Spring Migration Timing of Grasshopper Sparrows in Central Pennsylvania as Estimated from eBird Records and Two Nocturnal Flight Call Stations

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Abstract

Most of our knowledge regarding the migration timing of passerines comes from diurnal observations, even though much of the actual migration occurs at night. Global climate change is expected to advance the spring arrival of many migrant bird species, but documenting these changes requires knowledge of current migration phenology. This goal may be especially challenging in species, like Grasshopper Sparrow (*Ammodramus savannarum*), that are relatively cryptic and non-vocal following spring arrival on the breeding grounds. Nocturnal flight call monitoring, however, is a promising research method to elucidate the migration timing of such species by documenting their nighttime vocalizations made during spring migration. Here we compare spring observations from nocturnal audio recordings (April and May, 2018) to primarily diurnal eBird observations in central Pennsylvania (Centre and Union Counties, April and May, 2008-2018). We detected a minimum of 79 Grasshopper Sparrow nocturnal flight calls over this two month period, and the earliest detection occurred on 12 April. The pattern of our nocturnal flight call detections contrasts sharply with the largely diurnal observations submitted to eBird. Most noticeably, we documented a mid-April surge of Grasshopper Sparrow nocturnal flight activity that was largely absent from observations submitted to eBird. Grasshopper Sparrows were most frequently reported on eBird checklists during the last week of May, but our data suggested that spring arrival likely peaked during the first week of May. Our results caution against using diurnal birding data as the sole source of information regarding spring migration phenology, and underscore the benefit of integrating nocturnal flight call monitoring into investigations of climate-induced changes to movement behavior.

Introduction

Advances in the timing of spring migration have been reported for many bird species in connection with anthropogenic climate change (Knudsen et al. 2011; Gill et al. 2014). These migrant populations are potentially vulnerable to ecological mismatches, where peak resource availability no longer matches the peak in arrival or breeding dates of these populations (Jones and Cresswell 2010). Before we can detect advances in migration timing and assess the vulnerability of migrant populations to these mismatches, however, we must have good baseline estimates of arrival dates. Simply detecting the earliest spring arrivals can be challenging, and thus present a challenge to establishing such baselines. Vocalization rates tend to increase with the local density of conspecific competitors, so we would expect lower vocalization rates for the earliest arrivals compared to later arrivals, and vocalization rates of songbirds account for a large amount of variation in detection probability during avian surveys (Farnsworth et al. 2002). This is especially true for grassland sparrows and other relatively cryptic and less-vocal species, which can be difficult to detect when not singing (Tryjanowski and Sparks 2001; Diefenbach et al. 2003).

The Grasshopper Sparrow (*Ammodramus savannarum*) is an example of a bird species that can be difficult to detect when males are not singing, and female sparrows are rarely detected at all (Hill 2012). The Birds of North America account (Vickery et al. 1996) describes the species as so secretive that fall migration timing is largely unknown; during spring migration, the earliest males are thought to arrive on the breeding grounds in early-mid April (e.g., Missouri) to late April (e.g., Ohio). The bulk of spring migrants

Grasshopper Sparrow on former strip mine land on Strip Rd., Cambria 16 July 2019. (Laura Palmer)

likely appear a week or two later in May, and females arrive a week after that peak (Vickery et al. 1996). These estimates largely stem from diurnal anecdotal observations and typical birding data, and do not likely include nocturnal observations of this species (e.g., from nocturnal flight call monitoring or carcass recovery from buildings and energy infrastructure).

Alternative evidence about spring migration timing of Grasshopper Sparrows comes from a recently published light-level geolocator study that sought to monitor fall migration routes and timing and migratory connectivity in six populations of Grasshopper Sparrows across the eastern and central United States (Hill and Renfrew 2019). Some of the geolocators continued to function into the spring migration period, and 12 male sparrows commenced spring migration in early March (mean = 8 March, range = 15 January to 30 March). Three male sparrows arrived on their breeding grounds in Kansas ($n = 2$) and Wisconsin ($n = 1$) with functioning geolocators on 17 April, 20 April or 2 May. If we assume that these three males are representative of adult Grasshopper Sparrows, then these data suggest that most male sparrows arrive substantially earlier than estimated in Vickery et al. (1996) from diurnal observations. This finding is understandable, given that male Grasshopper Sparrows typically start singing in early May in Pennsylvania; before then, they are infrequently detected as they spend most of their time on the ground concealed in grassland vegetation (J. Hill personal observation).

