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Spectroscopy and transcriptomics provide novel insights into soil organic matter decomposition mechanisms in ectomycorrhizal fungi

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Decomposition of soil organic matter (SOM) is thought to involve saprotrophic fungi and not symbiotic fungi, which include ectomycorrhizal fungi; the latter are instead thought to bring plant carbon into the soil. This view is supported by the loss in ectomycorrhizal fungi of many genes encoding lignocellulose-degrading enzymes in their saprotrophic ancestors. However, we demonstrate here that ectomycorrhizal fungi can decompose SOM in the presence of glucose. Using spectroscopy, we show that five species of ectomycorrhizal fungi, representing at least four clades that have independently evolved symbiosis, have substantial capacity to decompose SOM extract using oxidative mechanisms. RNA-Seq analyses revealed that the genome-wide set of transcripts expressed during litter decomposition has diverged over evolutionary time. Each species expressed a different set of enzymes that are associated with oxidative lignocellulose degradation by saprotrophic fungi. The decomposition “toolbox” has diverged through differences in the regulation of orthologous genes, the formation of new genes by gene duplications, and the recruitment of genes from diverse but functionally similar enzyme families. A comparison of closely related species within the Boletales clade showed that ectomycorrhizal fungi oxidized components in the SOM extract as efficiently as brown-rot wood-decayers. The ectomycorrhizal species within this clade exhibited more similar decomposing mechanisms than expected from the species phylogeny in concordance with adaptive evolution occurring as a result of similar selection pressures. We propose that the ancestral decay mechanisms used primarily to obtain carbon have been adapted in symbiosis to scavenge nutrients rather than releasing carbon. However, when supported by energy from the host plant, the oxidative decomposing activity of ectomycorrhizal fungi may significantly affect the chemistry of organic molecules in SOM, which could influence fundamental soil functions including the turnover and stabilization of organic matter.