**What maintains a 400 million year old trophic interaction? Exploring evolutionary causes and ecological consequences in the mycorrhizal symbiosis.**

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The vast majority of plants form symbioses with soil fungi, which provide plants with nutrient uptake services in return for sugars from photosynthesis. Even though the symbiosis is widespread, several plant lineages have evolved the ability to exclude fungi from their roots, suggesting that the symbiosis is not always favoured by natural selection. To understand the causes of variation in the symbiosis, a ~3000 taxon database and a fossil calibrated molecular phylogeny were combined to reconstruct of the evolutionary history of the symbiosis. Evolutionary associations between ecological climate niches and the Arbuscular Mycorrhizal (AM), Ecto Mycorrhizal (EM) and Non Mycorrhizal (NM) character states were also explored. Estimates of transition rates away from the ancestral AM state suggested that losses of the symbiosis (the NM state) are more frequent than transitions to the EM state. Nevertheless, transition rates back to the AM symbiosis from the NM state were five times more frequent than losses, suggesting that natural selection tends to favour the evolution of this symbiosis. Transitions from the AM to the NM state and from the AM to the EM state were also accompanied by a shift to colder climate niches. This pattern is consistent with previous reports of greater cold sensitivity in fungal lineages that form AM associations relative to fungal lineages that form EM associations. Cold climates may therefore restrict the evolution of the AM symbiosis, but not the EM symbiosis. Using these patterns as a foundation, I will also explore how we can test causal hypotheses about the origin, maintenance and consequences of the mycorrhizal symbiosis within populations, where evolution takes place, as well explore how the symbiosis influences community and ecosystem processes.