Biologists help solve fungi mysteries

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Kabir Peay, assistant professor of biology at Stanford, measures the diameter of a tree at Point Reyes National Seashore.

(Phys.org) —A new genetic analysis revealing the previously unknown biodiversity and distribution of thousands of fungi in North America might also reveal a previously underappreciated contributor to climate change.

Pine forests are chock full of wild animals and plant life, but there's an invisible machine underground. Huge populations of fungi are churning away in the soil, decomposing organic matter and releasing carbon into the atmosphere.

Despite the vital role these fungi play in ecological systems, their identities have only now been revealed. A Stanford-led team of scientists has generated a genetic map of more than 10,000 species of fungi across North America. The work was published this week in the *Proceedings of the National Academy of Sciences*.

Fungi are much more important than most people realize, said Kabir Peay, an assistant professor of biology at Stanford and senior author on the new paper. "They are the primary decomposers in most of the planet's ecosystems," he said, "and if not for them, dead material would accumulate to the point where most other biological processes on Earth would grind to a halt."

Soil fungi can be divided into two primary groups. The saprotrophs live in the top layer of soil, digesting dead matter, breaking up molecules into individual components – converting proteins into amino acids and starches to simple sugars, and freeing up elements such as nitrogen – that plants rely on for growth.

The other group, mycorrhizal fungi, have an even closer bond with plants, living among their roots and converting older forms of organic matter into nitrogen and phosphorus for the plants. In return, the plants feed these fungi a steady stream of sugars they obtain from photosynthesis.

The soil stores three to four times as much carbon as the atmosphere, and all this microorganism activity also releases some of that carbon into the air, to a tune of 10 times the amount of carbon into the atmosphere as humans release through emissions.

"It's a huge flux of carbon into the atmosphere, and fungi are the engines," said Jennifer Talbot, a postdoctoral research fellow in Peay's lab and first author on the study. "But we do not know how much diversity matters in maintaining the carbon cycle. Are all fungi doing the same thing? Can you kill half the species on Earth and still have the same amount of carbon dioxide released into the atmosphere, carbon stored on land and nutrients recycled?"

DNA in the dirt

These questions are impossible to answer without first knowing which fungi are out in the world. So the researchers traveled to 26 pine forests across North America and collected 10-centimeter-deep soil cores, more than 600 in all. Within hours of collection, and with the assistance of local scientists and universities, they preserved the samples to extract and isolate the fungal DNA. The researchers then used modern genomic tools to sequence unique stretches of the environmental DNA that can be used as barcodes to identify all of the fungal species present in each sample.

The sequencing revealed more than 10,000 species of fungi, which the researchers then analyzed to determine biodiversity, distribution, and function by geographical location and soil depth. Interestingly, Peay said, there was very little overlap in the fungal species from region to region; East Coast fungi didn't show up on the West Coast or Midwest, and vice versa.

"People oftentimes assume that similar habitats in, say, North Carolina and California would have similar fungi, but this is the opposite of what we find," Peay said. "What's more interesting, despite the fact that soil fungal communities in Florida and Alaska might have no fungi in common, you find that many of the processes and the functional rates are convergent. The same jobs exist, just different species are doing them."

The team found this to be particularly true when comparing the functionality of fungi at different strata of the core samples. Even though the samples were collected thousands of miles apart, fungi near the top all performed the same task; similarly, bottom fungi performed very similar functions across the continent.

Peay said that more work is needed to understand fungal dispersal mechanisms and whether that plays a role in restricting species to particular regions, but the current finding that each bioregion has its own unique fungal fingerprint indicates that fungi could prove to be powerful forensic markers.

Impact on the climate

One surprising discovery was related to fungi producing oxidoreductases, enzymes used to break down particularly old forms of carbon-based molecules. In the study, the activity of oxidoreductases was associated with the abundance of mycorhizzal fungi. The new results suggest that these fungi may be far busier in degrading old organic material than previously thought.

"If mycorrhizal fungi are responsible for breaking down these types of carbon, even to a small degree, it totally changes our concept of how carbon is cycled through ecosystems and released into the atmosphere," Talbot said. "This shows that we really need to think about the biology of the system. We hope to provide some simple parameters so folks building climate change models will be able to fold in this type of biology."

More information: Jennifer M. Talbot, Thomas D. Bruns, John W. Taylor, Dylan P. Smith, Sara Branco, Sydney I. Glassman, Sonya

Erlandson, Rytas Vilgalys, Hui-Ling Liao, Matthew E. Smith, and Kabir G. Peay." Endemism and functional convergence across the North American soil mycobiome." *PNAS* 2014 ; published ahead of print April 14, 2014, www.pnas.org/content/early/201 … 584111.full.pdf+html

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