These reindeer survived, isolated, for 7,000 years, but will they survive climate change?

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The reindeer have managed to adapt to life on Svalbard, despite the fact that they have not been there for more than about 7,000–8,000 years. But will they be able to adapt to the rapid climate changes? Credit: Bart Peeters

Despite inbreeding and limited genetic diversity, the Svalbard reindeer has managed to adapt to extreme living conditions in record time—what researchers call a genetic paradox. But can they survive climate change?

"Of all the subspecies of reindeer found in the high north, the Svalbard reindeer has the most inbreeding and the lowest genetic diversity," says Nicolas Dussex, a postdoc at NTNU's Department of Natural History.

It was only 7,000–8,000 years ago that the first reindeer migrated to Svalbard, most likely from Russia via Novaya Zemlya and the islands of Franz Josef Land.

Perhaps there were no more than a few animals that established themselves on the arctic archipelago. Evolutionary theory suggests this is a poor starting point since inbreeding can quickly lead to an accumulation of harmful mutations and genetic variants followed by disease and death.

Rapid adaptation to an extreme environment

But this has not prevented the Svalbard reindeer from evolving into what is today a viable population of more than 20,000 animals.

"Despite the low genetic diversity, they have managed to develop a number of adaptations to life in the High Arctic. They are, for example, smaller in size and have shorter legs than other northern reindeer and caribou subspecies," says Dussex.

The ability to digest mosses in the absence of lichens, and to adjust their circadian rhythm to the extreme seasonal variations on Svalbard, are also traits the Svalbard reindeer have developed over the relatively short time they have lived isolated on the archipelago. Now, researchers at NTNU and collaborating institutions have analyzed genetic samples from 91 reindeer to see how they differ from their relatives on the mainland. The research is published in the journal *iScience*.

"Populations living on isolated islands are often small and are well-suited

studying genetic problems. The Svalbard reindeer has been isolated for at least 7,000 years and has a very high degree of inbreeding. In addition, they were nearly extinct in the early 1900s due to excessive hunting," says Michael D. Martin, a professor at NTNU's Department of Natural History.

Getting rid of harmful mutations

This near-extinction, where only a few individuals with their unique genetic variants survive, is called a bottleneck in population biology.

"In this case, we are dealing with a population that suffers from a high degree of inbreeding, which is usually bad news for a small population. But inbreeding can also help a population to get rid of harmful mutations, a phenomenon technically called 'purging,'" says Martin.

In a population with a high degree of inbreeding, offspring are more likely to inherit harmful mutations from both mother and father. Therefore, these "dangerous" mutations more quickly manifest in the form of genetic diseases and poorer health. Offspring carrying these mutations become less "fit," and they will either die before they have the chance to reproduce or they will have fewer offspring. Consequently, these dangerous mutations are less likely to be passed on to subsequent generations.

"Paradoxically, in the long run, inbreeding can be beneficial," says Dussex.

Harmful gene variants have disappeared from the kakapo parrots in New Zealand. Researchers believe the cause is inbreeding over time. Credit: Chris Birmingham / CC BY 2.0.

Punctuated evolution or steady and continuous?

Similar phenomena have been observed elsewhere in nature. In New Zealand, Kakapo parrots (Strigops habroptilus), which had lived isolated on the islands for at least 10,000 years, became endangered after the arrival of non-native species brought to the islands by humans.

In 1995, there were only 60 individuals left, but today the population has grown to around 200. Here too, Dussex and his colleagues found that harmful genetic variants had disappeared from the population thanks to a long period of inbreeding.

"This is important knowledge when it comes to population management. The fact that the Svalbard reindeer is in relatively good genetic condition considering harmful mutations, is good news," says Brage Bremset Hansen, professor of conservation biology at NTNU's Department of Biology and Center for Biodiversity Dynamics. Hansen is also a senior researcher at the Norwegian Institute for Nature Research (NINA).

This knowledge about the Svalbard reindeer can also change the way researchers study the effects of genetic bottlenecks, Dussex said.

"What we still do not know enough about is how quickly such harmful mutations are selected against. We will continue to work on this, using DNA samples collected from bone remains and antlers of animals that lived several thousand years ago. This way, we can see whether these mutations have disappeared quickly over a few centuries or if it has happened gradually over several thousand years," he said.

The researchers are also very interested in examining the development of beneficial mutations, which have allowed the Svalbard reindeer to adapt to the unique ecosystem.

"This is a 'work in progress,'" says Martin, who also worked closely with researcher Mathilde Le Moullec, who did the fieldwork to collect most of the bone samples from various locations on Svalbard.

Climate change may be too fast

It is far from certain that the Svalbard reindeer will be able to adapt as well to the rapid changes that result from global warming. The adaptations the reindeer have developed for the extreme arctic climate may fall short as the archipelago is now rapidly warming, which is changing both snow cover and vegetation.

"Global warming is causing Svalbard's climate to change faster than anywhere else in the world. Even though our results show that the Svalbard reindeer managed to adapt relatively quickly to a completely new environment after they colonized the islands, they might have trouble adapting to today's rapid warming. They may have simply lost too much genetic variation," says Hansen.

This also applies to other terrestrial animals that have limited opportunities to move as climate change makes life difficult for them.

"But this work now provides us with a better basis for understanding how quickly species can adapt to new environments," says Martin.

More information: Nicolas Dussex et al, Adaptation to the High-Arctic island environment despite long-term reduced genetic variation in Svalbard reindeer, *iScience* (2023). DOI: 10.1016/j.isci.2023.107811

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