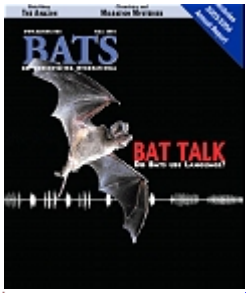

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Chemistry and Migration Mysteries
Fur holds clues to previous journeys
Paul Cryan

The bat was not only pregnant but downright angry as I snipped a bit of fur from her back. Within a few seconds, however, she flapped her powerful wings, took off from my hand and disappeared into the night, rejoining thousands of female hoary bats (Lasiurus cinereus) on their migration through the mountains of New Mexico.

Every spring, hundreds of these expectant mothers pass through this small stream drainage on their way to birthing grounds farther east. Their annual passage was first reported here more than 30 years ago, and it is still one of the few known migration corridors in the area.

My task that night was simple: catch hoary bats and snip tiny samples of fur from their thick coats, then let them continue on their way. The explanation, however, is a bit more complicated.

There is no doubt that hoary bats migrate long distances. Each autumn, they disappear from the colder latitudes of North and South America. Each winter, they show up in warmer areas where none were seen during summer. Evidence of their flight prowess is impressive. Wayward hoary bats have been spotted during spring and fall in such odd places as Bermuda, Iceland, Newfoundland and the Orkney Islands off the coast of Scotland – all far outside their normal range.

Perhaps one of the most amazing feats of dispersal ever accomplished by a mammal was the colonization of the Hawaiian Islands by hoary bats. Getting to the islands required a pregnant female, or perhaps a small group of bats, to make a nonstop flight of more than 2,500 miles (4,000 kilometers) across the Pacific Ocean. So daunting a journey seems possible only for a species that is highly adapted for long-distance travel.

Although we're certain that hoary bats migrate, we know few details of their travels – and those details are vital for effective conservation measures. That is what brought me to this isolated corner of New Mexico, armed with a pair of scissors and the hope that a few snips of fur might move us closer to the big picture of bat migration.

In the past, biologists studied the migratory movements of bats by attaching small bands to their wings and then finding them again after they moved. This was done primarily with bats that roost in caves and was much like looking for a needle in a haystack. First you had to find a colony of bats, then search for one of thousands (or millions) wearing a band on its wing.

If the banded bat is not of a species that roosts in large colonies in caves, you can end up looking for the needle in what amounts to a whole continent of haystacks. Hoary bats roost alone in the foliage of trees during summer, so banding them to study their migratory movements would be problematic at best. Therein lies the conundrum: Hoary bats likely are among the most far-ranging of bats, but they are also one of the most difficult species to mark and trail.

That's where the bat fur – and a bit of chemistry – enters the tale.

Our study, conducted with colleagues at the United States Geological Survey (USGS), hoped to determine just how far hoary bats travel during migration by analyzing stable-isotope ratios of hydrogen in their fur. Stable isotopes are simply the non-radioactive forms of an element, the atoms that do not decay but remain unchanged indefinitely. Isotopes of the same element differ only in the number of subatomic neutrons they contain.

We examined isotopes of hydrogen, which is the simplest element and has only two stable isotopes. These are called protium, which has one proton and no neutrons in its nucleus, and deuterium, which has a proton and neutron. (Tritium, a third hydrogen isotope with two neutrons, is radioactive and vanishingly rare in nature.) Deuterium, also called "heavy hydrogen," precipitates out of air to form water more readily than the single-neutron protium. As a result, moisture-filled air masses that originate in the tropics lose progressively more deuterium in the form of rainfall as they move toward the poles. Thus the percentage of deuterium isotopes in rainwater goes down (and the relative abundance of protium goes up) the farther you get from the equator.

This north-south gradient in stable-hydrogen-isotope ratios provides an excellent biological marker to track the movements of animals, because, as it turns out, you are indeed what you eat.

All of an animal's growing tissue – hair, for instance – incorporates hydrogen atoms from local water sources, and the water's isotope ratios remain relatively constant through the food chain. Thus, the local ratio of stable hydrogen is retained in any part of the body that grows while the animal is feeding.

And that is why I was giving haircuts to hoary bats.

By analyzing the stable-isotope ratios of hoary bat fur, we hoped to determine where the bat was living (the approximate latitude) when the hair was growing. In this, we received a great deal of help from other bat barbers all across North America.

Although hoary bats range across the Americas on their migrations, there are few places where they are easily captured. We requested the assistance of other bat biologists in gathering fur samples. Our call was amply answered, and we ob-tained more than 600 samples from all over the United States, Canada and Mexico.

The next step was to send the samples to the USGS Gas Chemistry Laboratory in Colorado. After working so hard to collect these tiny fur samples, it was tough to see them incinerated so their isotope ratios could be measured by a mass spectrometer. The results, however, were well worth the sacrifice.

The tests revealed that hoary bats undergo a single annual molt, replacing their fur each year, during late summer. This was a critical piece of evidence because it told us that hoary bats grow their fur before migrating in the fall, and their winter fur coats consist of hair grown on their summering grounds. The lab also verified that stable-isotope ratios of the fur generally reflect the ratios in precipitation at the summering grounds.

The next step was to look for differences between the isotope ratios of the fur and of local precipitation at their winter locations. The differences were far greater than the slight variations between fur and local precipitation during summer.

The fur taken from hoary bats in the winter told us that it typically had been grown much farther north. How far? Using conservative estimates that likely underestimate actual movements, our analysis found an average minimum distance between summer and winter habitats of approximately 250 miles (400 kilometers). Some individual bats traveled more than 1,250 miles (2,000 kilometers) on their fall migration. A less conservative interpretation suggests females may travel an average of about 685 miles (1,100 kilometers). Not bad for such a small mammal!

Our research clearly demonstrates that stable-isotope analysis can be a powerful tool for studying bat migrations. Hydrogen isotopes alone cannot pinpoint a bat's past location; they identify latitude but not longitude. Adding stable isotopes of other

elements to the analysis, however, may help to do so in the future.

It is crucial that we develop a better understanding of the seasonal whereabouts and migratory movements of hoary bats. Migration can be a dangerous time for bats because they become concentrated as they move, making them susceptible to storms, drought, contaminants and human disturbance.

For example, hoary bats are high on the lists of bats killed during autumn migrations at wind-turbine sites across North America. Since we currently have no way of assessing the health of hoary bat populations, declines may go unnoticed. We must act to minimize the impact that we, as humans, have on hoary bats as they migrate.

If we know where they are traveling, we may be able to stay out of their way. It was with that goal that we sought the help of chemists and learned that a little bat fur goes a long way.

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