The genomics of adaptation to global warming: a thermal tolerance experiment in zebrafish


Photo Dr. P Raymond

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Climate change is forcing many animals to adjust to increasing temperatures. Acclimation and relocation are well-established responses to a warming climate. However, it is still largely unknown if populations can adjust their biology through evolution, e.g. by increasing their ability to cope with higher temperatures (thermal tolerance). This is particularly relevant for ectothermic animals, such as fish, which have a body temperature that is controlled by the environment. Warmer waters then lead to higher body temperatures, which may have many consequences for physiology, behaviour, and life-history, which in turn may affect individual fitness. This may therefore cause aquatic ectothermic animals to be more sensitive to changes in the environment than some other animal groups. An important question is therefore how fast ectothermic vertebrates such as fish, with their relatively long generation times, will be able to adapt by increasing their thermal tolerance. It is also unknown which genes that evolve during strong selection for higher thermal tolerance, or if phenotypic changes are due to regulatory changes. With this fundamental knowledge lacking we are unable to make reliable predictions of the biological effects of climate change. These research questions are therefore currently very hot research topics, and will be the focus of this PhD-project.

The PhD project will be part of a unique artificial evolution experiment here at Department of Biology, NTNU. We will collect wild zebrafish from India and perform a multi-generational selection experiment. The most thermally tolerant individuals will be selected to reproduce in a set of replicate populations, while the least thermally tolerant individuals will be selected to reproduce in another set of replicate populations. After repeated selection in the same direction over multiple generations in each set of populations we will investigate how phenotypic evolution of high and low thermal tolerance, respectively, has changed their physiology, behaviour, life-history, and genetics.

One PhD-student, who is already financed by the department, will have the main responsibility for the selection experiment and physiological measurements. The PhD-student on the proposed project will help with the selection experiment, and focus on the genetic changes that occur in the populations during the artificial selection for high and low thermal tolerance. The PhD-student will exploit the annotated high-resolution zebrafish reference genome and use state of the art genomic techniques to: 1) map genes (QTL) coding for phenotypic changes related to evolution of thermal tolerance, 2) map genes (vQTL) important for any plastic responses in these phenotypic thermal tolerance traits, and 3) map expression genes (eQTL) that show expression level changes contributing to phenotypic variation in thermal tolerance. These analyses will be accompanied by 4) studies of variation in amino acid composition and expression levels of various candidate genes likely to be involved in thermal tolerance.

By combining cutting-edge genomics analyses and novel selection experiments on a uniquely suitable model species this project will be the first to provide information on how rapid thermal tolerance can evolve in a vertebrate, as well as the genetic mechanisms that are involved in this process.

Attachment to the PhD-project: “The genomics of adaptation to global warming: a thermal tolerance experiment in zebrafish”

Fredrik Jutfelt and Henrik Jensen

The proposed project will break new ground in the intersection between physiology, genomics and evolution. At the Dept. of Biology the project will be the foundation for novel collaboration between the research groups of Associate professor Fredrik Jutfelt (Physiology section) and Associate professor Henrik Jensen (Behaviour and Evolution section). Jutfelt and Jensen were recently employed as Associate professors, and both their groups as well as the Dept. of Biology will likely benefit greatly from establishing such inter-disciplinary collaboration at this early stage. First, the project will act as a link between the two research groups/sections by which members of both are likely to obtain better knowledge and scientific expertise. Second, through the collaboration, personnel, infrastructure and equipment across research groups/sections can be used more efficiently. Third, the collaboration is likely improve possibilities of seeing new avenues of ground breaking research and hence be advantageous to future project applications from the Dept. of Biology to e.g. the Research Council of Norway and EU.

By combining cutting-edge genomics analyses and novel artificial selection experiments on a uniquely suitable model species this project will be the first to provide information on how rapid thermal tolerance can evolve in a vertebrate, as well as the genetic mechanisms involved in this process. Such information will lead to better understanding of fundamental questions in eco-evolutionary physiology as well as improve predictions of how climate change will affect animal populations.

Associate professors Fredrik Jutfelt and Henrik Jensen will supervise the PhD-student working on the project. Both will be involved in planning the selection experiments and sampling procedures of the replicate selected populations. Jutfelt will be responsible for management and implementation of the artificial selection experiment, and for measuring physiological phenotypes in individuals. Jensen will be responsible for planning and supervision of the genetic analyses, both in the laboratory and the statistical modelling. Both Jutfelt and Jensen will contribute in the writing process, which will result in publications in high-ranking international journals.