Understanding how an invasive springtail adapted to cold sub-Antarctic Marion Island

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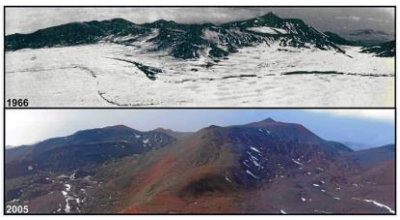
Abstract

Springtails are important soil dwelling microarthropods with a global distribution. They play a role in nutrient cycling and are commonly used as bioindicators of ecosystem health. On sub-Antarctic Marion Island, there are no vertebrate herbivores, but springtails, invertebrate herbivores, are abundant and therefore fulfil the role of herbivory, which makes them an ecologically important group on the island. Our study organism is the collembolan, *Isotomurus maculatus*, which has a natural distribution that includes Europe and North America, with some individuals present in the Western Cape, South Africa. It was introduced to Marion Island in the late 1970s and is now considered to be an invasive species on the island. Since *I. maculatus* is native to regions that are hot and dry, how did this springtail adapt to a cold and harsh environment such as that on Marion Island? In this study, we aim to answer this by identifying possible genes involved in adaptive selection, by sequencing the transcriptome of *I. maculatus* individuals from Marion Island. RNA sequencing technology is used to study the functional content of an organism's genome. We will apply a comparative genomic approach to investigate the genes and metabolic pathways involved in local adaptation and pinpoint the biochemical mechanisms that facilitate adaptation to a cold environment such as that experienced on Marion Island. The genomic basis of adaptation in invasive species is not well understood, therefore, the implication of this study is far-reaching as it will help to inform the management of invasive species.

What are springtails?

Springtails are important soil dwelling microarthropods and are commonly used as bioindicators of ecosystem health (1,2,3). They range in size from 1mm - 3mm (4). Despite the small size of springtails, they are often introduced into new habitats through human associated activities (5). Our study organism is *Isotomurus maculatus*. It was introduced to the Prince Edward islands in the late 1970s (5), however, it has a natural distribution that includes Europe and North America, with some individuals present in the Western Cape, South Africa. These climates substantially differ from that found on Marion Island. To the best of our knowledge there have not been any studies with a focus on genomic architecture of this species to investigate underlying evolutionary dynamics involved in adaptations to the harsh sub-Antarctic environment. Studies have shown that invasive springtails on Marion Island significantly differ from native springtails (6).

Climate change on Marion Island



Sub-Antarctic islands, due to their position at the pole, are directly impacted by the effects of climate change and are therefore considered useful as a barometer for climate change (7,8). Marion Island, located in the sub-Antarctic, is situated within the Antarctic circumpolar current allowing for changes in the climate to be directly studied without any additional factors at play. Since the 1960s to the early 2000s meteorological data has indicated that Marion Island is getting warmer and dryer, with fewer days of rainfall recorded as the years progress (9).

What are we doing?

We are investigating how an invasive springtail would adapt to a changing environment by sequencing its transcriptome after experimental exposures to increased heat. Messenger RNA, which makes up the transcriptome, provides insight into adaptive processes by showing us which genes are expressed in different situations, which is something we don't see with DNA and the conventional sequencing of DNA. Through a "common garden experiment", the springtails are exposed to an increasing temperature gradient to assess how they would adapt to a warming environment. This ties in with understanding how organisms would adapt to the warming climate we see on Marion Island.

Implications of this study

Conservation genetics theory suggest that populations that are small and lack genetic diversity are destined to become extinct through harmful effects associated with a lack of genetic diversity and small population numbers (10). However, even though invasive species lack genetic diversity, they still harbour higher levels of genetic variation compared to native species (11). This leads us to believe that invasive species could be the "golden key" to understanding adaptations in a world that is struggling to deal with the effects of ever-changing environments due to climate change (11,12). The way in which invasive species are able to adapt to different environments and establish successful populations through short term evolution is astonishing. Identifying this adaptive advantage may have far-reaching implications for the management of invasive species in their new habitats, as well as organisms in general dealing with the effects of climate change.