The aye-ayes have it: The preservation of color vision in a creature of the night

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A quest to gain a more complete picture of color vision evolution has led Biodesign Institute researcher Brian Verrelli to an up-close, genetic encounter with one of the world's most rare and bizarre-looking primates.

Verrelli and his ASU team have performed the first sweeping study of color vision in the aye-aye (pronounced "eye-eye"), a bushy-tailed, Madagascar native primate with a unique combination of physical features including extremely large eyes and ears, and elongated fingers for reaching hard to access insects and other foods. Verrelli, lead author George Perry, and collaborator Robert Martin's results, published in the journal *Molecular Biology and Evolution*, have led to some surprising conclusions on how this nocturnal primate may have retained color vision function.

Verrelli's group focuses on color vision to better understand genetic variation between human and other primate populations and the truly big evolutionary questions as to what makes us human. "At least within humans and some other primates, we know that there are three different genes responsible for color vision," said Verrelli. The genes, called opsins, come in three forms that shape our color vision palette, one for blue, another for green, and a third for red.

"What makes that very interesting is that the green and red are found on the X chromosome [sex chromosome], and it is the manipulation of those two genes alone which is related to color blindness for eight to ten

percent of the male population," explains Verrelli. In a 2004 study in the American *Journal of Human Genetics* by Verrelli and collaborator Sarah Tishkoff of the University of Maryland, they suggested that natural genetic selection has provided women with a frequent ability to better discriminate between colors than men.

"These three genes may explain all the variation that we might see across human populations in color vision," said Verrelli. "But how did our range of color vision variation come to be in the first place?"

To help trace back the evolution of color vision, Verrelli's collaborator Perry turned to the endangered aye-aye, a primate representative of lemurs. These primates split from other groups including humans, apes, and monkeys more than sixty million years ago, and are thought to be in some ways representative of the early primates that lived at that time. "We chose the aye-aye specifically because it has a very interesting behavior in that it is fully nocturnal, and so, it raises an obvious and straightforward question: If you are an animal that lives at night, do you need color vision?"

In a simple case of 'use it or lose it,' the prevailing theory suggested that nocturnal primates cannot use color vision to see, and so the genes that they have for color vision accumulated mutations and degraded over evolutionary time.

From a practical standpoint, studying color vision in the aye-aye proved to be a daunting endeavor. Since the aye-aye is an endangered species, obtaining DNA samples in the wild was not possible. The group turned to a few rare international research institutions and colleagues that have aye-ayes to obtain DNA samples for their study.

In all total, they obtained samples from eight aye-ayes for their study. It took a year and a half to analyze the samples, since Perry and Verrelli

had to invent the methodology to perform the first wide-range genetic analysis on the aye-aye. “From a conservation, population and functional viewpoint, it was the first study of its kind,” said Verrelli.

The results his team found were so startling that they had to recheck them twice. “When examining these genes in the aye-aye, we realized that they are not degrading,” said Verrelli. “In fact, for the green opsin gene, we did not find a single mutation in it. The opsin genes look to be absolutely fully functional, which is completely counter to how we had believed color vision evolved in nocturnal mammals.”

The authors plan to collaborate with others to perform behavioral studies to see if aye-ayes can respond to colors and further molecular studies to identify the exact color absorption by the opsin proteins to see how this may differ from other primates that are not nocturnal.

The study has not only proved important to understanding color vision evolution, but also has shown the value of examining the dazzling diversity of life, especially in endangered species.

Source: Arizona State University