Seminary Diary

Seminar One: Deep-time evolution of biological responses to temperature changes

Dimitrios Georgios Kontopoulos - 10th October 2019

To better forecast the impacts of climate change we need to look at how biological traits respond to temperature. The measure of biological traits at different temperatures typically produces a unimodal thermal performance curve (TPC).

The Metabolic Theory of Ecology has been used mainly for large-scale comparisons of trait performance. There is limited within species or evolutionary application.

The literature details multiple TPC hypotheses. These range from strong thermal dynamic constraints (‘Hotter-is-better’) to weak thermal dynamic constraints (‘Perfect biochemical adaptation’). To test these hypotheses, a phylogenetic comparative approach was used, looking at the correlation structure of parameters and their phylogenetic signal.

Phytoplankton growth rates were used to obtain estimates of TPCs and showed a ‘Hotter-is-better-pattern’. Maximum growth rate increased weakly with thermal optimum, but general thermal responses were broad and showed weak thermodynamic constraints.

This project then tested two hypotheses regarding the evolution of thermosensitivity: that thermal sensitivity evolves around an optimum value or evolves in other ways. The phylogeny showed random bursts of trait evolution. There is no global optimum, instead species explore the parameter space through evolutionary time.

The effect of temperature on mutation was also explored. Simulations showed that mutations became more destabilising with temperature. Further simulations with multiple species at multiple temperatures indicated weak evidence that higher temperatures reduce mutation rate. We need to look at varying levels of organisation, from genome composition to how species interact. A multidisciplinary, multi-level approach is needed to develop a unified picture of thermal adaptation.

Seminar Two: A manifesto for systematically describing consumer-resource interactions

Daniel Barrios-O’Neill, Leverhulme Trust, University of Exeter - 31st October 2019

Consumer-resource interactions are at the heart of ecology and worth quantifying. Capture rate contains information about the space in which the interaction occurs, whereas handling time relates to organismal biomechanics. Generally, larger, warmer animals have higher capture rates and shorter handling times.

Mutual interference suggests that as the density of predators in a patch increases, per capita consumption rate decreases. This may scale with body size, but more data is needed. It has also been shown that consumers moving through volume encounter each other more frequently than surface foragers, leading to a steeper scaling relationship of mutual interference.

When quantifying encounter rates, it is important to consider the impact of biomass, rather than units, and physical structure. Physical structure matters because we are changing it without understanding the consequences. Experimentally, it is necessary to work with artificial structures to precisely manipulate space.

In consumer-resource interactions, metabolic predictors are well established. However, the prevalence of model species skews the global data. To understand these interactions, modifiers of encounter rates are key and knowledge gaps must be addressed.

Experiments exploring consumer-resource interactions must consistently measure all appropriate variables, so that the data can be used by others. Opportunities to harvest that data are myriad, especially when combined with open access to data and tools. The large global ecological community must work together, and treat undescribed interactions with the same reverence as undescribed species.

Seminar Three: Flowers, bees and shifting seasons – how to adapt when Nature’s calendar goes out of sync in a warming world

Jacob Johansson, Theoretical Population Ecology and Evolution Group (The PEG), Lund University, Imperial College London - 21st November 2019

In recent decades there have been large shifts in biological events, including; flowering times, butterfly emergence and bird migrations. There is variation in the rate of these changes among species and events.

A major concern is phenological mismatch that may affect community function. Mismatch may have negative fitness consequences, as adaptive responses track seasonal optima, thus events have evolved to occur at optimal timings. Demographic consequences are comparatively understudied. A review of the literature indicated mixed demographic responses to climate change.

Plants and bees both exhibit an initial growth phase, followed by a switch to a reproduction stage. As production increases, optimal switching time moves closer to the end of the season.

Optimal switching time may be dependent on variation in seasonal production rate, as well as total growth capacity. Moreover, size dependent relative growth rates in plants and bees have shown that those species without exponential growth should reproduce earlier to increase productivity.

As season length increases, reproducing earlier would avoid competition, whilst switching later would lead to a larger population size. Different species may experience asymmetric shifts, thus resulting in changes to interspecific resource competition.

Demographic responses to climate change may show short term declines, but long-term population increases due to competitive release. However, phenological adaptation in one species may intensify competition. Adaptive responses may include evolutionary rescue to restore population sizes.

Overall, effects of climate change to community function will be varied and dependent on the unique features and adaptations of each system.