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Alex E. Jahn
National Zoological Park & Indiana University, alexjahn@iu.edu

Susannah B. Lerman
USDA Forest Service Northern Research Station

Laura M. Phillips
Denali National Park and Preserve

Thomas B. Ryder
National Zoological Park

Emily J. Williams
Denali National Park and Preserve

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First tracking of individual American Robins (*Turdus migratorius*) across seasons

Alex E. Jahn,[1,4]* Susannah B. Lerman,[2] Laura M. Phillips,[3] Thomas B. Ryder,[1] and Emily J. Williams[3]

ABSTRACT—The American Robin (*Turdus migratorius*) is one of the most widespread, common bird species in North America; yet, very little is known about its migratory connectivity, migration timing, and migratory routes. Using archival GPS tags, we tracked the movements of 7 individual robins from 3 breeding populations in the United States. Four robins captured in Denali National Park and Preserve, Alaska, overwintered in Texas, Nebraska, Oklahoma, and Montana, up to 4,500 km from the capture location. One robin captured in Amherst, Massachusetts, overwintered in South Carolina 1,210 km from the capture location, whereas 2 robins captured in Washington, D.C., spent the entire year within 6 km of their original capture location. Understanding the annual cycle and differences in migration strategies for a species that exhibits large regional variation in movement has the potential to provide novel insights into how conspecific populations respond to current and future heterogeneity in climate and habitat. The region-specific patterns presented here suggest robins could serve as sentinels of environmental change at a continental scale. *Received 24 July 2018. Accepted 21 September 2018.*

Key words: Alaska, annual cycle, Massachusetts, migration, Washington D.C.

Primer rastreo de *Turdus migratorius* entre temporadas

RESUMEN (Spanish)—*Turdus migratorius* es una de las especies de aves más comunes en América del Norte; sin embargo, se sabe muy poco acerca de la conectividad migratoria de sus poblaciones, la fenología de su migración y sus rutas migratorias. Usando rastreadores por GPS seguimos los movimientos de 7 *Turdus migratorius* de 3 poblaciones en los Estados Unidos. Cuatro individuos capturados en el Parque Nacional y Reserva Denali, Alaska, pasaron el invierno en Texas, Nebraska, Oklahoma y Montana, hasta 4.500 km del lugar de su captura. Un individuo capturado en Amherst, Massachusetts, pasó el invierno en Carolina del Sur a 1.210 km de donde fue capturado, mientras que 2 individuos capturados en Washington, D.C. pasaron todo el año dentro de un radio de 6 km de donde fueron capturados. Comprender el ciclo anual y las diferentes estrategias de migración para una especie que exhibe gran variación regional en sus movimientos tiene el potencial de proporcionar nueva información sobre cómo diferentes poblaciones responden a la heterogeneidad actual y futura del clima y el hábitat. Los patrones regionales presentados aquí sugieren que *Turdus migratorius* podría servir como centinela del cambio ambiental a escala continental.

Palabras clave: Alaska, ciclo anual, Massachusetts, migración, Washington D.C.

The number of studies on the annual cycle of migratory birds is rapidly growing, in large part driven by recent rapid advances in the miniaturization of tracking technologies (reviewed by Kays et al. 2015, López-López 2016). To date, however, the annual cycles of even the most common bird species on the planet are still poorly known, in large part because much research is focused on the breeding season (Marra et al. 2015). Such is the case for the American Robin (*Turdus migratorius*), one of the most widespread of North American birds.

Previous research on the migration of American Robins has been primarily based on observational data and band recoveries (reviewed by Vanderhoff et al. 2016), with no information currently available on individual-level migration timing or migration routes. Additionally, we lack basic data on continental-scale migratory connectivity for American Robin populations that breed from northern Canada to southern Mexico (Vanderhoff et al. 2016). American Robins are absent across most of Canada and much of Alaska during winter, but overwinter in southern Alaska, southernmost Canada, much of the continental United States, northern Mexico, and the western Caribbean (Vanderhoff et al. 2016). Other populations, such as those that breed in southern Mexico and in Baja California Sur, apparently do not migrate (Vanderhoff et al. 2016). The migratory status of other populations within North America where the

[1] Smithsonian Conservation Biology Institute, Migratory Bird Center, National Zoological Park, Washington, DC, USA
[2] USDA Forest Service Northern Research Station, Amherst, MA, USA
[3] Denali National Park and Preserve, Denali National Park, AK, USA
[4] Current address: Environmental Resilience Institute, Indiana University, Bloomington, IN, USA
* Corresponding author: alexjahn@iu.edu

species is observed throughout the year (e.g., the mid-Atlantic states) remains unclear.

