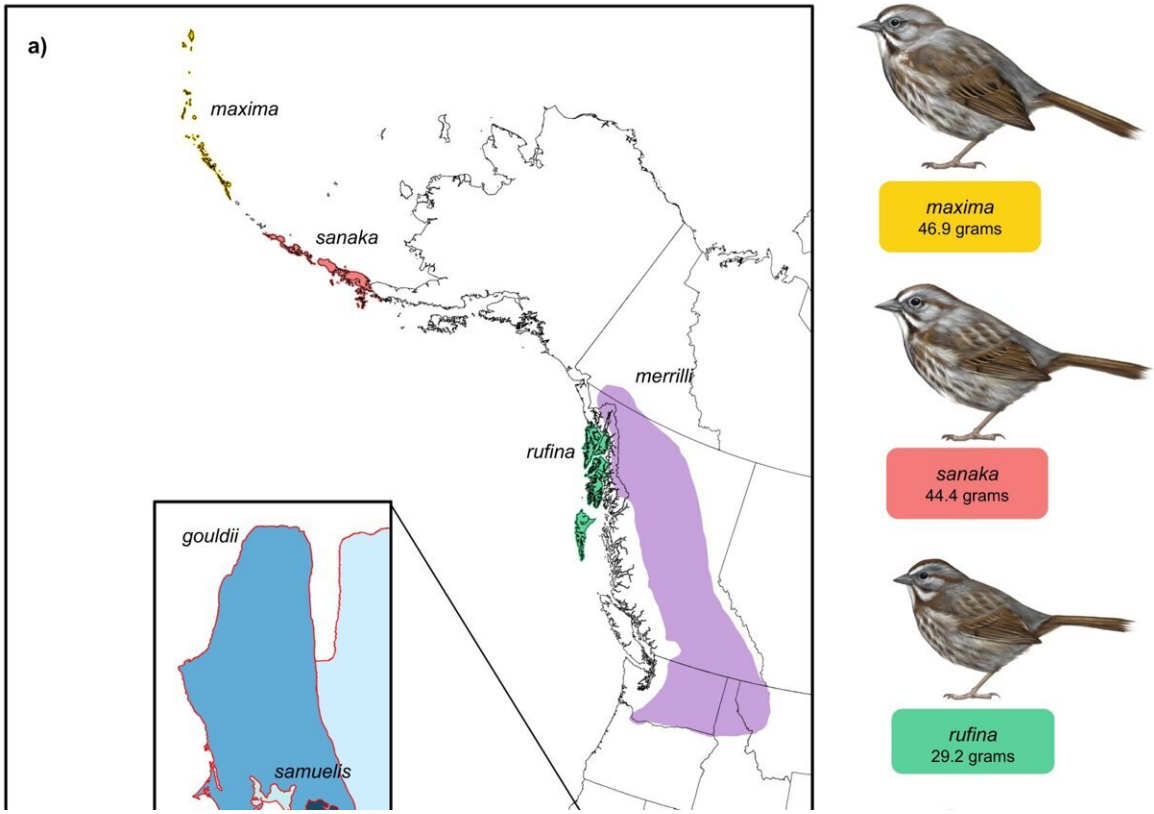
Local adaptation may buffer some birds against climate change

November 7 2023, by Pat Leonard



Song sparrow subspecies distribution, genetic divergence, and body size variation. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-42786-2

North American song sparrows may be more resilient to climate change thanks to a remarkable adaptation: a stunning range of body sizes found

throughout the bird's westernmost range.

Cornell researchers and their colleagues have done whole genome sequencing of North American song sparrows that has revealed the genetic underpinnings for the range of body sizes. This work is the first result from a larger research effort to sequence song sparrow genomes from across North America, spanning nearly all of the 25 recognized subspecies.

The current research published in *Nature Communications* by scientists from the University of British Columbia, the Cornell Lab of Ornithology, Ouachita Baptist University and the University of Alaska, Fairbanks.

