Evolution of thermal tolerance and its relation to pace of life syndromes

Supervisors: Fredrik Jutfelt, Animal Physiology and
Jonathan Wright, Behaviour and Evolution

PhD project

Climate change is forcing many animals to adjust their biology to increasing temperatures. Acclimation and relocation are well-established responses to a warming climate. However, it is still unknown if populations will be able to adjust their biology through evolution. Small organisms with rapid generation time can evolve thermal tolerance, but the question remains if vertebrates with their longer generation times will be able to adapt rapidly enough to mitigate the impact of climate change.

Pace of life syndrome theory suggests that correlated selection across a wide range of traits causes organisms to optimise their behaviour, physiology and life history along a major fast-to-slow axis, to fit their environment. This can be seen as co-evolved adjustments in many aspects of their biology, such as metabolic rates, growth, life history and behavioural traits. It seems intuitively likely that slower pace of life strategies would work better in colder temperatures, while a faster pace of life would be more effective in warmer temperatures. However, very little is known about how differences in pace of life link with physiological adaptations to environmental warming, both in terms of correlated selection and the integration of plasticity across traits involved in these associated areas of the phenotype. The role of pace of life syndromes as part of such adaptations to climate change is currently an important but largely under-explored research topic.

Ectothermic animals, such as fish, have a body temperature that is controlled by the environment. Warming waters leads to warmer bodies, which has many physiological, behavioural and genetic effects on the animals. This may also cause aquatic ectothermic animals to be more sensitive to changes in the environment than some other animal groups. It is still largely unknown how fish might respond both genetically and plastically to chronic warming and what the role might be of associated changes expected to their pace of life.

We propose a PhD project to participate in a unique artificial evolution experiment here at Department of Biology at NTNU. We will collect wild zebrafish from India and perform a multi-generation evolution experiment. The most thermally tolerant individuals will reproduce to form populations with increased tolerance to warm temperatures, while the least thermally tolerant individuals will reproduce and form populations with reduced thermal tolerance. After a number of generations we will investigate how evolution has changed the physiology, behaviour and genetics of these adapted populations of fish.

One PhD student, who is already financed by the department, will perform the selection experiment and physiological measurements. The current proposal is therefore for a PhD student to join our research team and help with the selection experiment, and to focus on behavioural and other pace of life syndrome traits. We will use multivariate statistical techniques to formally compare the relationships between behavioural personality, metabolic rates and life history traits to find out how the evolved populations differ in their pace of life, and which traits and trait co-variations were altered by the laboratory evolution. This information is vital for our ability to predict how climate change may affect ectothermic animals and their population and community dynamics.

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This project will initiate a new collaboration between Associate Professor Fredrik Jutfelt (Physiology) and Professor Jonathan Wright (Behaviour and Evolution) at the Department of Biology. As Jutfelt is new at the department, he has not previously collaborated with Wright or co-authored any publications together, and nor has there been any shared supervision of students or postdocs.

As the project is interdisciplinary and spans the topics evolution, thermal physiology, behavioural ecology and pace of life syndromes, the project would be difficult to perform within a single current research group. Therefore, the combined expertise of the two groups will synergistically increase the potential impact of the project.

The project also follows the research priorities of the Department of Biology strategy document, such as the involvement of topics like climate change, biological resources and exploitation of water resources, and it involves several of the Department's core disciplines (behaviour, evolutionary biology, ecology and physiology).

Both supervisors will equally supervise the student. Jutfelt will be responsible for supervision during the selection experiment and physiological measurements, while Wright will lead during the behavioural assessments, life history characterisations and the multivariate statistical analyses. Both supervisors will jointly design the experiments and contribute to the supervision of writing and publishing.