As part of a larger project on the annual cycle of species in the genus *Turdus*, we attached archival GPS tags to American Robins (hereafter, "robins") at 3 study sites within the United States to describe overall movement patterns of this species and generate hypotheses to test in future studies. Here, we describe preliminary results of the movements and wintering localities of 7 robins tagged in 2017, representing the first description of regional connectivity and latitudinal variation in seasonal movements of individual robins.

Methods

We studied robins in and near Amherst, Massachusetts (MA), along the first 4.8 km of the Denali Park Road in Denali National Park and Preserve, Alaska (AK), and at Montrose Park, Washington, D.C. (DC). We captured robins from May to July 2017 using polyester or nylon mist nets (3 × 12 m, 60 mm mesh) at sites where we saw robins foraging or nesting. Capture sites were often in backyards in semi-urban environments (i.e., MA), urban parks (i.e., DC), and rural semi-developed areas around roads and buildings (i.e., AK).

Upon capturing a robin, we held it in a soft cotton bag and banded it using a USGS numbered band and up to 3 color bands. We aged and sexed each bird based on presence of juvenile plumage, a brood patch, or cloacal protuberance (Pyle 1997). We also measured mass and unflattened wing chord, and attached a PinPoint-10 GPS archival tag (Lotek Wireless, Newmarket, Ontario) using a leg-loop harness made from Filament Kevlar (500 tex; Saunders Thread, Gastonia, North Carolina). The combined mass of the tag and harness was 1.3 g and represented no more than 2% the weight of the robins on which they were deployed (range = 1.5–2.0%). We only attached tags to breeding robins (i.e., determined by presence of a brood patch or cloacal protuberance), to increase the chance of recapture. We tagged 11 males and 3 females in MA, 12 males in AK, and 1 male and 4 females in DC. We recaptured birds during spring of 2018.

We analyzed data using program R (R Core Team 2017) to calculate great circle distances between fixes. According to Lotek Wireless, PinPoint-10 model tags can take a maximum of 130 fixes when enabled with the 'Swift fixes' program; however, the majority of tags we deployed only allowed a maximum of 20 fixes.

Results

We recovered tags from 7 robins during spring/summer 2018. None of the birds appeared to have experienced negative effects from the tag (e.g., no lesions on the skin). Most birds were recaptured near (i.e., <300 m) their original capture location, except for 2 robins in AK that were recaptured 2.0 and 3.6 km from their original capture locations.

A female captured in Amherst, MA, on 13 July 2017 was still in Amherst on 3 November 2017. The next fix was taken on 23 November 2017 at Manchester State Forest, Sumter County, South Carolina (Fig. 1). Four more fixes were taken in central South Carolina, the last being on 11 February 2018, 1,210 km from the capture location. That female was recaptured on 7 June 2018.

Four males were captured in AK between 4 May and 24 June 2017. All 4 migrated through western Canada (eastern British Columbia and Alberta) in mid-September, and were in southern Alberta, Saskatchewan, and the northern United States (Montana and North Dakota) in early October (Fig. 1). The last fix of a male captured on 4 May 2017 was in Roberts County, northern Texas, on 17 January 2018, 4,480 km from the capture location (Fig. 1). That male was recaptured on 17 May 2018. The last fix of a second male captured on 31 May 2017 was in Rosebud County, eastern Montana, on 8 December 2017, 3,259 km from the capture location (Fig. 1). That male was recaptured on 15 May 2018. The last fix of a third male captured on 24 June 2017 was taken on 18 November 2017 in Holt County, northeastern Nebraska, 3,959 km from the capture location (Fig. 1). That male was recaptured on 29 May 2018. The last fix of a fourth male captured on 24 June 2017 was in western Oklahoma on 6 February 2018, 4,508 km from the capture location (Fig. 1). That male was recaptured on 22 May 2018.

A female and male captured on 2 July 2017 in DC were among the robins on which a Swift-