Given the challenges of detecting Grasshopper Sparrows when not singing, nocturnal flight calls may be a more efficient method of detecting Grasshopper Sparrow arrival on the breeding grounds in spring (Evans and Mellinger 1999). Like most other grassland passerine species in the region, Grasshopper Sparrows are primarily nocturnal migrants that are highly vocal during night flight, with distinct call notes (Vickery et al. 1996). For some species, the timing of ground observations (e.g., from banding operations) during migration closely match nocturnal flight call detections (Sanders and Mennill 2014), but this is unlikely the case for Grasshopper Sparrows. In Texas, nocturnal flight call monitoring detected large numbers of Grasshopper Sparrows, but this species was not captured during simultaneous, nearby banding efforts (Evans and Rosenberg 2000). Based on the results of Hill and Renfew (2019), we would expect central Pennsylvania nocturnal flight call stations to begin regularly detecting Grasshopper Sparrows in mid-April: two weeks before birders generally begin

regularly detecting them in the region in late April. Grasshopper Sparrows are a conservation priority species in the state and much of their range (Vickery et al. 1996), and identifying the timing of their arrival on the breeding grounds could lead to changes in grassland management during this period.

Methods

Two stations were established to monitor nocturnal flight calls in residential communities in central Pennsylvania: near State College, Centre County (~40.7989°N, -77.8761°W) and in Lewisburg, Union County (~40.9657°N, -76.8803°W). Both stations were in typical suburban landscapes, and neither one was located in grassland habitat. Recordings were conducted all night--from astronomical dusk to astronomical twilight--every night through the months of April and May in 2018.

OldBird 21c microphones were connected to ThinkPad (Lenovo Group Limited) laptops and set to automatically record each night. OldBird Tseep-r software was used to extract high pitched noises from the microphones and to save as short .wav files. These files were browsed with the OldBird GlassOFire program which created small spectrograms for each snippet. Compared to a trained human observer, the software may miss a greater frequency of soft calls. However, it usually takes less than 20 minutes to identify Grasshopper Sparrow calls from a collection of extracts from an overnight recording compared to the 5 hours (late May) to 8 hours (early April) a human observer would spend in real time listening to full length recordings or live observation from astronomical dusk to astronomical dawn.

A single observer (author JG) learned to identify Grasshopper Sparrow calls based on spectrograms provided in O'Brien and Evans (2002) and from consultation with other nocturnal flight call enthusiasts. O'Brien and Evans (2002) list Seaside (*Ammospiza maritimus*), Bairds (*Centronyx bairdii*), and Saltmarsh Sparrows (*Ammospiza caudacuta*) as species with similar nocturnal flight call spectrograms, however, these species are extremely unlikely to occur in central Pennsylvania. Based on eBird records reviewed in June 2019, only Seaside Sparrow has been confirmed in Pennsylvania during April and May, and these detections were in southeast Pennsylvania. Author JG used a conservative approach to identify the nocturnal flight calls of Grasshopper Sparrows--some lower quality detections that might have been this species--were omitted. For some insight into identification quality, an eBird media search for Grasshopper Sparrow audio files uploaded from sites in Pennsylvania for observation dates in April-May of 2018 can be skimmed through--all the extremely short audio files are part of the analysis here. No Grasshopper Sparrows were detected repeatedly chirping many times in quick succession--it seemed based on timing that there were at most two calls per bird, and usually only one bird passing at a time giving just one detected call. Call counts from both stations were combined for analysis of migration timing.

For comparison to diurnal birding, we downloaded eBird frequency data for Centre and Union Counties from 2008-2018, April and May. These eBird data provide the number of complete checklists and the proportion of these checklists reporting Grasshopper Sparrow in these counties. Complete checklists include "traveling" and "stationary" eBird protocol data where observers indicated that they noted all species that they had identified during the count period. Nocturnal flight call protocol data is not included in the bar charts. eBird bar chart data is aggregated by "weeks" with the 29th through the 31st of any month included in week four. Again, both counties' data were combined for analysis.

Results

Across the two stations, we detected 79 nocturnal flight calls of Grasshopper Sparrows. At the Lewisburg station, the earliest detection dates were April 12th, two more calls from the 13th, and seven more calls from the 14th. In State College, Grasshopper Sparrow nocturnal flight calls were first detected during April 13-14. Overall, 34% of flight call detections occurred in April. Grasshopper Sparrow flight call detections continued through the final week of May. Overall, the trend in nocturnal flight calls was indicative of a mass arrival of Grasshopper Sparrow in the region starting mid-April and then a peak migration in the first week of May, steadily declining thereafter (Figure 1).

