Tracking migrant songbirds with stable isotopes

Migration is a fundamental aspect of avian biology, enabling birds to traverse vast distances in short time periods. Studies of stable isotopes have advanced our understanding of avian biology, their utility in studying migrant birds has been limited to those situations in which birds migrated from C4 to C3, or from terrestrial to marine systems. This limitation arises because the D and 15N values of animal tissues are primarily a result of diet rather than geographic location. So, these isotopes have limited capacity to act as general markers that link individual birds to geographic regions. D values of tissues, however, are not diet-dependent, and therefore hydrogen isotopes have potential for use as a general geographic marker.

3D as a geographic marker

Before 3D could be useful in studies of bird migration, three potential obstacles needed to be overcome. The first was finding a tissue that was renewed seasonally. That is, the 3D values of whatever tissue was sampled would have to reflect only the 3D signature of the breeding ground (or winter ground) and not an integration of the 3D signature from breeding, wintering, and migration areas. So only tissues formed entirely within a season (i.e. in a single region) would be useful; for songbirds, the obvious tissue is feathers (Box 2). The second obstacle was ensuring that the 3D values of this tissue represented a reliable record. This problem was potentially acute in feathers because 40% of the H contained in feathers is potential exchangeable with the environment. To be a useful marker in migrating birds, the actual exchange of H between feathers and the surrounding environment would have to be low. Chamberlain et al.2 provide the first evidence that the 3H isotopic ratios of feathers are largely fixed once they are fully formed (Box 2). The third and final obstacle was documenting the relationship between the 3D values of feathers and those values of precipitation in the region where the feathers were grown. To address this issue, Hobson and Wassenaar analyzed the 3D in feathers collected from six species of migrant insectivorous passerine birds. Feathers were collected at locations ranging from Alaska to the southeastern USA. From the isocline map they interpolated to derive estimates of 3D values in precipitation at sites where feathers were collected. The correlation between 3D of the feathers and the isotopic composition of the collection sites was very high (r = 0.91). This correlation is the first evidence that there is a tight linkage between the 3D isotopic composition occurring in the precipitation where the feathers were grown.

To provide further evidence of this relationship, Hobson and Wassenaar analyzed the 3D in feathers collected from five species of neotropical migrant songbirds on their wintering grounds in Guatemala. The isotopic ratios of these feathers placed all the individuals within the known breeding range of that species. Based on these and other results Hobson and Wassenaar conclude that the large hydrogen isotopic gradient in growing season rainfall across North America currently allows for ready discrimination of distinct breeding populations of songbirds and other organisms on a large scale. This ability alone makes it likely that this technique will provide new insights into old questions about the biology of migration.
The real power of $^2$H isotope analysis, however, probably lies in combined comparisons of $^13$C, $^15$N, and $^34$S in feathers and the surrounding environment. The first glimpse of this power is shown in Chamberlain et al.’s study. By combining analyses of the $^13$C, $^15$N, and $^34$S in feathers, these authors were able to differentiate three regions of the breeding range of the black-throated blue warblers (Dendroica caerulescens). Also, the isotopic signatures of feathers collected during winter in Jamaica, Puerto Rico and the Dominican Republic corresponded to locations within the breeding range of black-throated blue warblers. From these findings, the authors concluded that isotopic ratios have the potential to serve as geographic markers for migrant birds.

Implications for the future

These innovations have particular relevance because of the recent concern over the population status of migrant songbirds. Early concern over the possibility of widespread population declines has given way to a more complex picture of regional and habitat-based declines in some species groups and stable or increasing trends in others. Nonetheless, some species and groups of species are suffering long-term sustained population declines that warrant attention. The ability to manage these populations effectively depends on our understanding of the links between breeding, wintering and migratory populations. Toward this end, analyses of stable isotope ratios could play an important role in the conservation of neotropical and other migrant birds.

Beyond these direct applications to conservation, the ability to delineate the migration corridor and wintering grounds of birds that breed in North America is fundamental to our understanding of the ecology of these species. This information will provide new insight into long-standing questions about migration biology, such as the following. Is the timing of passage of individual migrants related to their breeding location? Are particular stopover sites used more frequently by birds that breed in particular latitudinal bands? How do migration patterns and wintering populations vary in more northerly areas? Do migrants follow the same flyway in both spring and fall? How common is differential migration among sex and age classes? New insights into these basic questions have the potential to revise our understanding of bird migration.

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References

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