Drought in Africa Caused Delayed Arrival of European Songbirds

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Advancement in phenological events such as spring arrival of songbirds at their breeding grounds is well documented (*1*). Despite this, the arrival in 2011 at northern European breeding grounds of several trans-Saharan migratory bird species was among the latest documented since 1950 (Fig. 1A). Local nonbreeding conditions can affect subsequent life-cycle stages at the level of individual birds (*2*). Here, we confirm this by showing a link of causality between the drought at the Horn of Africa (*3*) and the migratory behavior of individual birds resulting in subsequent delayed arrival at breeding grounds thousands of km away.

Photoperiod (*4*) and local environmental conditions (*5*) control timing of life-history events in migratory animals. Timing may also be affected by events during migration, e.g., on stopover sites. We followed individual movements of two long-distance migratory songbird species [18 red-backed shrikes (RS) and eight thrush nightingales (TN)] during three consecutive annual cycles (2009 to 2012) by miniature light-level geolocators (*6*) with the purpose of assessing the impacts of environmental conditions at different life-history stages. Breeding area arrival was documented by using 63 years of monitoring data and related to en route conditions by using remote-sensing data (31-year vegetation index series).

The exceptional 2011 delay in spring arrival could be traced back to a significant prolongation of stopover time during northward migration at the Horn of Africa, which was at that time affected by extreme drought (Fig. 1C). Mean stopover time in this region was longer during the drought year 2011 (18 days, SE = 1.72, n = 5 for RS and 29 days, SE = 4, n = 3 for TN) compared with the mean stopover time for the adjoining years, 2010 and 2012, combined (9 days, SE = 0.90, n = 13 for RS and 21 days, SE = 5, n = 5 for TN). This carried over to a corresponding delay in spring arrival and breeding start in Europe (Fig. 1A and fig. S1) even apparent at the individual level (two individuals tracked during two consecutive years; supplementary materials). There was no significant difference in the timing of migration between 2010/2012 and 2011 up to the spring stopover period in northeast Africa.

The extent of the catastrophic drought (*3*) at the refueling area (*6*) is illustrated by vegetation indices (Fig. 1C and fig. S2). The drought probably caused food shortage, which slowed down refueling rate and increased time needed to reach the necessary fuel loads. Other southeast African migrants were also delayed, whereas species not relying on the Horn of Africa for refueling were not (table S1). Thus, this demonstrates cross-season interactions in individual migratory animals (*2*).

Advances in tracking technology currently revolutionize migration research. Our results elucidate how new technology helps establish a direct link between local climate during migration and arrival/breeding conditions. Still, improvements in small-animal tracking are required to provide better precision globally (*7*).

Migration delay may have cascading effects on breeding success, mortality, and timing of later life-history stages. Start of breeding of RS was delayed in 2011, but population sizes and reproductive success were reported to be close to average (supplementary materials). However, the implications of our results are that even very local stopover conditions during short time periods have crucial importance for the entire migration system, emphasizing the challenges in conserving migration routes and systems (*8*).

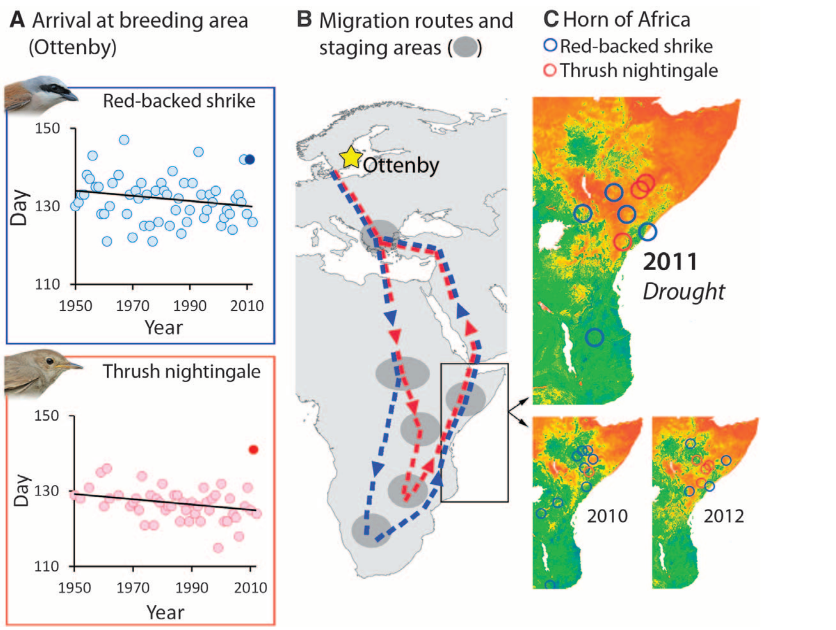

Fig. 1. (**A**) Trends in first-arrival day of RS and TN at Ottenby, Sweden, during 1950 to 2012 (solid dots are 2011 arrivals). (**B**) Migration revealed by year-round tracking of individuals during 2009 to 2012. (**C**) Horn of Africa staging positions of individual RS (blue; n = 9 in 2010, n = 5 in 2011, n = 4 in 2012) and TN (red; n = 1 in 2010, n = 3 in 2011, n = 4 in 2012). Background maps show eMODIS normalized difference vegetation index (NDVI) (15 to 30 April); color range (red to green) indicates increasing presence of green vegetation. The difference in number of northeast African staging days between 2010/12 and 2011 was significant for both species combined (P = 0.006, n = 26) as well as RS alone (P < 0.002, n = 18), but not the small sample of TN (P = 0.46, n = 8; Kruskal-Wallis).

References and Notes

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Supplementary Materials

www.sciencemag.org/cgi/content/full/338/6112/1307/DC1
Materials and Methods
Supplementary Text
Figs. S1 and S2
Table S1
References (*9–17*)

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