

Research Project Title: Modelling gene drives in pathogenic fungi

Research Theme: Environment Sustainability and Resilience

The Environment Sustainability and Resilience theme addresses problems of food security; which is under constant and growing threat from pathogenic fungi. Losses due to persistent epidemic fungal outbreaks in rice, wheat, maize, potatoes and soya bean leave food resources depleted and unstable. If a severe fungal epidemic occurred in all 5 groups simultaneously there would only be enough food left to sufficiently feed 39% of the world's population. (<https://www.nature.com/articles/nature10947>) This catastrophic potential of pathogenic fungus is globally overlooked. Their complex lifecycles include multiple modes of reproduction giving them a large evolutionary advantage over their hosts. (<https://link.springer.com/article/10.1186/s43008-019-0020-8>) Meanwhile the world's growing population puts immense pressure on industrial agriculture leading to mass monocropping; leaving crop communities highly susceptible to fungal infection. In my project I will be researching this interaction between monocropping and the high diversity of fungi.

Fungal gene drives are genetic elements that manipulate gametogenesis and reproduction to increase their own transmission to the next generation. (<https://royalsocietypublishing.org/doi/10.1098/rspb.2019.2709>) The aim of my project is to devise a working mathematical model that calculates a qualitative indication of the conditions needed for successful gene drives in pathogenic fungi. My model will compute the optimum conditions to maximize the transmission of synthetic gene drives through target fungal populations. Such synthetic gene drives have the potential to control agricultural fungal outbreaks by reducing crop infections, thus reducing the global food crisis.

This project enables me to combine the two disciplines of my mathematical bioscience degree. It allows me implement practical applications of coding I have learnt and to expand upon principles learnt in genetics and evolution. A previous research project I undertook at the university of Birmingham first introduced me to gene drives. Whilst using the GMR driver to express target genes in the developing drosophila eye I became intrigued by the possibility of exploiting the power of drives to manipulate populations to our advantage.

To ensure the success of my project I have devised a research plan to attain my goals in the given timescale. In the early stages of the project I will be conducting a literature review upon gene drives and pathogenic fungi. I will highlight differences in life cycles, classify behaviors and key dynamics between species. I will incorporate relevant material into a conceptual mathematical model and use this to simulate the behavior of gene drives in pathogenic fungi. I will translate this understanding of natural drive mechanisms into the design of conditions promoting the success of artificial drivers. This expands upon skills learnt in mathematics for the sciences1 and 2, vector calculus and applied mathematics modules. Specifically, the use of mathematical modelling and Ordinary Differential Equations. I plan to share my findings in a seminar for the mathematical biology group, thus increasing their overall impact.

My preference for the second summer is to volunteer on an international expedition to implement and develop the leadership skills learnt throughout the scholarship and make a positive impact in a remote community.