Picky penguins: Does mate choice depend on genes that help resist disease?

September 5 2012

Magellanic penguins have a high level of variation in genes associated with the ability to fight infectious disease, but a recent study found that the mechanism the penguins use to ensure that diversity is far from black and white. Credit: J. L. Bouzat

Magellanic penguins have a high level of variation in genes associated with the ability to fight infectious disease, but a recent study found that the mechanism the penguins use to ensure that diversity is far from black and white.

Found exclusively south of the equator in South America, Magellanic penguins assemble in large nesting colonies along the coasts of Argentina, Chile, and the Falkland Islands. They typically mate for life, producing clutches of two eggs that are cared for by both parents. While individual colonies can number in the millions of birds, the species as a whole appears to be in decline, and is therefore classified as "Near Vulnerable" by the IUCN Red List.

A recent study published via Advance Access in the Journal of Heredity tested whether the significant diversity in the Major Histocompatibility Complex (MHC) genome region observed in these birds is attributable to mate choice or genetic selection based on disease exposure.

The study first confirmed that MHC diversity is high in these birds compared to other closely-related penguin species. Gabrielle Knafler, a graduate student at Bowling Green University and the first author of the study, explained, "By looking at the MHC genotypes of 50 breeding pairs of Magellanic penguins, we found considerable levels of genetic variation, detecting a significantly greater number of MHC variants or alleles than those reported for Galapagos penguins and Humboldt penguins." Forty-five alleles were found at the gene locus for the Magellanic penguins, sampled from a wild population in southern Patagonia, compared to 3 for Galapagos penguins and 7 for captive Humboldt penguins.

The authors of this study then investigated two possible mechanisms for maintaining the high MHC diversity in the Magellanic penguins: balancing selection, in which heterozygous individuals are better adapted to combat a wide range of diseases and are therefore more likely to survive to pass on their genes, and disassortative mating, or preferentially choosing a mate with a different MHC genotype.

How might a penguin know that a potential mate has different MHC genes? Smell could tell. Dr. Juan L. Bouzat of Bowling Green University, the lead scientist on the study, said, "In some species in which disassortative mating has been detected, individuals discriminate among potential mates by MHC type on the basis of olfactory cues."

To test the mechanism for maintaining MHC diversity, the authors studied the genetic variation of 50 breeding pairs of penguins. They examined whether MHC diversity was greater between breeding pairs as compared to random mating, and determined whether MHC genotype was correlated with measures of reproductive fitness, such as number of eggs hatched and number of chicks fledged.

Surprisingly, they found no direct evidence for disassortative mating based on the genotypes of the breeding pairs. Incidence of shared alleles between males and females in breeding pairs was not significantly different from what would be expected by chance.

But heterozygosity was found to be associated with increased fitness of adults, as heterozygous females hatched significantly more eggs and fledged significantly more chicks than homozygous females (in fact, none of the homozygous females that hatched eggs actually fledged any chicks). This finding suggests that a mechanism for balancing selection is at work in maintaining MHC diversity, even if it is not promoted by disassortative mating.

Other evidence for balancing selection was also found, including a gene phylogeny for MHC alleles from Magellanic, Humboldt, and Galapagos penguins. This analysis, akin to developing a "family tree" for genes, found that MHC alleles did not group together by species, suggesting that balancing selection has maintained different alleles even as species evolved over millions of years.

"There are likely other mechanisms at work as well," said Bouzat. "Spatial and temporal patterns in exposure to different pathogens may shape which alleles are favored at different times," changing selection pressures on the MHC genes. "The direct association of MHC genes with mechanisms of disease resistance suggests that the maintenance of MHC diversity could be driven by periodic selection due to different pathogens, similar to epidemics in humans."

More information: doi: 10.1093/jhered/ess054

Provided by Journal of Heredity