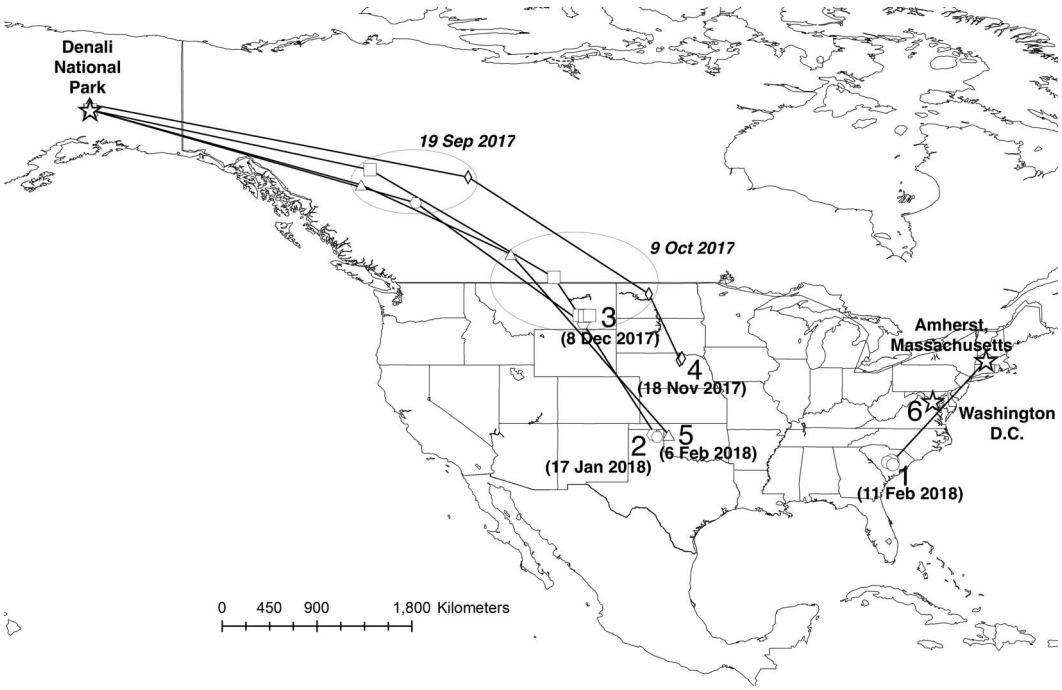

Figure 1. Map of American Robin capture localities (stars), fall migratory routes, and wintering localities. Ellipses denote groups of fixes taken during migration, with the date on which fixes were taken in italics. Numbers represent each robin's wintering locality (with 2 nonmigratory robins in Washington, D.C.): (1) South Carolina, (2) Texas, (3) Montana, (4) Nebraska, (5) Oklahoma, (6) Washington, D.C. The date of the last fix taken for each migratory robin is denoted within parentheses.

enabled tag was deployed, with 65 fixes received for the male and 70 fixes received for the female. The majority of fixes throughout the year for both birds were from the vicinity of the neighborhood of Georgetown (Fig. 1). The farthest the female traveled from the capture location was 4.6 km on 18 September 2017. The last date a fix was received from her tag was 3 April 2018 and the bird was recaptured on 4 May 2018. The farthest the male traveled from the capture location was 6.0 km on 24 November 2017 and the last date a fix was received from his tag was 16 March 2018. That male was recaptured on 12 May 2018.

Discussion

We found that substantial variation exists in the timing and distance of fall movements among populations of American Robins distributed across the continent. Although further research is needed for a comprehensive evaluation of the movements of the populations sampled, these results suggest that robins across North America face a wide range of selective pressures molding their movement strategies. Robins tagged in AK migrated in fall over 3.5 times the distance of the robin we tagged in MA, whereas 2 robins tagged in DC spent the entire year within a few kilometers of the capture location. The robin from MA did not migrate until November, whereas the AK robins were well to the southeast of the capture location by September.

Such high variation in migration timing and distance among populations suggests that ecological, behavioral, and physiological comparisons among robin populations could lead to novel insights into the challenges to survival facing different migratory and nonmigratory bird populations under rapidly changing conditions. For example, some models predict that birds that migrate shorter distances are at lower risk to climate change than those that migrate longer distances (Jones and Cresswell 2010). Evaluating the relationship between movement strategies and molt timing (Barta et al. 2008), demography (age

and sex), physiology (e.g., energetic condition; Peig and Green 2009), and survival (e.g., with mark–recapture models; Hostetler et al. 2015) offers novel insights into the challenges facing migratory birds, which are increasingly affected by rapid global change (e.g., Both et al. 2006, Wilcove and Wikelski 2008, Jones and Cresswell 2010). The American Robin's high abundance, use of a variety of habitat types, and large range suggest that it could serve as an ideal model organism for studying how migratory songbirds are coping with rapid and widespread changes to their environment.

Notably, fall migration timing of the 4 robins from AK was very similar, with all 4 located in western Canada in mid-September and in the northern Great Plains in early October. Correctly timing migration is important for acquiring adequate food resources, and failing to do so has the potential to lead to population declines (e.g., Both et al. 2006). A promising direction for future research on robin movements is to understand the amount of variation in migration timing within and among populations. Additionally, collecting movement data on individual robins over multiple years will be key to understanding the plasticity of their migratory behavior. Combining such movement data with population genomics and environmental data offers a unique opportunity to understand if and how migratory bird populations are adapting to rapid environmental changes (Bay et al. 2018).

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