Project: **"Unleash the potential: developing novel statistical methods to assess biological plasticity in multidimensional fitness landscapes"**

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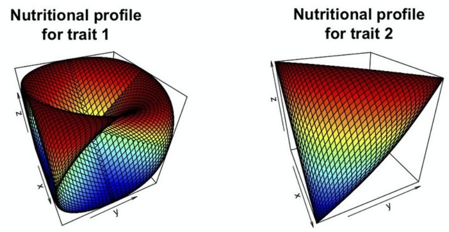
Aims

The overarching aims of the project are

(1) Develop novel statistical approaches to quantify plasticity in multidimensional landscapes
(2) Analyse publicly available data to validate the robustness of the model
(3) Introduce complexity into the statistical models to control for collinearity between traits (e.g., landscape for size vs length) and for phylogenetic relationships between species
(4) Familiarise the student with the pipeline for writing an R package;

Background



In 1993, a powerful method for measuring the effects of nutrition on the performance of animals and humans was devised – known as *'nutritional geometry'*. The method allows for the investigation of *n*-nutrients simultaneously. The idea is simple. Each axis represents the intake of a nutrient, and there is one axis that represents the performance trait. For *n* nutrients, we will then have *n-1* nutrient axis. For example, to investigate the effects of protein and carbohydrate intakes (nutrients) on lifespan (performance), the x- and y- axis are protein and carbohydrate intakes of animals, and the z-axis is the lifespan of animals that have eaten the combinations of protein and carbohydrate. Unfortunately, the development of quantitative methods to analyse these landscapes have lagged behind, and only recently we have had models to test the differences between peaks and valleys in these nutritional landscapes. Yet, a lot of information on these landscapes are still unexplored.

One important feature of animals (and humans) is their ability to express performance traits (e.g., lifespan) in different diets – a term we can call 'plasticity'. Plasticity can be defined as

- The ability of organisms to have similar fitness in different conditions (diets); or
- The ability of organisms to have different fitness in similar (or same) conditions (diets);

This implies that we are not interested the peaks or valleys, but in how much fluctuations ('wobbly') of the performance exists across diets, and how quickly on average the performance goes from very low to very high. To date, however, we do not have a quantitative method to measure plasticity in multidimensional landscapes generated by nutritional geometry studies.

Approach

In this project, the student will first use simulated data and test a range of statistical for generating the multidimensional landscapes (e.g., Thin-plate splines, GAMs, GLMs, Machine Learning), which often require interpolation. Next, the student will construct a statistical framework to measure plasticity in these multidimensional landscapes. Parameters of interests include wobbliness, as well as e.g., the size of the peaks and valleys of the landscape. Once the approach(es) to quantify plasticity parameters have been established and validated in simulated data, the student will then apply the approach to available empirical data for various traits and species, to validate the approach for real world data. Finally, the student can wrap up the project by starting to write an R package, which will ultimately make the approach available to the academic community. It is important to mention that depending on the project timeline, there is scope to add complexity to the approach(es), and control for collinearity of traits as well as phylogenetic relationships between species. For example, body size and weight are collinear, and thus comparing the landscapes of these traits can be misleading at face value. Likewise, some species are more closely related to each other than others (e.g., insects-insect vs insect-plants), which can also mislead estimates and comparisons.

Impact to the academic community

With climate change, the ability of species to rapidly respond to changing conditions is crucial. These rapid responses are associated with plasticity. However, to date, there are no reliable statistical methods that unleash our full potential to measure plasticity in highly controlled, detailed experiments. This project develops a novel method to measure plasticity in studies of animal and human nutrition. As a result, the project will have the potential to advance how we measure plasticity and ultimately, how we can predict species' ability to adapt to our changing world.