In the April-May eBird data consisting of 15,754 complete checklists, Grasshopper Sparrow were rarely reported in the first week (one checklist), second week (three checklists), and third week (four checklists). Thereafter in late April and throughout May, Grasshopper Sparrow reports increased dramatically (Figure 2).

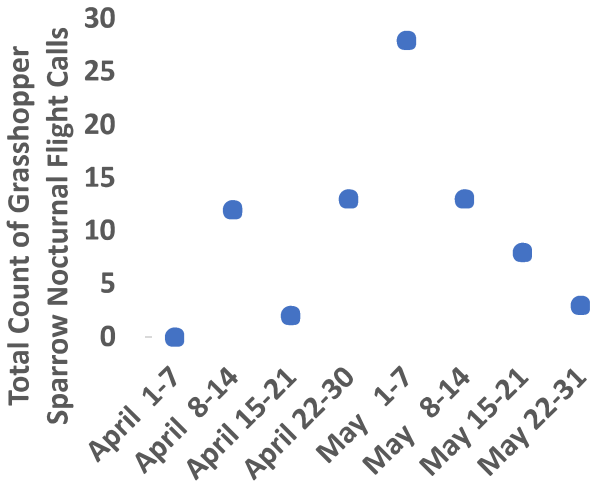

Figure 1. Total number of nocturnal flight call detections for Grasshopper Sparrows monitored at two nocturnal recording stations in Central Pennsylvania between astronomical dusk and astronomical dawn in April and May of 2018. (Note that data are aggregated into "weeks" to be comparable to eBird summary data, where the final "week" of the month is longer than 7 days.)

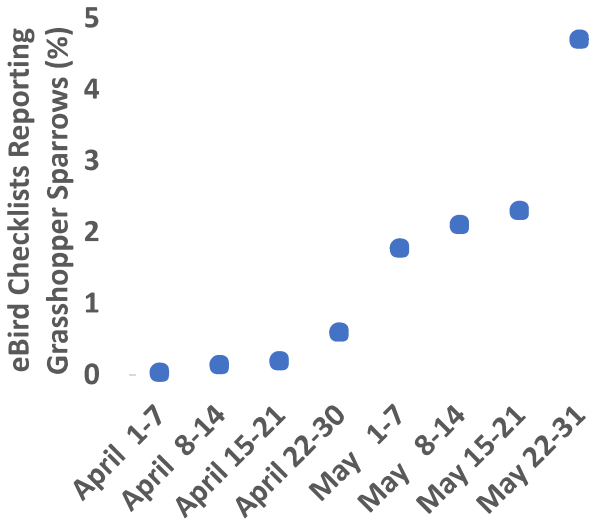

Figure 2. Proportion of complete traveling or stationary protocol eBird checklists from Union and Centre Counties, Pennsylvania, reporting Grasshopper Sparrows in April and May of 2008-2018. (Note that the final "week" of each month is longer than 7 days.)

Discussion

During spring migration, we detected substantial numbers of Grasshopper Sparrow via nocturnal flight calls, before this species was regularly detected in eBird checklists. If both datasets had recorded the timing of migration equally well, then we would have expected similar estimates to the timing of passage through Central Pennsylvania (Figures 1-2). Both datasets were generally consistent with the literature review by Vickery et al. (1996), which estimated that most Grasshopper Sparrows arrived on the breeding grounds in May, with fewer individuals arriving in late April. Our nocturnal flight call dataset, however, strongly suggested that about 15% of Grasshopper Sparrows arrived in the first half of April, with a migration peak in early May. An early, somewhat cryptic migration of Grasshopper Sparrow is consistent with the geolocator data collected by Hill and Renfrew (2019). Together, these converging lines of evidence suggest that Grasshopper Sparrows likely arrive in Central Pennsylvania at least several weeks before they are regularly detected by birders. Several more years of monitoring during spring migration would help to determine how much these dates vary between years. For example, in 2019 at a monitoring station on Isle of Que in Snyder County (12 miles south of the Lewisburg station), the first Grasshopper Sparrow nocturnal flight call of the spring was detected on April 7--five days prior to the earliest detection in 2018 (JG personal observation).

