Imperial College London
2019-20 MRes CMEE Seminar Summary

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1 Deep-time evolution of biological responses to temperature changes

Dr. Dimitrios-Georgios Kontopoulos (Imperial College London)
seminar date: 10-Oct-2019

Climate change is logically one of the major threats to modern biodiversity. This project hence is providing a baseline information of how fast evolution is coping with temperature changes. A variant of Sharpe-Schoolfield model was used to describe the Thermal Performance curve (TPC) of a population. The model had an assumption of “an unit’s growth rate considered in the model is only depended on one rate-limited thermal-driven enzyme”.

Unsurprisingly, most of the results were expected. Thermodynamic constraints caused a negative correlation between thermal optimal performance (B_{pk}) and the temperature difference between the half-to-peak efficiency (W_{op}). Cell size was weakly- and negatively-correlated with enzymatic peak performance. Existing species were having diversity around local thermal optimums. Phylogenetically patchy evo-rate shifts on thermal sensitivity with high environmental factors involvement. Protein mutations had higher damages in high temperatures due to the increase of sub-molecular kinetics.

There was a point which lacked further explanation. “High temperature select for lower substitution rate” (a result from presentation) does not firmly oppose the idea of “high temperature favours evolution” (the metabolic theory) in this presentation. High temperature increase substitution probabilities in all single nucleotide positions (SNPs) can also accommodate both statements. So even though most of the mutations were selected against (due to the destructive protein kinetics), the rate of getting beneficial mutations was still higher than other scenarios. So more evidence would be beneficial to completely falsify the theory.

In conclusion, the presentation only gave numerical proof to existing knowledge. Hence, more investigations should be done in the future to put this in context of the current climate change.

2 A manifesto for systematically describing consumer-resource interactions

Dr. Daniel Barrios-O'Neill (University of Exeter)
seminar date: 31-Oct-2019

Organisms' fitness are tightly bonded with their ability to survive. Resource consumption is hence a crucial ability to master. However phenotypic plasticity is a extremely-complex stimuli-response mechanism that is difficult to breakdown. This seminar has a well-thought out plan to design appropriate methodologies for these pairwise interactions.

It is hard to seek for a general equation for describing these important interactions because of two main reasons – the existing data is taxonomically-skewed and there are a high number of pseudo-replications among published data. Yet, large endotherms were still found to have statistically higher capture rate and lower handling time than the others.

3-D printing was used to try isolating pairwise consumer-resource interactions for active predators. Good quality data was generated from the methodological precision designed to minimize co-variation effects. However it is inevitably hard to technically control refuge space without customizing the artificial habitat features with ratio based upon the predator body size.

A problem of contemporary bio-data collection was well-highlighted – the inconsistency and insufficiency of data attributes. This effect was magnified for poorly-represented taxa clades, including passive predators and oceanic benthic organisms. In this seminar, the impact of missing data attributes were very obvious because this problem has made data unavailable for statistical analyses. Hence data attribute standardization should be seriously enforced in order to make the overflowing data being useful to data-mining researches.

In conclusion, this seminar was inspirational on designing methodologies and collecting bio-data.

3 Climate-driven variation in mosquito density predicts the spatiotemporal dynamics of dengue

Dr. Ruiyun Li (Imperial College London)
seminar date: 14-Nov-2019

Dengue fever is a serious threat to coastal populations. Under climate change impact, this climate-sensitive mosquito-borne disease is expanding towards the inland. Currently about half of the global population is at risk. Through a decade-long mosquito population and dengue case data in China, the presenter has combined different drivers and risk factors into a simple-parameterized integrated model.

Two factors were investigated – “mosquito abundance” and “per mosquito vector efficiency”. Two species of mosquito data were combined because the difference between species were not biologically apparent. Five southern cities were included in the field sampling, which has several severe dengue outbreaks within the latest decade. Although human exposure time can be a potential confounding factor, it was not considered in the primitive model.

Mosquito abundance was found to be dominating the outbreak patterns and the simple model was able to capture most of the past severe outbreaks in time and severity. The result has indicated the current approach of mosquito control is correct. Since there was an observed one-month time lag between climate pattern changes and mosquito abundance, an accurate model can potentially be an effective alarm for the health departments to react and implement strategic plans against potential dengue outbreaks in the future.

In the presentation, the presenter has talked about constructing a susceptible-infected-recovered (SIR) model as a proceeding predictive model to the above one. However a more complex model require more high-quality data for calibration. In conclusion, the current model is powerful in prediction of climate-driven local dengue outbreaks. Yet if the associated governmental bodies are responding accordingly, dengue can potentially be controlled and there would not be enough data for the SIR model calibration.

4 Flowers, bees and shifting seasons: how do adapt when Nature's calendar goes out of sync in a warming world

Dr. Jacob Johansson (Lund University, Sweden; Imperial College London)
seminar date: 21-Nov-2019

Under the warming climate trend, it is unclear that whether fitness of bees would be affected by shifting flowering season. These phenological mismatches are potentially leading to negative fitness effect but demographic factor was seldom considered. In this research, general graphic shape functions were emphasized.

Four models were used to investigate the optimal switching time between somatic and reproductive part of a hive – the time of producing workers and sexuals. These phenological models are 1. seasonal variation in production rate; 2. demographic responses; 3. resource competition; and 4. interspecific competition. Through different models, it is hopefully making the overall picture clearer on investment trade-off between hive expansion and reproduction.

There were multiple ways to shift optimal reproduction time earlier. Higher nutrition condition, increasing individual productivity and earlier flowering period were the three factors mentioned. Inter-generational environment feedback have provided resilience to the plant-bee interaction couple. The brief interaction was listed as follow: Bees must maximize their hive gain from the flower or else cheaters may squeeze into this mutualism relationship. While gaining benefits, overexploitation of nectar can lead to next-generation resource depletion while the opposite may cause resource overflow. Since resource overflow will strengthen the hive while the opposite will strike down a hive's health, some hives may active responding to the shift by not altering hive response to floral changes. Given a higher ability adapting to floral activity variability, annual bees life cycles can only be affected by long-terms floral cycle shifts.

In conclusion, climate change will force floral cycle to fluctuate more. Yet bees will only be affected by long-term trend and phenological mismatches will only show its effect after generation lags.

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