Why do birds migrate at night?

September 12 2019

Credit: SMU

It was a puzzle about birds.

Migratory birds are known to rely on Earth's magnetic field to help them navigate the globe. And it was suspected that a protein called cryptochrome, which is sensitive to blue light, was making it possible for birds to do this.

Yet many of these animals are also known to migrate at night when there isn't much light available. So it wasn't clear how cryptochrome would function under these conditions in birds.

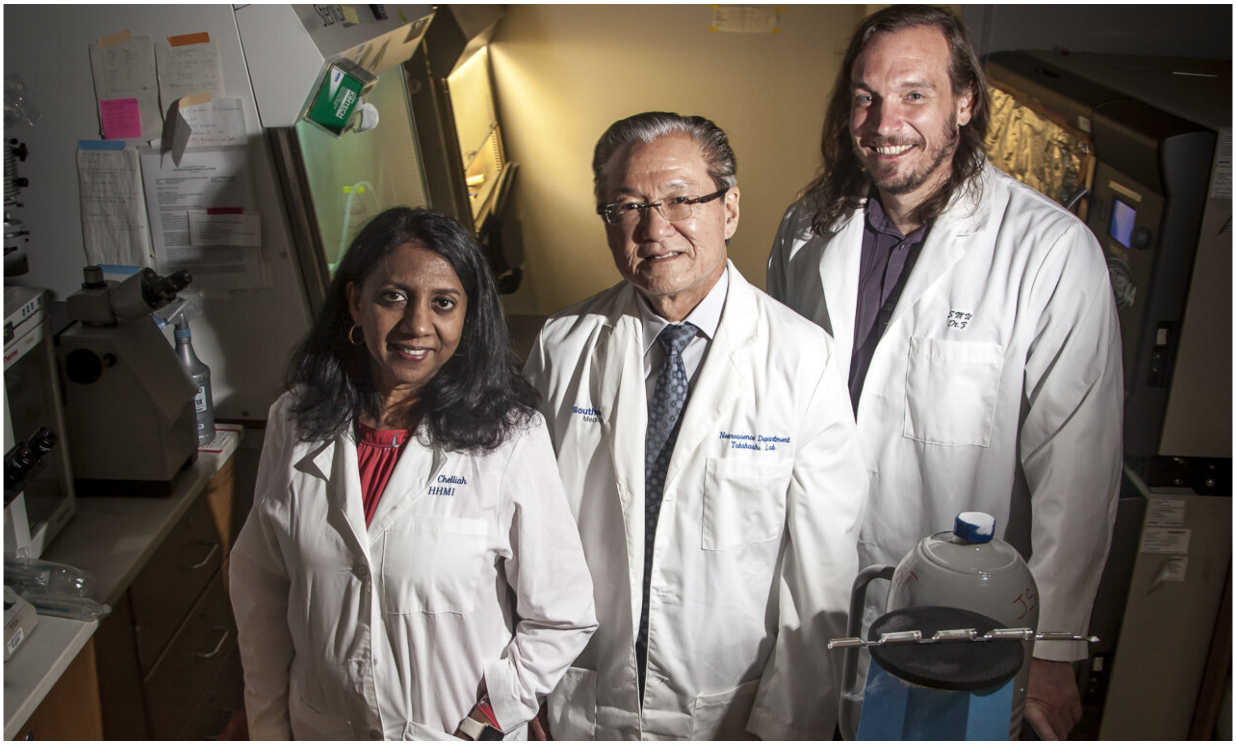
A new study led by UT Southwestern Medical Center in collaboration with SMU (Southern Methodist University), though, may have figured out the answer to that puzzle.

Researchers found that cryptochromes from migratory birds have evolved a mechanism that enhances their ability to respond to light, which can enable them to sense and respond to magnetic fields.

"We were able to show that the protein cryptochrome is extremely efficient at collecting and responding to low levels of light," said SMU chemist Brian D. Zoltowski, who was one of the lead authors of a new study on the findings. "The result of this research is that we now understand how vertebrate cryptochromes can respond to very low light intensities and function under night time conditions."

The study was published in the journal *PNAS* in September.

Cryptochromes are found in both plants and animals and are responsible for circadian rhythms in various species. In birds, scientists were specifically focused on learning more about an unusual eye protein called CRY4, which is part of a class of cryptochromes.



(From left) UT Southwestern Medical Center research specialist Yogarany Chelliah, Dr. Joseph Takahashi, and SMU's Dr. Brian Zoltowski. Credit: SMU (Southern Methodist University), Kim Leeson

The lab of Joseph Takahashi, a circadian rhythms expert at UT Southwestern Medical Center, worked with other UT Southwestern scientists to purify and solve the crystal structure of the protein—the first atomic structure of a photoactive cryptochrome molecule from a vertebrate. The lab of Brian Zoltowski, an expert in blue-light photoreceptors, studied the efficiency of the light-driven reactions—identifying a pathway unique to CRY4 proteins that facilitates function under low light conditions.

"Although in plants and insects, cryptochromes are known to be photoactive, which means they react to sunlight. Among vertebrates much less is known, and the majority of vertebrate cryptochromes do not appear to be photoactive," said Takahashi, chairman of neuroscience at UT Southwestern and an investigator with Howard Hughes Medical Institute. "This photosensitivity and the possibility that CRY4 is affected by the magnetic field make this specific cryptochrome a very interesting molecule."

Researchers took a sample of the CRY4 from a pigeon and grew crystals of the protein. They then exposed the crystals to x-rays, making it possible for them to map out the location of all the atoms in the protein.

And while pigeons are not night-migratory songbirds, the sequences of their CRY4 proteins are very similar, the study noted.

"These structures allow us to visualize at the atomic scale how these proteins function and understand how they may use blue-light to sense magnetic fields," said Zoltowski, associate professor of chemistry at SMU's Dedman College of Humanities & Sciences. "The new structures also provide the first atomic level detail of how these proteins work, opening the door for more detailed studies on cryptochromes in migratory organisms."

In the study, researchers discovered unusual changes to key regions of the protein structure that can enhance their ability to collect light from their environment.

"Cryptochromes work by absorbing a photon of light, which causes an electron to move through a sequence of amino acids. These amino acids typically consist of a chain of 3 or 4 sites that act as a wire that electrons can flow through," explained Zoltowski. "But in pigeons, it was identified that this chain may be extended to contain 5 sites."

This mutation of the electron chain in pigeons makes cryptochrome less dependent on a bird's environment having a lot of light for the protein to be activated.

"Birds have evolved a mechanism to enhance the efficiency. So even when there is very little light around, they have enough signal generated to migrate," Zoltowski said.

More information: Brian D. Zoltowski et al, Chemical and structural analysis of a photoactive vertebrate cryptochrome from pigeon, *Proceedings of the National Academy of Sciences* (2019). DOI: 10.1073/pnas.1907875116

Provided by Southern Methodist University