The early surge of migrants are likely mature males arriving in hopes of securing high-quality territories. For many passerines (e.g. Kokko et al. 2006, Coppack and Pulido 2009) and several species of sparrows (e.g. White-throated Sparrows [*Zonotrichia albicollis*], Mazerolle and Hobson, 2007; Seaside and Saltmarsh Sparrows, Borowske et al., 2016), adult males initiate migration and arrive earlier than females--a phenomenon called protandry which is generally associated with territory procurement and maximizing individual fitness (Morbey and Ydenberg 2001). Furthermore, for many passerines, older males may arrive earlier than first year individuals (Stewart et al. 2002).

If these early arriving Grasshopper Sparrows are indeed mature males eager to seek out and defend territory, why would so few be detected by diurnal birding activities upon arrival in mid-April? Do these early individuals bypass the easily accessible (to birders) hayfields of our populated valleys to land in remote, and under-surveyed, grassland habitats? Or are these Grasshopper Sparrows simply staying quiet and cryptic until the population density rises at the end of April and early May, thus finally allowing most birders to begin to detect them? Alternatively, most birders may eschew grassland habitat in April, under the false assumption that grassland birds have not yet returned. In our experience, Grasshopper Sparrows in mid-April rarely sing or perch when flushed; they fly several meters and drop to the ground (JH personal observation) which makes identification extremely difficult for most birders. During this time of year, tail shape and color (the only field marks visible from a Grasshopper Sparrow flushing low and away from you) are the best fields marks for positively identifying this species (JH personal observation).

Systematic surveys of the full suite of potential Grasshopper Sparrow habitat during April would help to refine estimates of their arrival into our region. Grasshopper Sparrows are known to use parklands (grassland-woodland mix), brushlands (≥30% woody canopy coverage), and woodlands (closed canopy with trees ≥3 m tall) during non-breeding periods (Igl and Ballard 1999)--habitat that they do not generally use for breeding (Vickery et al. 1996). Flexible habitat use during migration may be an adaptive strategy for Grasshopper Sparrows, because they typically travel only short distances (<100 km per night) during spring migration over a ~35-day period (Hill and Renfrew 2019). Extensive grasslands, suitable as breeding habitat, may not be available at an adequate spatial frequency throughout their migration corridor.

Grasshopper Sparrows have declined dramatically throughout their breeding range (~71% decline) and within Pennsylvania (~95% decline) from 1996 through 2015 (Sauer et al. 2017). These declines are likely driven by the conversion of grasslands via the intensification of agricultural practices (e.g., converting pastures to row crops; Hill et al. 2014). Habitat preservation programs (e.g., Conservation Reserve Enhancement [CRP]) are an important tool for Grasshopper Sparrow management in the U.S. and Pennsylvania (Wilson and Brittingham 2012; Hill et al. 2014). However, management practices such as burning, mowing, and discing are also commonly used in spring to improve habitat for Grasshopper Sparrows. To avoid disturbing breeding populations, these activities are frequently timed to occur in the two week window prior to the presumed arrival of Grasshopper Sparrows (Dechant et al. 2002). Our findings, and those of Hill and Renfrew (2019), suggest that these management activities may actually be occurring after some Grasshopper Sparrows have already returned to the breeding grounds. Further research and nocturnal flight call monitoring is needed to determine if the timing of these practices have unintended consequences on the settlement patterns and population dynamics of Grasshopper Sparrows and other grassland obligate bird species.

Grasshopper Sparrow in farm fields near Belleville, Mifflin 27 June 2019. (Rob Dickerson)

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Literature Cited

Borowske, A., C. Gjerdrum, and C. Elphick. 2016. Timing of migration and prebasic molt in tidal marsh sparrows with different breeding strategies: comparisons among sexes and species. The Auk 134:51-64.

Coppack, T., and F. Pulido. 2009. Proximate control and adaptive potential of protandrous migration in birds. Integrative & Comparative Biology 49:493-506.

Dechant, J.A., M.L. Sondreal, D.H. Johnson, L.D. Igl, and C.M. Goldade. 2002. Effects of management practices on grassland birds: Grasshopper Sparrow. USGS Northern Prairie Wildlife Research Center. 30 pages.

Diefenbach, D.R., D.W. Brauning, and J.A. Mattice. 2003. Variability in grassland bird counts related to observer differences and species detection rates. The Auk 120:1168-1179.

