Genetic study shows major impact of climate change on Antarctic fur seals

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Genetic analysis of Antarctic fur seals, alongside decades of in-depth monitoring, has provided unique insights into the effect of climate change on a population of top-predators. Published in *Nature* this week, the findings show that the seals have significantly altered in accordance with changes in food availability that are associated with climate conditions. Despite a shift in the population towards 'fitter' individuals, this fitness is not passing down through generations, leaving the population in decline.

Environmental change is expected to affect many species and biological systems throughout the world. To understand these changes long-term monitoring is required. The British Antarctic Survey's unique Long Term Monitoring and Survey programme has given researchers a rare opportunity to explore how fur seal life histories have changed over time in relation to the climate and food availability.

Researchers from the British Antarctic Survey and Bielefeld University in Germany analysed data gathered from as far back as 1981 to assess changes over generations of female fur seals on South Georgia, in the South Atlantic Ocean.

Lead author, Dr Jaume Forcada from the British Antarctic Survey explains:

"Compared with 20 years ago, we can see that female fur seals are now born with a lower weight, those that survive and return to breed tend to

be the bigger ones and they have their first pup later in life than they used to. Such changes are typically associated with food stress.

"An important food source for the seals is Antarctic krill. Decades of data collected at South Georgia show how changes in the seal population have occurred over time with changes in krill availability. Even if krill is very abundant, environmental variation determines its availability in the seals' feeding grounds. This environmental variation is driven by the climate which impacts local atmospheric, sea ice and oceanographic conditions. Adverse climatic conditions are typically associated with low krill availability, and reduce the survival and breeding success of fur seals."

The researchers found that females who did survive to motherhood were likely to be more 'heterozygous'. This is where an individual possesses a higher level of genetic variation and is associated with higher fitness in many species. Whilst these females are more likely to survive and breed, their pups will only have the same advantage if they too are heterozygous. However, the heterozygous characteristic is not inherited; it depends on which male the female mates with and so arises mostly through chance. This means that many seals are born who are not heterozygous and are therefore less able to cope with the changing environment.

Co-author, Dr Joe Hoffman from Bielefeld University explains:

"We found that, over the last two decades, the proportion of breeding females that are highly heterozygous has increased, as these individuals are more likely to survive the changing conditions. Strong selection by the environment can drive rapid evolution. However, in this case the seals do not appear to be evolving because surviving females do not pass their high heterozygosity on to their offspring.

"Therefore, with each new generation, the process of selection has to start all over again, with only those individuals that happen to be born more heterozygous having a good chance of survival. As the climate continues to change, many fur seal pups are not surviving to adulthood and the population is declining."

Climate change is already altering environmental pressures on many species, and scientists do not yet know how populations will cope with these new environments. This study shows that natural selection on a fur seal population has altered as a result of climate change and that the seals have been unable to evolve in response.

Impacts on one species can affect a whole ecosystem. The world continues to change and, if we are to adapt, it is essential to anticipate future changes in natural systems. Long-term data sets are a valuable resource for biologists who must forecast how species will respond to future environmental change.

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