Songbird-body changes that allow migration may have human health implications

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White-throated sparrows are among the best-studied North American songbirds. With a typical wingspan of 6 to 7 inches, it breeds primarily in northern boreal coniferous and mixed forests and, a short-distance migrant, winters mainly in the southeastern US. To make these migrations, the bird's body changes significantly. Credit: Paul Bartell / Penn State

Songbirds that pack on as much as 50 percent of their body weight

before migrating and that sleep very little, exhibit altered immune system and tissue-repair function during the journey, which may hold implications for human health, according to Penn State researchers.

"Imagine if you became morbidly obese before running a marathon, you didn't sleep for a few days before competing—and you performed so well that you win," said lead researcher Paul Bartell, associate professor of avian biology. "Then, consider that you were protected from the cardiovascular and metabolic disease that normally would result from either obesity or long-term sleep deprivation. That's the example I like to use to illustrate how amazing the changes are that occur in these birds to allow migration." Although similar changes occur in other songbirds that make their migration flights at night, the species that Bartell refers to is the white-throated sparrow. His research group, based in the College of Agricultural Sciences, studied the birds' physiological mechanisms that confer protection against the consequences of sleep deprivation while simultaneously allowing for the increased physical performance required for migration.

Many birds undertake long, biannual, migratory voyages during the night, Bartell noted, and during these times of the year birds drastically reduce their amount of sleep, yet curiously perform as well on tests of physical and cognitive performance as during non-migrating times of the year. This inherent physiological protection disappears when birds are forced to stay awake at other times of the year, so these protective changes only are associated with the nocturnal migratory state.

To see the physical manifestation of migratory changes, researchers performed RNA-sequence analyses of heart and liver tissues collected from birds at different times of day under different migratory states and evaluated the data using genetic analysis. They identified changes in gene expression implicating multiple systems and pathways that regulate many aspects of metabolism, immune function, wound repair and

protection of multiple organ systems.

"We picked the heart and liver because the heart is a good representative of cardiovascular system output and the liver reflects the chemical changes behind physiological fluctuations," Bartell said. "And we know that the heart of the white-throated sparrow will change size when they migrate, getting larger, allowing the birds to perform better, and then shrink after engaging in migratory activity without functional damage to the organ."

In the study, recently published in *Scientific Reports*, 48 white-throated sparrows were captured using mist nets in Centre County, Pennsylvania, and transported to animal housing at the University Park campus. All birds were housed and fed together in a large flight cage for six months to standardize recent life history and avoid introducing uncertainty into findings caused by variations in diet and movement.

During confinement, researchers manipulated hours of light and darkness to stabilize both migratory and non-migratory states, roughly approximating seasonal timing in the wild.

Performing dissections under these conditions allowed comparisons between migratory and non-migratory conditions without discrepancies caused by light exposure. Bartell knew from previous research that white-throated sparrows enter a migratory state and that the birds' behavior and supporting morphological and physiological changes occur twice a year, based upon the timing of their internal clocks, which are normally synchronized to changes in day length.

He believes that the research will lead to a more complete understanding of the birds' unique ability to dynamically reduce sleep requirements while completing ultra-endurance events without associated negative consequences. The study provides new insights into the seasonal changes

that occur during nocturnal migration in birds.

But beyond avian applications, Bartell thinks follow-on studies already underway in his lab and others to come will establish workable links between songbird migratory physiology and human health. "That's why the Navy was willing to pay for the study," Bartell said, referring to a grant awarded by the Office of Naval Research. "But I think the value will be higher than just learning how to make our war fighters function at a higher level when they are physically active and sleep deprived."

These photos of the underside of white-throated sparrows show changes in fat deposition. Before migration, the birds can gain up to 50% of their body weight and then convert the fat to fuel their long flights. Credit: Paul Bartell / Penn State

He suggested that scientists might eventually be able to transfer aspects of the bird's miraculous migratory abilities to humans. Of most interest is their capacity to maintain tissue repair and remodeling at high efficiency.

"Simultaneously, the birds break down tissue for fueling flight and fix damage to tissue resulting from prolonged use," he said. "And ultimately, their bodies provide a clean scaffolding network for tissue regrowth after migration."

Bartell credited Penn State's unusual combination of state-of-the-art genomic facilities at the university's Huck Institutes of the Life Sciences and top-of-the-line avian facilities in the Department of Animal Science for allowing the innovative research to proceed.

"In the College of Agricultural Sciences, we are blessed with wonderful animal facilities," he said. "Much of this study was done at the Poultry Research Center, where essentially an entire wing of the building is used for sparrows and other birds."

Provided by Pennsylvania State University

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