Combining genetic diversity data with demographic information reveals extinction risks of natural populations

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The researchers used the well-known ecological model system of the Glanville fritillary butterfly metapopulation in the Åland islands, SW Finland. Credit: Marjo Saastamoinen

Genetic diversity, a key pillar of biodiversity, is crucial for conservation.

But can snapshot estimates of genetic diversity reliably indicate population extinction risk? New research shows that genome-wide genetic diversity is a strong predictor of extinction risk, but only when confounding factors are accounted for.

The paper is published in the journal *Proceedings of the National Academy of Sciences*.

As species face increasing environmental pressures, their populations often decline, leading to a loss of genetic diversity. This reduction in genetic variation can have serious consequences, including increased inbreeding and a diminished capacity to adapt to changing conditions.

Genome-wide genetic diversity is often used as an indicator of species' vulnerability to extinction. However, recent studies have suggested that genetic diversity does not always predict population viability.

The collaborative research sought to clarify under what circumstances genetic diversity can accurately predict extinction risk. The findings suggest that while genetic diversity is indeed linked to extinction risk, the strength of this relationship varies depending on other factors such as population size and the potential for rescue through dispersal.

The importance of integrating demographic data

The study highlights the dangers of relying solely on genetic data to assess population viability. "Our research demonstrates that inferences about the role of genetic diversity in extinction risk must be informed by demographic and environmental data," explains Professor Marjo Saastamoinen, senior author of the paper.

"For instance, we observed a strong negative relationship between genetic diversity and extinction risk, but this correlation was largely

driven by underlying population size. Without accounting for demographic factors, we would have drawn misleading conclusions."

Dr. Michelle DiLeo, the leading author of the study, cautions, "Had we focused only on genetic diversity, we might have incorrectly assumed its effects on extinction risk were uniform across different populations and environments. Conversely, ignoring the interactions between genetics and demographics would have led us to underestimate the importance of genetic diversity in explaining extinction risk.

"Our results suggest that both genetic diversity and demographic factors, such as population size, population trends and immigration, must be considered in conservation strategies.

"Not all populations with low genetic diversity were doomed to extinction, as they were rescued by dispersal from other populations."

Recommendations for conservation

Given that most species are data-deficient, the researchers emphasize the need for strategic data collection to inform conservation efforts. They recommend focusing on three key pieces of information: estimates of genome-wide or neutral genetic diversity, population size trends, and the potential for rescue via dispersal.

Population size trends and population connectivity are already used in some global biodiversity frameworks, but more work is needed to integrate these metrics with genetic data for a comprehensive assessment of species vulnerability.

The study also underscores the importance of maintaining connectivity among populations to mitigate the risks associated with low genetic diversity in the face of environmental change.

More information: Michelle F. DiLeo et al, Demography and environment modulate the effects of genetic diversity on extinction risk in a butterfly metapopulation, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2309455121