Tracking animal migration with stable isotopes

openaccessgovernment.org

16 March 2023

Keith A. Hobson from Western University and Environment and Climate Change Canada, walks us through tracking animal migration with stable isotopes, starting with some background information

Animal migration is one of the most iconic of all natural phenomena and humans have marvelled at animals' ability to navigate over vast distances often under arduous conditions. Periodic to-and-fro migration is the most familiar form, and birds have clearly captured our imagination on that front with their conspicuous annual movements and arrivals between continents. However, how animals successfully move in this way is still not fully appreciated, and a full understanding will ultimately involve expertise from diverse disciplines.

In addition to being a fascinating example of complex evolution, the phenomenon of animal migration across political boundaries presents considerable challenges to governments tasked with their conservation and protection. Once animals leave one political jurisdiction, they enter another with commensurate changes in levels of protection, habitat availability, and natural and anthropogenic hazards. Various levels of protection are afforded to migratory animals through inter-government cooperation (e.g. Migratory Bird Convention Act in North America). Still, it is becoming clear that many migratory species are declining faster than their non-migratory counterparts and that whole taxonomic groups of migratory animals have been essentially overlooked.

So, while all animals face increasing challenges due to a changing world, added challenges of long-distance animal migration elevates migratory species to a category of special concern. Arguably, migratory hunted species have received the most attention historically (e.g. North American Waterfowl Management Plan). Still, for non-game species, which represent the vast majority of migrant animals, conservation and management are inherently more challenging. Without a doubt, the primary challenge here is our general ignorance of migratory connectivity or the degree to which a species' population in one place is linked or connected to another space in another part of the world.

How do we track animal migration?

Human ingenuity seems unlimited when it comes to using extrinsic marker techniques to follow individual animals during migration. Marking individuals with unique identifying tags and recovering that tag elsewhere can provide direct spatial links. The massive ringing or banding programs in Europe and North America have involved millions of migratory birds. Even small monarch butterflies have been marked with numbered light-weight wing tags in the United States and Canada, and their recovery at their Mexican roost sites has provided a wealth of information (Monarch Watch). Devices that can communicate with satellites provide impressive real-time location information and miniaturized "geolocators" can now be used to download positions from day length and time of solar noon. Small VHF radiotracking devices can now be affixed to much smaller animals, which can communicate with dedicated receiving tower networks such as the MOTUS system in North America. The trend is toward smaller and smaller electronic devices, and the results are becoming impressive!

Unfortunately, all extrinsic devices have weaknesses that are often overlooked by enthusiasts. First, with the exception of transmitting tags, extrinsic markers require two captures, once to equip the animal and secondly to retrieve it. No information is possible from an unmarked individual. Second, all transmitting or receiving tags have a minimum weight dictated largely by battery requirements and are necessarily expensive. Finally, extrinsic tags can alter the behavior of the animal carrying them.

For these reasons, there has been considerable interest in the possibility of using naturally occurring intrinsic markers. These are markers carried by the animal, requiring only one capture, with all captures providing information. The pursuit of this goal has occupied Hobson's research for the last 30 years, specifically involving the use of stable isotopes.

Stable isotopes ratios and animal information

Elements in nature often occur in more than one stable form, and such isotopes of the element are chemically identical but differ in mass. Heavy isotopes of an element are rare, but the ratio of the heavier to lighter isotopes can provide an immense amount of information once measured. In food webs used by migrant animals, the elements C, N, H, O, S, (with isotopes depicted as δ13C, δ15N, δ2H, δ18O, δ34S) provide key information on diets and locations.

For animal migration, the measurement of isotope ratios in metabolically inert or "fixed" tissues such as hair, feathers, scales or insect wings do not change once formed and can indicate source location if measured after the animal has moved. The discovery that the stable isotope ratios of H in precipitation are faithfully passed on to consumers has revolutionized using stable isotopes to trace terrestrial animal migration. This is because the average precipitation δ2H values across continents form repeatable patterns or isoscapes.

In the mid-1990s, the research team at Environment Canada in Saskatoon, Canada, were the first to demonstrate that migrant animals could be probabilistically placed to origins of inert tissue growth (i.e., molt site, natal site) by measuring the δ2H values in such tissues. That early work was performed on migrant monarch butterflies and neotropical migrant birds and unleashed a renaissance of forensic tracking of migrant animals.

Thus, information on origins is now possible from a single tissue measurement of an otherwise unmarked individual.

Research opportunities for isotopic tracing

Hobson's research team have applied the isotopic tracing technique to many animal migrations, from migrant butterflies and dragonflies to a suite of migratory birds, including songbirds and game species. They have pioneered multi-isotope (C, N, H) isoscape patterns in Africa that have assisted migratory research of birds using that continent. A viable isotopic tool has now been developed to track the illegal trade in wildlife parts and the movement of disease vectors such as the avian influenza virus. The future also looks bright with current research into stable isotope measurements of individual molecular compounds versus bulk tissues to refine assignments to origins and to understand migrant animal nutrition.

Please Note: This is a Commercial Profile