Dead trees are alive with fungi

January 10 2018

Deadwood logs of different tree species were laid out at three areas of temperate forests by UFZ scientists. They want to analyze which fungus species inhabit dead trees. Credit: Witoon Purahong

Little research has been conducted to date on fungi that live on dead trees, although they are vital to forest ecology, breaking down dead wood and completing the elemental cycle between plants and soil. Soil

biologists from the UFZ have now discovered that the number of fungus species inhabiting dead trees is 12 times higher than previously thought. Once trees die, they are also colonized by different fungal communities depending on their species.

Fungi that live on trees perform an important function in the forest ecosystem by breaking down dead wood. This is no easy feat, because wood is very resilient, held together by a biopolymer known as lignin, which, together with cellulose and hemicellulose, form the cell wall of woody plants and give the wood its stability. Fungi are able to break down the robust lignin and the flexible cellulose fibres by releasing enzymes that cause the polymers to degrade and become mineralised. As part of the ecosystem's cycle, the leftover material becomes part of the humus layer, which gives the soil its stability and forms the substrate for a new generation of trees.

The study took the UFZ researchers to three areas of temperate forests in the Schorfheide-Chorin Biosphere Reserve, the Hainich National Park and the Schwabische Alb Biosphere Reserve, where they laid out around 300 dead tree trunks of eleven different species, each up to four metres long. The trees included seven deciduous species such as beech, oak, poplar and ash and four coniferous species: spruce, Scots pine, Douglas fir and larch. Three years later they returned to see what kind of fungal communities had established themselves in the trunks. The results were astonishing: "The diversity of fungi living in the trees was an order of magnitude greater than previously thought," says Dr Witoon Purahong, a soil ecologist based at UFZ in Halle and the first author of the study.

The researchers identified between 22 and 42 operational taxonomic units (OTUs) per trunk. OTU is a scientific term used by molecular biologists to describe organisms that can be equated with individual species due to their DNA but do not already have a species name of their own. All in all, the UFZ team identified 1,254 OTUs in the dead trunks.

In a previous study, researchers found just 97 fungal species living on the same logs - about 12 times fewer than the UFZ scientists have now discovered. Dead conifers generally had greater species diversity of fungi than most deciduous trees. The greatest diversity occurred on Douglas fir, larch and oak and the smallest amount of diversity on beech and hornbeam.

The reason why the UFZ soil ecologists found so many different species of fungi lies in the modern molecular technique they used. The researchers used a DNA sequencing technology known as next-generation sequencing to determine DNA markers of the fungi hidden in the wood. In previous, similar studies, only the fruiting bodies of the fungi growing on the surface of the dead trees were documented. This gave rise to the misleading impression that only a small number of fungus species inhabit dead trees. "It's like an iceberg: you can't see most of the fungi because they are inside the trunks in the form of a fine mycelium," says Prof François Buscot, who heads the department of soil ecology at the UFZ. In other words, the visible fruiting bodies are only a tiny part of the entire fungal communities inhabiting a dead tree.

But it's not just the much greater diversity of fungi than previously suspected. The UFZ soil biologists also discovered that wood-inhabiting fungi prefer certain species of trees and don't simply have a general preference for either conifers or deciduous trees, as scientists previously assumed. They discovered seven such distinct fungal communities on deciduous trees and two on coniferous species. For example, oak and ash each harbour very specific communities fungal species whose composition is very different from those found on other deciduous trees. In the case of the conifers, the fungi growing in dead Scots pine were clearly distinct from those found in the other coniferous species investigated. It is not yet clear why there are such marked differences between the fungal communities in different species of dead wood. "Oak and ash have many identical characteristics, such as the wood structure

and the carbon-to-nitrogen mass ratio, but they are very different when it comes to the number of fungal OTUs," says Witoon Purahong. The fungal communities found on these two species are more different from each other than compared tp any of the other tree species the team investigated, he adds.

Now the soil ecologists from UFZ in Halle will focus on identifying the mechanisms that determine whether or not a fungus colonises a particular species of tree. "The millions of years of coevolution between trees and wood-inhabiting fungi could provide an explanation for their coexistence - just as we see with symbiotic fungi, for example," says Purahong. What is fascinating, however, as Buscot adds, is that in some cases the specialisation of fungi on dead wood is greater than the oneof symbiotic fungi on living plants. The coexistence of communities of fungi, bacteria and invertebrates living in dead wood could also account for specific colonisation strategies.

The results of this study have increased our understanding of the biodiversity of communities living in dead wood. This is important not only because it will enable us to improve the protection of wood-inhabiting fungi, which may be threatened by the expansion of forest monocultures. It is also important because the fungi that grow in dead trees include species already known as soil-dwellers, plant pathogens or symbiosis partners, which appear to use dead wood as a temporary habitat. "Dead wood is an integral part of forest ecosystems, which plays a vital role in the function and maintenance of biodiversity," says Buscot.

More information: Witoon Purahong et al, Molecular evidence strongly supports deadwood-inhabiting fungi exhibiting unexpected tree species preferences in temperate forests, *The ISME Journal* (2017). DOI: 10.1038/ismej.2017.177