Mercury pollution threatens to impair the ability of birds to migrate

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Coal-fired power plant in Florida. Credit: Rebecca Humann

Migrating birds today must contend with numerous dangers and challenges that never existed before, from twirling wind turbines and shiny glass buildings in the sky to ever-shrinking amounts of stopover habitat and scores of outdoor cats lying in wait. A report from the Connecticut-based Great Hollow Nature Preserve & Ecological Research Center is now warning of a new, invisible threat to bird migration ? mercury pollution. The article, recently published online in the journal *Ecotoxicology*, presents a sobering assessment of the many ways in which global mercury pollution from coal combustion and other human activities threatens to interfere with the ability of birds to successfully migrate, including their ability to navigate, sustain flight for long periods, rapidly refuel during stopovers, and avoid sickness and oxidative stress.

"Conservation practitioners are greatly concerned about anthropogenic threats to bird migration and they are also concerned about the environmental impacts of pollution, but few people seem to have put two and two together," said Great Hollow's Executive Director and the author of the study, Chad Seewagen. "While there have been many studies of the effects of mercury on reproduction and other endpoints related to fitness and health in birds, we know practically nothing about its effects on migration compared to other life cycle events."

Recent research on songbirds in Canada found that mercury levels were higher in autumn migrants than those passing through the same place the following spring, suggesting that the birds that started out with the greatest amount of mercury exposure were at some point lost from the population (DOI:10.1111/jav.01656). This raises many questions about the mechanisms by which mercury could have this possible influence on migration performance and survival. To identify potential ways in which mercury could affect a migrating bird, Seewagen synthesized literature concerning the physiological and histological effects of mercury on non-migrating birds as well as non-avian vertebrates, including humans and other mammals, amphibians and fish, while keeping the biological requirements of migration in mind. What he found was alarming: many of the unique and specialized neurological and biochemical processes that make long-distance bird migration possible appear to be ripe for disruption by mercury exposure.

Seewagen first noticed that there are wide-ranging neurotoxic and biophysical effects that mercury is known to have on the visual systems of humans and many other non-avian vertebrates, which could also interfere with the sensory pathway that underlies the amazing ability of migratory birds to "see" and navigate by Earth's magnetic fields. Visual magnetoreception is fundamental to the navigational abilities of nocturnal migrants, and any disruption of it could be disastrous for a bird attempting to find its way to a destination that is thousands of miles away.

Seewagen then considered the unique

physiological processes that allow birds to fuel those long-distance flights with fat rather than carbohydrates and thereby achieve a level of endurance that is nearly unrivaled in the animal kingdom. He found that mercury has a broad ability to inactivate enzymes, which could include the many enzymes that play critical roles in the rapid mobilization and catabolism of a bird's fat stores during flight. He then found evidence to suggest that mercury could limit the upregulation of transport proteins that are equally important to quickly getting those fatty acids into the cells of working muscles for use as energy. What's more, mercury has been found in non-migrating birds to inhibit the production of hemoglobin, which is responsible for carrying oxygen to the muscles for the aerobic conversion of fat into flight energy. Any such impediments to fatty acid catabolism would be sure to compromise the endurance of migratory birds that allows them to fly astonishingly long distances.

Next, the study found that mercury could spell additional trouble for birds during and immediately following flight by challenging their ability to maintain oxidative balance. Mercury is a well-known contributor to oxidative stress in birds and other vertebrates due to its ability to generate reactive oxygen species while simultaneously impeding antioxidant defenses. This double whammy raises concerns that birds exposed to mercury are sustaining additional oxidative stress beyond that which is already imposed by the extreme energetic demands of migration, and potentially later experiencing adverse effects on their health and fitness as a result.

Seewagen goes on to posit that mercury exposure could limit a bird's ability to rapidly replenish its fat stores during the brief stopovers that separate flights. The study points to the endocrine-disrupting effects of mercury that have been observed in many vertebrates, including humans, and the important role of hormones, such as insulin, in the physiological processes involved in fattening. Any inhibition of the refueling rates of birds could prolong their stopovers, delay arrival to their final destination, and ultimately limit their access to the highest quality mates and breeding/overwintering habitat.

Lastly, the article warns that migration performance and possibly survival might be limited by the suppressive effects that mercury has on the immune system of birds. The energetic demands of migration already reduce immunocompetence, and so any additional immunosuppression caused by mercury would be expected to increase the likelihood and severity of infections during migration. Pathogen infections in migrating birds have been shown to shorten flight distances, reduce stopover refueling rates, delay arrival, and even reduce their survival.

"Although only a very small number of studies have attempted to determine the effects of mercury on migration, what we know for now is that there is an abundance of information from non-migrating birds and non-avian taxa warning us that mercury pollution poses a substantial threat to bird migration in multiple ways," says Seewagen. "Hopefully the article will inspire future direct investigations of the proposed mechanisms and lead to a fuller understanding of the threats that this global pollutant poses to birds. Research on the impacts of mercury pollution on birds has been and will likely continue to be a strong driver of improved emissions regulations and policies around the world."

More information: Chad L. Seewagen. The threat of global mercury pollution to bird migration: potential mechanisms and current evidence, *Ecotoxicology* (2018). DOI: 10.1007/s10646-018-1971-z

Provided by Great Hollow Nature Preserve & Ecological Research Center

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