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commentary

The geographic consequences of climate change for migratory birds

Modern global climate change can affect species in natural communities in a variety of ways. One outcome that has received broad attention within the biogeographical community is species' range shifts. There is growing empirical evidence for shifts that, in the majority of cases, follow climate change expectations with species moving to higher latitudes or to higher elevations (Parmesan 2006). With the growing appreciation that species are indeed responding to climate change, there has been an expanding modeling effort to project the long-term geographical consequences. Specifically, workers have developed models that use species' climatic niches (or envelopes) within their current geographic range to forecast species' distributions under future climate-change scenarios (Pearson & Dawson 2003).

When birds are considered in these investigations, shifts in breeding ranges in northern temperate-regions are often examined with little attention given to winter ranges in equatorial regions or the consequences of range shifts for migratory routes and strategies. In many cases, this is due to simple data limitations: the most thorough occurrence information for birds is typically confined to breeding and non-breeding ranges in Europe and North America. Migration under climate change has been an important topic of investigation (Parmesan 2007); however, most analyses address questions related to phenology where data tends to be more prevalent. In a recent article in the *Journal of Biogeography* (Doswald et al. 2009), Nathalie Doswald and colleagues applied climate envelope models to both the breeding and non-breeding ranges of 17 European *Sylvia* warblers, a group of birds that are common residents and visitors to Europe. Doswald et al. (2009) extends the findings of earlier investigations (e.g., Huntley et al. 2006) by quantifying the geographical consequences of climate change for migratory species, thus expanding the predictive breadth of recent modeling endeavors and also our appreciation of the many challenges birds and other taxa will likely face under climate change.

Migration is a common strategy for birds. To have enough energy to undertake long journeys, birds must build large quantities of fat reserves. If climate change results in greater migration distances, the viability of this phenomenon could be seriously challenged. Doswald et al. (2009) found that the majority of breeding ranges for the 17 *Sylvia* species were projected to shift northwards, but there was no evidence for a consistent directional shift with winter ranges. Thus, potential changes in migratory distances were, in most cases, a consequence of shifts in breeding ranges rather than winter ranges. Assuming species retain both breeding and non-breeding ranges and all individuals migrate in a similar fashion, migration distances were estimated to increase by an average of 413 km for trans-Saharan migrants and 201 km for resident and short-distance or partial migrants. Assuming increases in fuel requirements for longer migrations can be physiologically accommodated, these species are likely to require more time for feeding or richer food resources prior and during migration to achieve these longer distances. Alternatively, migration behavior might diminish to the point where separate breeding and non-breeding ranges are no longer a necessity, particular for short-distance or partial migrants whose breeding and non-breeding ranges are located at higher latitudes.

An additional pattern examined by Doswald et al. (2009) was the degree of range overlap between the current and projected breeding and non-breeding ranges. These values were found to be highly variable among species with an overlap of 33% and 36% on average for breeding and non-breeding ranges, respectively. Regions of overlap can be seen as important transition zones, allowing populations to persist within their historical ranges, thus providing valuable time for species to respond to changing climatic conditions. They also found that the degree of overlap was correlated with range size, thus range-shift gaps (*sensu* Colwell et al. 2008) are more likely for species with narrow distributions. In addition, range size has been found to be strongly correlated with dispersal ability in *Sylvia* warblers (Böhning-Gaese et al. 2006). In total, current evidence suggests migratory birds with widespread ranges are in a better position geographically to respond to climate change.

Doswald et al. (2009) expands the application of climate envelope models by quantifying the potential affects of climate change on migration strategies. If the projected increases cannot be bridged for long-distance migrants due to physiological or other limitations or if the climatic niche associated with the breeding or non-breeding ranges no longer exists (Williams et al. 2007), new migration strategies will have to be developed, in many cases quite rapidly, for these species to persist. When considered under the context of other pressures that these species are likely to face, particularly from land-use change within their breeding and non-breeding ranges (Jetz et al. 2007), long-distance migrants are at particular threat of population decline and extinction.

Climate envelope models remain problematic with many untested assumptions (Pearson & Dawson 2003). However, evidence for accelerating climate change (Beaumont et al. 2008) hastens the need to build and apply models that can generate predictions that are geographically accurate and ecologically comprehensive. Migration strategy is one of the many biological factors that need to be incorporated into these models before we will have a truly robust and defensible representation of the consequences of climate change for biodiversity. Until them, we are likely to remain passive observes not grasping the full biological implications of climate change until they have been fully manifested.

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