The Biology of Small Populations: A few more thoughts on genetics

Surviving with low genetic diversity

I argued from first principles that loss of genetic diversity is more likely to be a *symptom* of endangerment than a *cause* of endangerment. Milot et al. [2] present an example that is consistent with my argument.

The authors compare levels of genetic diversity (as judged with AFLPs[1]) in the wandering albatross and the Amsterdam albatross. Based on molecular clock estimates, these two taxa diverged from one another about 800,000 years ago. The Amsterdam albatross is recovering from an extreme bottleneck. When first discovered in the early 1980s, only 5 breeding pairs were known. Approximately 130 adult birds now exist (http://en.wikipedia.org/wiki/Amsterdam_Albatross). Only 5% of AFLP loci are polymorphic in wandering albatross, and only 2% are polymorphic in Amsterdam albatross. In contrast, other vertebrates show polymorphism at 17-99% of AFLP loci.

Simulations suggest that the low levels of polymorphism are *not* the result of population bottlenecks in the species' evolutionary history.[2] Instead, it appears that they both inherited a low level of polymorphism from their ancestor. If that's right, then both species have survived for 800,000 years with very low levels of genetic diversity, suggesting that lack of diversity is a reflection of their life history and that it did not contribute to very small population sizes in the Amsterdam albatross.

A caveat

There is one detail about AFLP markers that's important to know. Differences among individuals at most AFLP loci probably have little or no impact on survival and reproduction. Lack of diversity at these loci provides information on levels of adaptively significant variation only through several steps of logic (low neutral diversity implies small effective population size

[1]The molecular basis of this variation isn't important for our purposes. If you're interested, ask me.

[2]Remember, only the Amsterdam albatross shows evidence of recent recovery from a bottleneck. The wandering albatross has substantially larger populations.

means natural selection is less effective means loss of diversity even if it's favored by selection). It's possible that levels of adaptive diversity in wandering and Amsterdam albatrosses are markedly higher than at AFLPs. Nonetheless, it seems likely that they are still lower than levels of adaptive diversity in other vertebrates.

Avoiding inbreeding depression

I mentioned that animals from Texas were introduced into southern Florida in an attempt to alleviate problems associated with inbreeding depression in the Florida panther, and I mentioned that preliminary evidence suggests that the attempt was successful. I didn't mention that beyond the obvious concern that many conservationists have about manipulating populations in this way, it isn't always successful.

You may remember from your study of evolutionary biology that barriers to reproduction between species may arise as a result of hybrid breakdown. Hybrid breakdown occurs when there are epistatic interactions among loci causing only certain combinations of alleles at different loci to work well together. A phenomenon like hybrid breakdown can occur when crosses are made between populations of the same species that have become differentially adapted — outbreeding depression. So there's the risk that in attempting to alleviate problems associated with inbreeding depression, conservation managers could introduce new problems associated with outbreeding depression.

The resulting advice is pretty simple in principle, if difficult to put into practice: "[M]anagers can minimize the risks of both inbreeding and outbreeding by using intentional hybridization only for populations clearly suffering from inbreeding depression, maximizing the genetic and adaptive similarity between populations, and testing the effects of hybridization for at least two generations whenever possible" [1, p. 463].

References

[1] Suzanne Edmands. Between a rock and a hard place: evaluating the relative risks of inbreeding and outbreeding for conservation and management. *Molecular Ecology*, 16(3):463–475, 2007.

[2] E. Milot, H. Weimerskirch, P. Duchesne, and L. Bernatchez. Surviving with low genetic diversity: the case of albatrosses. *Proceedings of the Royal Society B: Biological Sciences*, 274(1611):779–787, 2007. doi:10.1098/rspb.2006.0221.

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