VRG22-007 - Biotrophic fungal diversity & functional responses to climate change

Abstract

Plant and soil microbiomes are massively interconnected ecological organs mediating the terrestrial carbon (C) cycle. Fungi are the primary regulators of above-belowground C cycling because they are prolific decomposers and ubiquitous plant-biotrophs governing productivity. Every plant in the environment harbors a mycobiome comprised of mutualists, commensalists, and parasites. One of the most vital groups are mycorrhizae, which inhabit plant roots and form symbiotic relations with ca. 90% of land plants. These fungi increase plant nutrient uptake and pathogen protection in exchange for 10-40% of a plant's photosynthetic energy. On the opposite extreme, plant pathogens cause disease in plants and are a major source of local species imperilment and extinction. Many pathogenic fungi are also able to live as saprotrophs and are particularly versatile and stress tolerant. Somewhere in-between mycorrhizae and pathogens are fungal endophytes, capable of living asymptomatically in any plant organ and able to promote plant resistance to disease by activating plant immune systems to better cope with stress and pathogens. We can address fundamental challenges in climate and global change research by considering the inter-relatedness among biotrophic fungi and plants beyond what can be understood in botany and mycology alone. In this proposal, I will explicitly identify the factors structuring biotrophic fungal communities and elucidate how species interactions drive plant development under current and future environmental conditions. A major goal of this project aims to build a reliable theory for predicting how and why biotrophic fungi cause variation in plant development under global change and to validate these principles using a range of observational and experimental techniques. In this proposal, I will tackle three complimentary questions that address fundamental challenges in environmental and climate change research using a plant-fungus systems approach and strong quantitative and modeling methods. In question 1 (Q1), I will test how fungal communities respond to concurrent climate changes and how this impacts plant development. The over-arching goal of Q1 is to measure how fungi respond to experimental drought and warming, either alone or in combination, across a large spatial scale and to specifically isolate the roles of mycorrhizal fungi in mediating plant and soil ecosystem-level responses. In Q2, I will characterize the biogeographic drivers of biotrophic fungal diversity and test whether climatic predictors of fungal taxa accurately capture how fungi respond to climate change. The overarching goal of Q2 is to test whether species shifts due to climate change can be accurately estimated using biogeographic modeling in order to make predictions into the future where we lack empirical data. In Q3, I will experimentally test how mycorrhizal, endophytic, and pathogenic fungal co-occurrence and diversity shapes plant defenses, growth, and nutrition under concurrent global change conditions. The overarching goal of Q3 is to disentangle how endophyte-mycorrhizae-pathogen interactions along a diversity gradient drive plant development now and into the future. This research will fundamentally advance the field because it not only tests how plants and microbial communities will shift with future environmental changes but also how their interactions will transform to influence emergent ecosystem function in a changing world. This work is highly innovative in how it blends experimental (Q1 and Q3) and modeling techniques (Q2) for the first time. This approach will allow me to develop robust principles for understanding how biotrophic fungi will respond to global changes, and it will disentangle the benefits and limitations of purely experimental versus modeling techniques by blending them together. This will not only provide basic insights that allow us to generate strong, broadly applicable biodiversity theory under any environmental conditions, but it will also help us to better prepare for an uncertain future. In the face of climate change, it is vital to understand and accurately predict how interactions above- and belowground will change because this feeds back to influence Earth system functions necessary to support biodiversity and humanity into the future.

Scientific disciplines:
Ecosystem research (50%) | Plant ecology (25%) | Mycology (25%)

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Further links to the persons involved and to the project can be found under
https://wwtf.at/funding/programmes/vrg/VRG22-007/