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Wild sparrow study traces social behaviors in the field to specific gene

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The white-throated sparrow is considered a good model organism for the genetic basis of behavior. Credit: Cephas/Wikipedia

A unique study of the white-throated sparrow has identified a biological pathway connecting variation in the birds' aggression and parenting behaviors in the wild to variation in their genome.

The *Proceedings of the National Academy of Sciences* (*PNAS*) is publishing the results of the experiments, conducted by the lab of neuroscientist Donna Maney in Emory University's Department of Psychology.

The research, which comprised behavioral observations of the study subjects in the field and laboratory analyses of their gene expression in the brain, showed that variation in the expression of the estrogen receptor alpha (ER-alpha) gene strongly predicts the birds' behavior.

"We believe this is the most comprehensive study yet of how the rearrangement of a chromosome affects social behavior in a vertebrate," says Brent Horton, a post-doctoral fellow in the Maney lab and lead author of the study. "So much of the process of genetic discovery is restricted behind closed doors in a laboratory. But our study began in the woods, where we first observed the social behaviors of the actual subjects of our experiments in their natural setting. The results provide valuable insight into the mechanistic basis of aggression and parenting in all vertebrates, including humans."

Such integrated studies "are exceedingly rare," Horton adds, "because they require such a variety of resources, expertise and well-balanced collaboration."

In addition to Horton and Maney, the principal investigators included Eric Ortlund, a biochemist and an expert in the ER-alpha gene at the Emory School of Medicine; and James Thomas, a human geneticist who was formerly with Emory and now works at the National Institutes of Health. Co-authors include William Hudson, a graduate fellow in Ortland's lab; Wendy Zinzow-Kramer, a post-doc in the Maney lab; Sandra Shirk, a research associate; and Emily Young, an undergraduate student of biology at Georgia Tech.

The white-throated sparrow is considered a good model organism for the genetic basis of behavior due to a genetic event that has divided the species into two distinct forms that differ in their behavior. These two forms, the white-striped morph and the tan-striped morph, are easily distinguished by their plumage markings.

At some point during the evolution of the species, a chromosome broke and flipped. This process, called an inversion, rearranged the sequence of the chromosome.

The white-striped birds, which all possess at least one copy of the rearranged chromosome, tend to be more aggressive and less parental than the tan-striped birds, which do not have the rearranged chromosome.

"The two morphs work beautifully in evolution because one color morph almost always mates with the opposite color morph," Horton says. "They complement each other."

For the past decade, the Maney lab has been a leader in documenting the neuroendocrine and genetic differences between the white-throated sparrow morphs. For the current study, funded by the National Institutes of Health, Maney recruited Horton, a field biologist and an expert in the natural history of the white-throated sparrow.

"At heart, I'm a behavioral ecologist," Horton says. "I want to integrate neuroscience and genetics into my work to understand the behaviors that I see in the wild."

The scientists knew that the different behaviors of the two sparrow morphs were linked to the chromosome inversion. "We wanted to know what genes captured by that chromosome also differ between the morphs, in order to identify the genetic mechanisms that may explain the behavioral differences," Horton says.

The white-throated sparrow winters in the South, but mates and raises its young during spring and summer in the North. "In a sense, I migrated with these birds," Horton says, explaining how he conducted fieldwork over three years. Each summer, he packed up his family and left Atlanta for Argyle, Maine, to tag birds for the study and spend weeks observing their behaviors in a forest.

White-throated sparrows nest on the ground under shrubs or low in trees. They are one of the most common birds seen in the forest and at suburban bird feeders. Their distinctive song is often likened to the phrase, "Old Sam Peabody … Peabody … Peabody."

To measure parental behaviors in the birds, Horton recorded the number of feeding trips they made for their young during a specified time. To measure aggression, he recorded their song rate in response to a simulated territorial intrusion: A live sparrow in a cage was displayed in the breeding territory of the wild study subjects, accompanied by the broadcast of a male song.

"The song of the birds is a form of aggression," Horton explains. "They're saying 'get out of my territory.' The rate at which they sing gives a measure of their level of aggression."

The field observations were followed by laboratory analyses of the study subjects, to hone in on differences in their neuroendocrine gene expression.

The researchers focused on ER-alpha as a primary candidate, since it is one of the genes captured by the chromosome inversion and had been previously linked to social behaviors in vertebrates.

Their analyses documented how the genetic differentiation between the morphs affects the transcription of ER-alpha. In one brain region thought to be important for aggression, white-striped birds had three times the level of ER-alpha than did the tan-striped birds. By looking at both the behavioral data and the lab data together, the researchers found the expression of ER-alpha in that region and others predicted variation in territorial aggression and parenting.

"The behaviors that differ between the morphs are known to rely on sex steroid hormones such as testosterone," Maney says. "But we already showed in 2009 that even when their testosterone levels are equal, the white-striped males still sing more than the tan-striped males. This finding led us to suspect that brain sensitivity to hormones differs between the morphs. ER-alpha has a hormone receptor that makes the brain sensitive to testosterone, so it makes sense that the white-striped birds have higher levels."

The researchers hypothesize that the mechanism they have identified may have played a major role in behavioral evolution.

"Humans also show variation in aggression and parenting," Horton says, "but we know little about what contributes to this variation and how our behavior can in turn affect our brains. This bird gives us important clues about what to look for as we try to understand the complex interplay between genes, proteins and our own social behaviors."

The ER-alpha findings conclude the first phase of the work. The research team is also investigating a suite of other neuroendocrine genes captured by the chromosome rearrangement that are thought to be important players in the regulation of social behavior.

More information: Paper: www.pnas.org/content/early/201 … 165111.full.pdf+html

Provided by Emory University

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