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Digest: Avian genomes are permeable to introgression for a few million years*

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How wide is the time window for introgression after divergence? Pulido-Santacruz et al. addressed this question by studying the evolutionary history of the bird genus *Dendrocincla*. They found five introgression events that occurred between a few hundred thousand and around 2.5 million years after divergence. The introgressed genomic proportion declined exponentially with the age of the hybridizing taxa. Hence, this study suggests that species boundaries are permeable up to 2.5 million years after divergence.

Hybrid inviability evolves slowly in birds. On average, it takes about 21 million years of divergence before avian hybrids become inviable, whereas mammals produce inviable hybrids after about 4 million years of evolution (Fitzpatrick 2004). However, the production of viable hybrids does not necessarily result in introgression (i.e., the exchange of genetic material by means of hybridization and backcrossing). Hybrids might be sterile or unable to find a partner. In contrast to the evolution of hybrid inviability, it is unknown how long it takes before introgression is impossible.

In this issue, Pulido-Santacruz et al. (2020) explore this scenario using the Neotropical bird genus *Dendrocincla*. This group of cryptic forest birds contains six species (*Dendrocincla tyrannina*, *Dendrocincla merula*, *Dendrocincla fuliginosa*, *Dendrocincla homochroa*, *Dendrocincla anabatina*, and *Dendrocincla turdina*) that have been classified into 26 subspecies, some of which show deep divergence and might themselves be distinct species (Schultz et al. 2019). Based on a genomic dataset (generated using a Genotyping by Sequencing approach), Pulido-Santacruz et al. (2020) reconstructed the phylogeographic history of the genus *Dendrocincla* and inferred introgression between taxa.

The genomic analyses uncovered five introgression events. This number is probably an underestimate because the applied method—the D-statistic or ABBA-BABA test—only captures introgression between nonsister taxa (Ottenburghs et al. 2017). The introgression events occurred between a few hundred thousand and around 2.5 million years after divergence. Surprisingly, the authors found no introgression between the subspecies *D. f. atrirostris* and *D. f. rufoolivacea* that interbreed along a hybrid zone and diverged approximately 3 million years ago (Weir et al. 2015). Together, these results suggest that *Dendrocincla* woodcreepers have a time window of roughly 2.5 million years for introgression. How wide this introgression window is for other bird taxa remains to be investigated.

Next, Pulido Santacruz et al. (2020) calculated the genomic proportion that was exchanged during the five introgression events. These proportions turned out to decline exponentially with the age of the hybridizing taxa. Interestingly, this pattern resembles the accumulation of genetic incompatibilities during the build-up of postzygotic isolation (Gourbière and Mallet 2010). These genetic incompatibilities do not increase linearly but instead seem to snowball because each new mutation is increasingly likely to be incompatible with a previous mutation. The findings in this study are in line with the snowball pattern and suggest that species boundaries become less permeable to introgression as genetic incompatibilities accumulate. For

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Dendrocincla woodcreepers, the species boundaries seem to become impermeable after about 2.5 million years of divergence. This analysis will need to be applied to other bird taxa to see whether the exponential decline in introgressed material is a common feature of avian speciation. Nonetheless, this study shows that despite the slow build-up of postzygotic isolation (about 21 million years), birds appear to have only a narrow time window for introgression (up to a few million years).

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