COMMENTARY

How migratory birds might have tracked past climate change

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Organisms' responses to past climatic extremes provide a useful perspective for understanding the impacts of ongoing and increasingly rapid climate change. Volant organisms can disperse long distances, allowing them to find and colonize new habitats during periods of change. However, the ability to move long distances does not necessarily imply increased responsiveness or resiliency to change. For example, long-distance migratory songbirds rely on innate genetic programs that may lack evolutionary flexibility, making it more challenging to track rapid environmental change (1). The responses of migratory birds to historical climatic extremes, such as those of the Last Glacial Period, provide important context for the current challenges facing the natural world. In PNAS, Thorup et al. (2) show that a bird species could have maintained migratory behavior through the last 120,000 y, and that a migratory lifestyle might have been key to adapting to climatic shifts without suffering population declines.

During the Last Glacial Maximum (21,000 y before present), ice covered large extents of the present-day breeding ranges of bird species that breed in the Northern Hemisphere during the boreal summer, including that of the red-backed shrike (*Lanius collurio*). Red-backed shrikes are birds of open habitats with scattered woody vegetation and hunt insects and other small animals, often impaling their prey on twigs, thorns, or wire. Today, the birds breed across western Eurasia and leave the Northern Hemisphere in the boreal winter; Thorup et al. (2) tracked individuals from breeding grounds in Scandinavia to nonbreeding grounds in southern Africa. At the Last Glacial Maximum, areas that, today, host suitable habitat would have been inhospitable for shrikes, and the species would have been almost or entirely absent

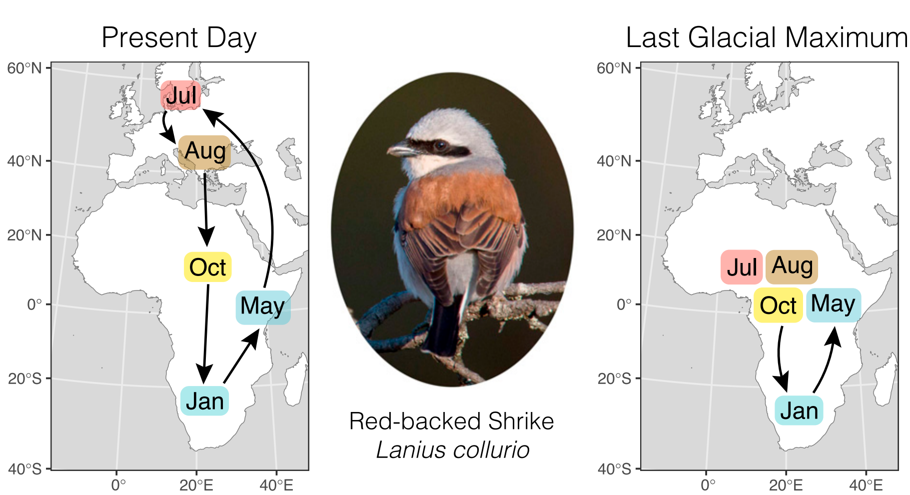

Fig. 1. Present-day and predicted historical migration routes of the red-backed shrike. Red-backed shrikes migrate from Eurasian breeding grounds to southern African nonbreeding grounds, undertaking a complex loop migration route. Thorup et al. (2) show that this species could have maintained a migratory lifestyle for the last 120,000 y. In times of glaciation, shrikes could have bred in central Africa and migrated to southern Africa during the nonbreeding season. Red-backed shrike photo courtesy of Ian Davies.

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from its current European breeding range. Forced south by ice, migratory shrikes could have responded in two ways. First, they could have switched to a sedentary strategy, occupying warm tropical regions year-round instead of undertaking seasonal migrations. Alternatively, they could have maintained migration while shifting their range in step with changing climate. To date, there is evidence to support both strategies in bird species across the globe (3–5). Thorup et al. (2) show support for the latter hypothesis: Shrikes could have maintained migration not only through the Last Glacial Maximum but through 120,000 y before present. When Europe was ice bound, red-backed shrikes could have bred in northern Africa and migrated to southern Africa for the winter (Fig. 1). As the climate subsequently warmed, they could have shifted their breeding range north while still migrating to nonbreeding quarters in southern Africa.

