 1 inch) wide chanterelles, growing like Oyster mushrooms on wood. The aptly named olive-yellow *Cantharellus pleurotoides* is presumably ectomycorrhizal with *Dicymbe corymbosa*, the one local ectomycorrhizal tree species, which forms monocultural islands in a huge forest of trees that “do it” with arbuscular mycorrhizal fungi. Growing on wood above the forest floor is perhaps one way to keep the fruitbodies away from the soddenness that prevails during the rainy season. The local people do not eat their chanterelles, but the visiting North American mycologists enjoy them very much.

**Toxic Amanitas**


Pringle, A., R. I. Adams, H. B. Cross, and T. D. Bruns, 2009. The scanty was that there are two distinct taxa under the name Amanita muscaria, one in America, and one in Eurasia, with a third species, Amanita regalis, at high altitudes and latitudes. In a follow-up study, the Alaska-based group of Lee Taylor and Gary Laursen added Laursen’s Alaska collections to those of the Japanese. Lo and behold, all three taxa occur in Alaska! Could it be that this is the original birthplace of all fly agarics? A recently published third study stirs the pot with collections from far eastern Russia, just across the Bering Strait from Alaska, and from many parts of the U.S.A. With more samples from more places, the picture becomes clearer and more confused at the same time. One group of Fly agarics is widely distributed throughout the northern hemisphere from Europe eastwards to Alaska (though sampling from northern Canada and Greenland is spotty). Another extensive group is present in large areas of North America. Then, several really different (where different in this case means different in genes), smaller groups are scattered across North America and found in the southern states, in the Pacific Northwest, and especially on the Channel Islands off the coast of southern California. These small rugged islands, which are hardly inhabited by humans, harbor at least four different types of A. muscaria, only one of which falls within the big North American group. Such variation on such a small scale is remarkable, and makes one wonder how specialization takes place, and whether spore dispersal is very short-range. Note that though we are aware of the diversity in Fly agarics, we are still waiting for the naming of the various entities.

Amanita muscaria is not confined to the Northern Hemisphere. It accompanied Monterey Pine from European nurseries, and is found nowadays in the southern hemisphere where millions of acres are covered with exotic pines. Amanita muscaria has escaped from these plantations and is slowly making its way into the native vegetations of New Zealand and Tasmania, where it associates with the native Nothofagus trees.

Almost every winter, central California gets a case of Amanita phalloides poisoning. This death cap species is common under coastal live oak, fruits heavily and entices people to eat it.

The history of this species in North America is convoluted. It was first mentioned in pre-1900 literature from the eastern states but, after careful reconsideration, it became clear that these records refer to other, brown, Amanita species. Both literature and molecular studies have contributed to the picture that is now emerging. In the West the first confirmed fruitings were in California and date from 1938 (Monterey), and 1945 (Berkeley). The American populations share their genetic makeup with those from Europe, though the variation in Europe is greater than in the U.S.A. It is safe to suppose that there were one or more introductions some time during the first half of the 20th century, but it is not known with which trees A. phalloides arrived on the West Coast; Cork Oak, introduced for the wine industry, is a possible original host. What makes this species different from many other introduced mycorrhizal species, is that it has changed hosts, and made its way into the native coastal Live Oak forests (Quercus agrifolia), where it now behaves as if it were native. It is unfortunate that such a menace is such a successful invasive ectomycorrhizal species in North America. Amanita phalloides is also found now in a few places in the eastern part of the U.S.A., but there it has not yet made the jump to other hosts. The same is true for the ones growing with European beech on the grounds of the government buildings in Victoria on Vancouver Island. Amanita phalloides has traveled with its hosts from Europe to Australia, South America, and South Africa, everywhere causing death, but no other cases of genuine invasion are known yet.

**Ganbajun**


Yunnan in southwestern China is renowned for its variety of edible mushrooms and the intense interest people show for them. As soon as the mushroom season begins, stalls appear along the roads to sell locally gathered mushrooms. One of the sought after delicacies is an endemic Thlephora species, called Th. ganbajun, described late in the 1980s. It is collected and eaten when the fruitbodies are young and look very different than the mature specimens. A genetic-molecular study revealed that much is going on in this species, or rather species complex. At least five quite different groups can be recognized, based on the ITS sequences. Most new collections fell in the same part of the *Thelephora / Tomentella* tree but one collection which might even be the same species as the type collection because it came from the same area (unfortunately the type specimen itself could not be sequenced) is quite different from collections elsewhere. The genus and species borders in this group of genera are clearly in need of more clarification.