Evans, W.R., and Mellinger, D.K. 1999. Monitoring grassland birds in nocturnal migration. Studies in Avian Biology 19:219–229.

Evans W.R., and M. O'Brien. 2002. Flight Calls of Migratory Birds Eastern North American Landbirds. Old Bird Inc. http://oldbird.org/pubs/fcmb/start.htm

Evans W.R., and K.V. Rosenberg. 2000. Acoustic Monitoring of Night-Migrating Birds: A Progress Report. *In* R. Bonney, D.N. Pashley, R.J. Cooper, and L. Niles, eds. 2000. Strategies for bird conservation: The Partners in Flight planning process; Proceedings of the 3rd Partners in Flight Workshop; 1995 October 1-5; Cape May, NJ. Proceedings RMRS-P-16. Ogden, UT: U.S.Department of Agriculture, Forest Service, Rocky Mountain Research Station. Pages 151-159.

Farnsworth, G.L., K.H. Pollock, J.D. Nichols, T.R. Simons, J.E. Hines, and J.R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. The Auk 119:414-425.

Farnsworth, A. 2005. Flights calls and their value for future ornithological studies and conservation research. The Auk 122:733-746.

Gill, J.A., J.A. Alves, W.J. Sutherland, G.F. Appleton, P.M. Potts, and T.G. Gunnarsson. 2014. Why is timing of bird migration advancing when individuals are not? Proceedings of the Royal Society *B 281*:20132161.

Hill, J.M. 2012. Population Ecology of Grassland Sparrows on Reclaimed Surface Mine Grasslands in Pennsylvania. Dissertation. 187 pages. https://etda.libraries.psu.edu/files/final_submissions/7847

Hill, J.M., and R.B. Renfrew. 2019. Migratory patterns and connectivity of two North American grassland bird species. Ecology and Evolution 9:680-692.

Hill, J.M., J.F. Egan, G.E. Stauffer, and D.R. Diefenbach. 2014. Habitat availability is a more plausible explanation than insecticide acute toxicity for U.S. grassland bird species declines. PLoS One 9(5):e98064.

Igl, L.D., and B.M. Ballard. 1999. Habitat associations of migrating and overwintering grassland birds in southern Texas. The Condor 101:771-782.

Jones, T., and W. Cresswell. 2010. The phenology mismatch hypothesis: are declines of migrant birds linked to uneven global climate change? Journal of Ecology 79:98-108.

Knudsen, E., A. Linden, C. Both, N. Jonzen, F. Pulido, et al. 2011. Challenging claims in the study of migratory birds and climate change. Biological Reviews 86:928-946.

Morbey, Y.E., and R.C. Ydenberg. 2001. Protandrous arrival timing to breeding areas: a review. Ecology Letters 4:663–673.

Ruth, J.M. 2015. Status Assessment and Conservation PLan for the Grasshopper Sparrow (*Ammodramus savannarum*). Version 1.0 U.S. Fish and Wildlife Service, Lakewood, Colorado. 109 pp.

Sanders, C.E., and D.J. Mennill. 2014. Acoustic monitoring of nocturnally migrating birds accurately assesses the timing and magnitude of migration through the Great Lakes. The Condor: Ornithological Applications 116:371-383.

Sauer, J. R., D. K. Niven, J. E. Hines, D. J. Ziolkowski, Jr, K. L. Pardieck, J. E. Fallon, and W. A. Link. 2017. The North American Breeding Bird Survey, Results and Analysis 1966 - 2015. Version 2.07.2017 USGS Patuxent Wildlife Research Center, Laurel, MD. https://www.mbr pwrc.usgs.gov/bbs/trend/tf15.html

Stewart, R.L.M., C.M. Francis, and C. Massey. 2002. Age-related differential timing of spring migration within sexes in Passerines. Wilson Bulletin 114:264-271.

Tryjanowski, P., and T.H. Sparks. 2001. Is the detection of the first arrival date of migrating birds influenced by population size? A case study of the red-backed shrike *Lanius collurio*. International Journal of Biometeorology 45:217-219.

Vickery, P. D. 1996. Grasshopper Sparrow (*Ammodramus savannarum*), version 2.0. In The Birds of North America (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA.

Wilson, A.M., and M.C. Brittingham. 2012. Initial response of bird populations to conservation grasslands in southern Pennsylvania. Journal of Soil and Water Conservation 67:59-66.