To reach their conclusions, the authors (2) used dynamic seasonal models, which predict a species' distribution through the entirety of the annual cycle. The authors trained their models with location data from tracked individual birds. Then, they applied their models to paleoclimatic simulations to determine what shrikes' distributions might have looked like in the past, assuming they occupied similar seasonal niches as they do today. To compare historical distributions to population trends, they estimated historical effective population sizes with genomic data. They supported their conclusions with data from a second species, the thrush nightingale (*Luscinia* luscinia). Like red-backed shrikes, thrush nightingales eat mostly insects and migrate between Eurasia and southern Africa. Dynamic seasonal modeling suggests that thrush nightingales also maintained migration during the Last Glacial Period, although the predicted range shifts were less dramatic than in the red-backed shrike.

The research (2) highlights that seasonal migration is much more than a simple commute between a breeding territory and a nonbreeding area. The recent proliferation of miniaturized tracking devices has revealed numerous complexities in birds' migratory routes, such as asymmetric "loop migrations," in which individuals use different routes in spring and fall (6). In red-backed shrikes, autumn migrants from Europe cross the Sahara and make an extended stop in the eastern Sahel before continuing to southern Africa for most of the winter. In the spring, they take a more easterly route, stopping in eastern Africa before looping north through the Arabian Peninsula toward European breeding grounds (7). This present-day loop migration appears to be innately controlled by the birds' annual cycle and may be linked to resource availability or prevailing wind patterns (8). The results from Thorup et al. (2) suggest that looped migration routes could represent an ancient behavioral paradigm.

Current climate change has been linked to population declines in migratory bird species across the globe (9–11), and North America alone has lost nearly 3 billion birds in the last half-century (9). The proximate mechanisms for population declines in migratory species include phenological mismatch, changing habitats, and even extreme weather. Unlike those of the present day, Thorup et al. (2) find that the climate extremes of the past may not have been associated with population fluctuations in migratory red-backed shrikes. In fact, their results suggest that shrike populations were robust at the Last Glacial Maximum. These results represent encouraging evidence that migratory birds—and migrations themselves—can survive, and even thrive, through climatic extremes. However, it is important to note that ongoing climate change is advancing more rapidly than even the most extreme climatic shifts observed through the Last Glacial Maximum (12).

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Whether migratory organisms will be able to keep pace with current and future climate change is a topic of active debate. A key question is whether migratory birds can rapidly evolve changes in their innate migratory programs. Foundational research with Eurasian blackcaps (*Sylvia atricapilla*) in the 1990s demonstrated that migratory birds can change migration behavior in only a handful of generations (13). Blackcaps in the wild have increasingly adopted a novel migratory route, migrating north from Europe to spend the winter in the British Isles instead of flying south to the Mediterranean. These shifts are linked to climate change and supplementary bird feeding (14). Numerous other bird species are changing, shortening, or even ceasing migration altogether, including hummingbirds in North America (15) and Richard's pipits in Eurasia (16). The advancing phenology of migration in response to warming springs has been well documented globally (1, 17). Many climate-induced changes in bird migration are the result of phenotypic plasticity, but increasing evidence also supports a role of microevolutionary change in birds' innate migratory programs (18).

Thorup et al. (2) find that the breeding range of the red-backed shrike could have shifted over 20° north in a period of only 6,000 y (12,000 to 18,000 y before present), as the climate rapidly warmed. These results underscore the dynamism of habitat distributions during periods of climatic change and provide a stark reminder about the present: The ranges organisms occupy today will not be the ranges they occupy 50 y from now. Long-distance migrants like red-backed shrikes may have the capacity to undertake dramatic shifts in distribution, but sufficient natural habitat must exist for these species to occupy. For shrikes, availability of suitable habitat in northern Africa may have been key to their success during the Last Glacial Period. This reminds us that it is crucial to conserve and protect not only the present-day habitats of threatened species but also the areas that may become suitable habitats in the future. Of particular importance is conserving areas that will act as future corridors and refugia, to allow organisms to disperse and survive in a changed climate (19). Thorup et al. (2) provide evidence that migration in red-backed shrikes is not a transitory phenomenon associated with interglacial periods but an ancient adaptation to seasonality (20)—and something well worth protecting.

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