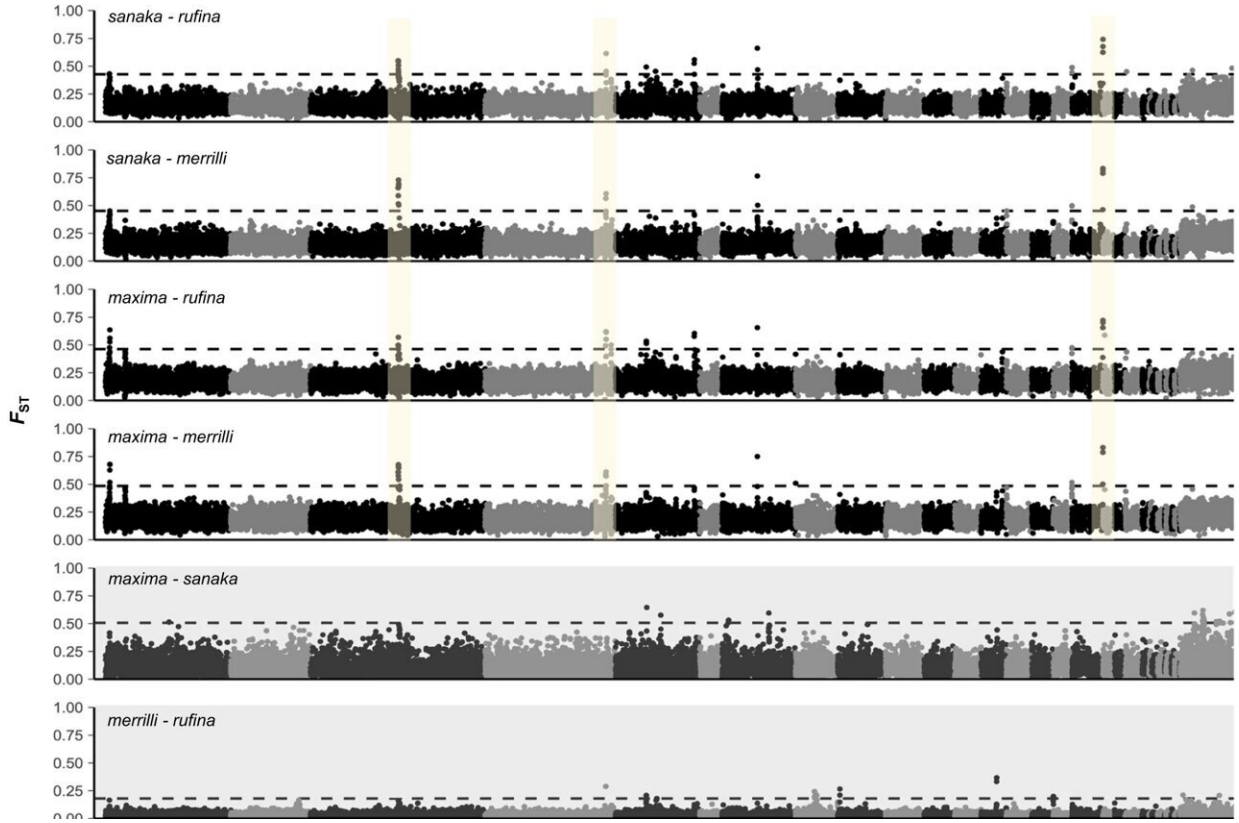
The study offers support for what is known as Bergmann's Rule, which states that broadly speaking, among organisms that regulate their own heat, natural selection in colder climates leads to larger-bodied organisms while warmer climates lead to smaller bodies. Larger bodies are more efficient at retaining heat. Smaller bodies allow an organism to stay cooler.

Song sparrows that live year-round on Alaska's Aleutian Islands can be up to three times larger than their cousins near San Francisco Bay.

"The size difference among song sparrows is wild to even think about," said co-author and researcher Jennifer Walsh at the Cornell Lab of Ornithology. "Our results show that song sparrows have substantial capacity for adapting to local environmental change, and the genetic mechanisms underlying those changes are quite clear. We thought there would be a more complicated genetic component, or many more genes working together, to create the huge size difference."

For this study, the researchers sequenced and compared 79 genomes

from nine song sparrow subspecies originating from multiple locations, work done at the Fuller Evolutionary Biology Program at the Cornell Lab of Ornithology.



Genome-wide differentiation between northern subspecies. Genome-wide distribution of F_{ST} for pairwise comparisons between large- and smaller-bodied northern subspecies (white background) and control comparisons (gray background). Manhattan plot show genome-wide differentiation in 50-kb windows. The dashed line indicates the 99.9th percentile of genome-wide mean. The yellow highlighted regions indicate a subset of divergent windows on contigs 3361 (chr 2), 1534 (chr 3), and 391 (chr 17) held in common between all pairs. Chromosomes were identified by their position on the zebra finch genome. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-42786-2

Tissue samples used for this study came from specimens at the University of Alaska Museum of the North, collected between 1997 and 2000, along with previously published whole genomes for California subspecies. Song sparrows are an especially useful study species because they are so widespread and are adapted to live in so many different types of environments.

"We found eight gene variations in the genomes we sequenced, all associated with body mass as predicted by Bergmann's Rule," said lead author Katherine Carbeck, a Ph.D. candidate at the University of British Columbia in Vancouver. "What this tells us is that there is a genetic basis for song sparrow adaptation to local climate conditions, stretching from the coldest locations in the far north to the warmest parts of its range in California."

We tend to think of evolution as occurring over millions of years, but microevolutionary processes—changes taking place over a short period of time—play a crucial role in helping song sparrows survive even in novel climate conditions, Carbeck said.

The findings suggest a resilient future for these birds, said Peter Arcese, a co-author and professor in UBC's department of forest and conservation sciences.

"Our findings imply that some, if not all, locally adapted song sparrow populations may continue to adapt to climate change, as long as we maintain habitat conditions that facilitate the movement of individuals and genes between populations," he said.

Understanding the nuances of microevolution makes a difference when it comes to conservation, the scientists said. For example, song sparrows in northwestern regions, such as Alaska and British Columbia, show stable or increasing populations currently, but the opposite is true for

populations along the West Coast of the continental United States, with some San Francisco Bay populations listed at the state level as threatened.

Declines in one portion of the range could mean loss of genetic diversity in locally specialized populations, despite the overall trends for the species. And though song sparrows have been shown to be very adaptable to local climates, there is a limit.

"Although micro-evolution has the potential to partly offset the effects of climate change," Carbeck said, "the key question is whether local adaptation can keep pace with the speed at which overall climate change is happening."

More information: Katherine Carbeck et al, Candidate genes under selection in song sparrows co-vary with climate and body mass in support of Bergmann's Rule, *Nature Communications* (2023). DOI: 10.1038/s41467-023-42786-2

Provided by Cornell University