New study shows effects of prehistoric nocturnal life on mammalian vision

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Since the age of dinosaurs, most species of day-active mammals have retained the imprint of nocturnal life in their eye structures. Humans and other anthropoid primates, such as monkeys and apes, are the only groups that deviate from this pattern, according to a new study from The University of Texas at Austin and Midwestern University.

The findings, published in a forthcoming issue of Proceedings of the Royal Society B, are the first to provide a large-scale body of evidence for the "nocturnal bottleneck theory," which suggests that mammalian sensory traits have been profoundly influenced by an extended period of adaptation to nocturnality during the Mesozoic Era. This period lasted from 250 million years ago to 65 million years ago.

To survive in the night, mammals had a host of visual capabilities, such as good color vision and high acuity, which were lost as they passed through the nocturnal "bottleneck."

"The fact that nearly all living mammals have eye shapes that appear 'nocturnal' by comparison with other amniotes [mammals, reptiles and birds] is a testament to the strong influence that evolutionary history can have on modern anatomy," says Chris Kirk, associate professor of anthropology at The University of Texas at Austin.

According to Kirk, early mammals were predominantly nocturnal during the Mesozoic partly as a strategy for avoiding predation by day-active dinosaurs.

"It's a bit surprising to still see the effects of this long period of nocturnality on living mammals more than 65 million years after non-avian dinosaurs went extinct, but that's exactly what we found," Kirk says.

The research team, led by Margaret Hall, an evolutionary biologist at Midwestern University's Arizona College of Osteopathic Medicine, analyzed one of the largest datasets on eye morphology ever assembled. Using a sample of eyeballs from 266 mammal species, the researchers used a multivariate statistical method to show that mammals active by day or night show only minor differences in eye morphology.

The researchers then compared the eyes of mammals, birds and lizards using the ratio of cornea size and eye length—two functionally important measures of the eye's ability to admit light and form sharp images. These analyses showed that diurnal (only active by day) and cathemeral (active by both day and night) mammals don't differ in their eye shapes. At the same time, both groups have eye shapes that are very similar to those of nocturnal birds and lizards. These results reveal that most day-active mammals have eye shapes that appear "nocturnal" when compared with other vertebrates.

One likely reason for these findings, Kirk says, is that after the extinction of non-avian dinosaurs, some nocturnal mammals became day-active and there was less pressure to evolve eye shapes for acute diurnal vision like those of other day-active vertebrates.

Anthropoid primates are the only mammalian group that re-evolved eye shape for fine detailed daytime vision. Like diurnal birds and lizards, most anthropoids have small corneas relative to eye length as an adaptation for enhanced visual acuity.

Kirk says the study provides a deeper understanding of human sensory

systems and our intrinsic connection with our closest living primate relatives: the monkeys and apes.

"Humans and other anthropoid primates are so dependent on vision for everything that they do," Kirk says. "In this case, we are radically different from other mammals. We found that the distinctive eye shapes that set humans apart from most other mammals evolved a long time ago—way back with the origin of anthropoid primates."

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