The Literature

GENETICS & GENOMICS

A Female Bird’s Muted Colors

THE PAPER

Male red siskins (Spinus cucullatus), a species of finch, flaunt orange-red bellies and backs, contrasting with their black heads and dark wing markings. The females, on the other hand, are mostly muted shades of grey (though pops of orange-red and black do appear on their bellies and wings). Such differences in coloration between the sexes, called sexual dichromatism, occur in many bird species, but their root cause has confounded scientists for years.

Geneticist Miguel Carneiro of the Research Centre in Biodiversity and Genetic Resources (CIBIO) at the University of Porto in Portugal had previously discovered that a siskin gene called CYP2J9 encodes an enzyme that helps convert yellow carotenoid compounds from seeds in the birds’ diet into the red carotenoids found in their feathers. But he wanted to know why this happened only in males, so he and then-graduate student Malgorzata Gazda, together with Pedro Miguel Araújo of the nearby University of Coimbra, studied another, human-bred bird, the mosaic canary. These birds were created by breeding red siskins with common domestic canaries (Serinus canaria), which are not sexually dichromatic, and then backcrossing them with the common canaries and selecting for birds that are sexually dichromatic. Apart from their color and sexual dichromatism, mosaic canaries are nearly genetically identical to common canaries.

Gazda sequenced the genomes of the mosaic canaries and compared them to the genomes of four non-dichromatic canary breeds and one slightly dichromatic wild canary. They found one stretch of the mosaic genome that was associated with sexual dichromatism. They then looked for a region within that stretch that contained only siskin single nucleotide polymorphisms (SNPs) and found a sequence approximately 36 kilobases in length that contained three genes. The researchers measured the expression of those genes in regenerating tail feather follicles of mosaic canaries and found that only one, beta-carotene oxygenase 2 (BCO2), was expressed differently in females and males. When BCO2 is expressed, mosaic birds’ feathers are white because BCO2 degrades carotenoids. (In red siskins, color is bit more complex; they also possess a gene for melanin, which adds a gray tint.)

Gazda next investigated whether other finch species also used BCO2 to generate sexual dichromatism, or if they’ve evolved different mechanisms. She found that BCO2 expression varied with the amount of carotenoids in feathers in the sexually dichromatic European serin (Serinus serinus) and in wild canaries from the Canary Islands (which show very slight sexual dichromatism), but not in the house finch (Haemorhous mexicanus), which must use another molecular mechanism. “The genes responsible for dichromatism are very exciting, and in this case it seems to be a common gene across finches (and possibly other birds!),” Pennsylvania State University evolutionary biologist David Toews, who was not involved in this study, writes in an email.

Further experiments showed that it’s likely that an enhancer or promoter near the BCO2 gene turns it on, and Gazda suspects it is regulated by estrogen. “When the females get old [and make less of the hormone], they start to look a little bit more like males—they have more color,” she explains. Females without ovaries also look like males. Gazda says more experiments are needed to determine whether estrogen, or some other trigger, flips BCO2’s switch.

“Identifying and characterizing the role that carotenoid processing genes [play], particularly this one, BCO2, has been elusive,” Toews writes, adding that the new study “has important consequences for our understanding about the evolution and genetics of animal coloration and signaling.”

—Rachael Moeller Gorman