How evolution tracks climatic transitions in trees

Antoine Kremer*[1], Thomas Caignard , Jun Chen , Dounia Saleh , Sylvain Delzon , and Martin Lascoux

[1]INRAE – INRAE – UMR BIOGECO, INRAE, Université de Bordeaux, 69 Route d'Arcachon, 33612 Cestas, France, France

Résumé

While microevolution has been intensively investigated over the long-lasting postglacial warming in trees, evolutionary responses during short climatic changes are poorly understood. However, climatic transitions have paved the late Holocene with an alternation of short abrupt cold and warm periods. We retrospectively monitored genetic changes in multicentennial oak populations during the climatic transition between the cold Little Ice Age (1450-1850) and the warm Anthropocene (1850-today) at the genomic and phenotypic level. In oaks, most of the selection occurs at the seedling stage, and signatures of selection can therefore be assigned to the period corresponding to the recruitment of the trees. We assessed whole genomic changes among four age-structured cohorts of *Quercus petraea* (dating from about 1680, 1850, 1960 and 2008) and similarly temporal genetic changes of 16 phenotypic traits in the offspring of the three oldest cohorts raised in a common garden experiment. The levels of observed genomic diversity (*in natura*) and the levels of genetic variation of the phenotypic traits (in the common garden) did not change among cohorts. However, significant temporal shifts were observed for allelic frequencies and for growth and phenology related traits. These temporal shifts were correlated with differences in the prevailing temperatures during the recruitments of the cohorts. Hence, the frequent extreme events (very cold winter and dry summers) associated with the climatic transition appear to be the predominant selective causes of the changes we observed. More importantly, change in both allele frequencies and phenotypic traits were of opposite sign during the cold and the warm periods, suggesting fluctuating evolution during the climatic transition. This almost "instantaneous" reversal of the direction of genetic changes in response to new climatic conditions highlights the capacity of oaks for rapid evolution following the establishment of new selection pressures. In conclusion, rapid and fluctuating selection responses during the Little Ice Age – Anthropocene transition point to underlying mechanisms able to generate "immediate" genetic shifts. Those mechanisms are also likely at work under current ongoing climate changes. We illustrate and discuss these mechanisms, some of which can be enhanced by human interventions.

Mots-Clés: microevolution, Little Ice Age, Anthropocene, Quercus

*Intervenant