Climigrate

Understanding and Better Forecasting the Impact of Climate Change on Mammals by Integrating Ancient DNA analysis and Ecological Modelling

OBJECTIVES

Forecasts accounting for future changes in temperature tend to predict high rates of species extinctions over the next 100 years. In particular, there is growing concern about the survival of mammal species in Europe. However, such predictions include high uncertainty in how species respond to environmental change and habitat availability, i.e. whether species will chase new habitats, adapt or go extinct. In this context, the Climigrate team has investigated what happened in the last Ice Age, when dramatic changes in temperature lead to large-scale re-distribution of many species, which can reduce uncertainty as to future predictions. More precisely, the Climigrate team aimed at:

1. Significantly improving the understanding of species/population responses to large-scale environmental change by analysing ancient DNA and responses of species distribution in the last Ice Age;
2. Improving forecasts of future species responses to climate change, reducing their uncertainty and allowing for an improvement of conservation strategies.

APPROACHES

Climigrate assessed the consequences of climate change on the demography of a set of cold and temperate mammal species by looking at the effect of past changes in climate across Europe. The team recovered DNA from a large number of specimens ranging from present day to 50,000 years old and analysed both cold and warm-adapted species including collared and true lemming, woolly mammoth, arctic and red fox, Neanderthals, brown and polar bear, cave lion, red deer and willow and rock ptarmigan. The team then explored local climate and environmental data, identifying the timing and route of expansions or local extinctions, their genetic consequences and correlations with broader climate trends and major temperature increases following the last Ice Age.

MAIN ACADEMIC FINDINGS

- Climigrate allowed building or completing datasets on present and/or past (^{14}C-dated fossils) DNA for thirteen mammal and bird species.
- The team demonstrated that past environmental changes have had a considerable effect on the demography and distribution of both cold and warm-adapted species [18, 19, 20, 21, 22, 23, 24, 25, 26, 27].
- The general pattern observed in studied species during warming periods shows that these appeared unable to track habitat availability, leading to drastic extinctions of southern communities and exacerbating reductions in genetic diversity [21, 26, 28].
- However, both studied ptarmigans (*Lagopus* birds) have been able to track and follow shifts in habitats distribution during major temperature increases at the end of the last Ice Age.

Using both present and fossil record data, the researchers predicted the future response of ptarmigan in Europe, and found that even if ptarmigan manage to track future changes in habitat resulting from temperature change, their overall abundance is likely to decrease due to a 30 to 50% habitat loss in modelled projections running up to 2080.

Consortium partners:

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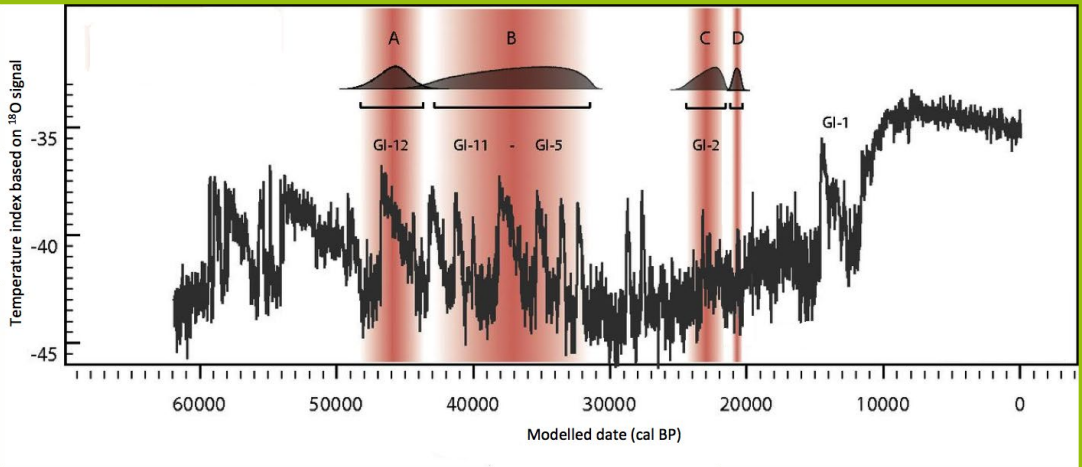
All references available in the complete document at www.biodiversa.org/893

ACADEMIC RESULT HIGHLIGHT



Past genetic turnover events (A,B,C & D, lineage turnover events represented in red) for collared lemming occurred during periods of climatic oscillation, in particular the climatic warm peaks, Greenland Interstadials GI-12 and GI-2. After Brace *et al.* 2012 (*PNAS*).

The global extinction of many terrestrial mammal species during the Late Pleistocene has been a subject of intensive scientific study. Yet, previous studies on the effects of past climate changes have mainly focused on large mammal species, in particular those that went extinct, whereas smaller mammals were overlooked and considered less affected. The Climigrate scientists focused on a small mammal species (collared lemming – *Dicrostonix torquatus*) and explored its response to past climate changes using ancient DNA techniques sampled across three sites in North-West Europe.

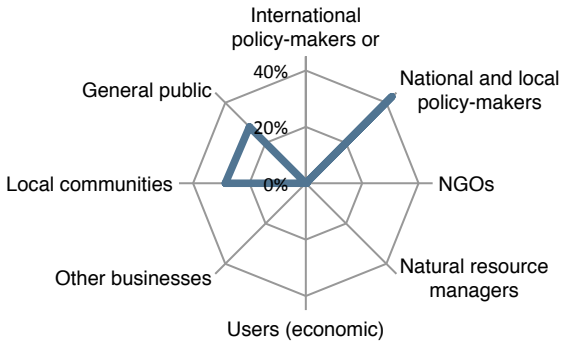
The results of the study reveal a dramatic reduction in genetic diversity in this species over the last 50,000 years. Repeated regional extinctions in this key prey species were climate-associated and likely had an impact on the wider steppe-tundra community. This shows how climate change has been a major force in structuring Late Pleistocene biodiversity, even for small mammal species (and the species that depend on them).

* Brace *et al.* (2012). Serial population extinctions in a small mammal indicate Late Pleistocene ecosystem instability. *Proceedings of the National Academy of Sciences of the USA* 109: 20532-20536

STAKEHOLDER ENGAGEMENT AND PRODUCTS RELEVANT TO SOCIETY/POLICY

Climigrate worked mainly retrospectively on the effect of past climate changes on biodiversity, which explains the particular profile of types of stakeholders involved in the research (see Figure).

- Climigrate informed a number of stakeholders on the lessons learned from ancient DNA, and on the effects of climate change on biodiversity. For example, they informed local people with the Swedish Saami association, school children during presentations in the broader context of polar research, and the general public by giving interviews. In particular, Climigrate scientists participated to the "Mammoth, back from the dead" documentary of National Geographic (https://www.youtube.com/watch?v=UcBGOC8-mCI).



Types of stakeholders engaged in Climigrate

- Climigrate also interacted with the Swedish Foreign Ministry and the Embassy of Russia in Sweden during workshops and fora, presenting results and promoting support for transnational cooperation in arctic research to strengthen collaborations in the region.