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Source: Waterbirds, 45(1) : 108-112

Published By: The Waterbird Society

URL: https://doi.org/10.1675/063.045.0113

Trends in Rail Migration Arrival and Departure Times Using Long-term Citizen Science Data from Mississippi, USA

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Abstract.—Little is known of rail migration ecology, consequently limiting efforts to effectively conserve rail populations. Therefore, we investigated changes in the migratory arrival/departure dates for Virginia Rails (*Rallus limicola*), King Rails (*Rallus elegans*) and Sora (*Porzana carolina*) north of Ocean Springs, Mississippi. Using citizen science data collected over the last 25 years, we inspected summarized data for patterns of primary arrival and departure windows indicated by first or last observations of each species at the lagoons, respectively, alongside 10th/90th quantiles that controlled for outliers (i.e., early arrivals, late departures). Regression models found no differences in spring migration departures for any species. In fall migration we found a difference only in Virginia Rail arrivals, which became later over time. King Rail arrived in autumn first in mid-September (September 22nd) followed by Sora (October 5th) and Virginia Rails (October 21st). In spring migration, Virginia Rails departed first (March 19th), then King Rails (March 24th), and Sora (April 20th). Trends for King Rails may have been skewed by some individuals having non-migratory behavior. Despite limitations, citizen science efforts were useful for an initial investigation of rail migration ecology, and future applications could be used to identify and assess factors affecting migration timing (e.g., climate change, habitat availability, weather shifts). *Received 22 Jan 2021, accepted 1 Dec 2021.*

Key words.—Climate Change, Fall Migration, King Rail, Migratory Timing, Mississippi, Sora, Spring Migration, Virginia Rail.

Waterbirds 45(1): 108-112, 2022

Migration of birds is complex, featuring many static and dynamic systems (Alerstam and Hedenstrom 1998; Jenni and Kéry 2003). Environmental cues often initiate migration (e.g., temperature changes, changes in day length; Skov *et al.* 2010), but forces influencing migratory events can include internal rhythmic systems (e.g., location in time) and external stimuli (e.g., seasonal celestial observations or annual geomagnetic events; Åkesson *et al.* 2001; Liu and Chernetsov 2012). Long-distance migrations are often thought to be more "instinctual" or "genetic" while short-distance migrations can be linked to optimal foraging strategies (Jenni and Kéry 2003; Shocat *et al.* 2004), which has implications for how we might anticipate these species will adapt to climate change, and how conservation efforts might be implemented.

Secretive marsh birds (e.g., rallids, bitterns, grebes), common indicators of wetland health and quality (Cherkaoui and Hanane 2018), are one group of species especially difficult to study in terms of migratory timing because of their low detection rates and the small size of many species. Despite these challenges, rails and other marsh birds have been used as metrics of wetland restoration success (Rush *et al.* 2009). Therefore, understanding their migration ecology is critical for determining the limits of adaptability of avian populations globally in the near future amid multiple conservation challenges (e.g., habitat loss, sea level rise, climate change).

Despite their conservation importance, rail migration has been studied less than for other wetland birds such as waterfowl (e.g., ducks, geese, swans) and wading birds (e.g., herons and egrets; Cherkaoui and Hanane 2018) because of the challenges in detecting and capturing rails. Improving our understanding of rail natural history could concomitantly inform wetland management approaches and lessen conservation concerns

(Rush *et al.* 2009; Pickens and King 2013). Therefore, we investigated trends in migration timing of three rail species: Virginia Rails (*Rallus limicola*), King Rails (*Rallus elegans*) and Sora (*Porzana carolina*) in Jackson County, Mississippi, U.S.A. King Rails are unique among those three species in that some individuals are present in the area year-round, and others migrate in for the winter. Our objective for this study was to determine if the migratory dates for earliest arrivals and latest departures for Virginia Rails, King Rails and Sora have changed over 26 years of weekly counts (i.e., 1993 – 2017). We predicted that the tenth quantile of autumn arrival and spring departure of each species would shift over time, with spring departures becoming earlier, and autumn arrivals later over time.

METHODS

The study area was the West Jackson County Water Treatment Facility (henceforth, sewage lagoons) in Ocean Springs, Mississippi (30° 30′ 14.9142″N, -88° 47′ 59.0238″W). The facility used constructed wetlands with natural vegetation, sunlight, and water movement as secondary treatments to purify wastewater. These wetlands had varying vegetation structure from dense vegetation to large portions of open water providing habitat for marsh birds, with restricted public access. Mississippi Sandhill Crane National Wildlife Refuge surrounded the facility, further reducing disturbances to the wetland.

We used citizen science data, collected by members of Mississippi Coastal Audubon Society, to investigate trends in migration timing from 1993–2017 (n = 26 years). The data comprised of weekly bird surveys where a variable number of people met in early morning and walked the levees around the sewage lagoons. Members of the group did not necessarily stay together or follow a standard path or coverage of the area. All species seen or heard were recorded. Surveys were only postponed until the following week if wind speeds were > 12 km/hour or heavy rains were present. Effort was infrequently recorded, and thus we did not include effort information in our analysis. We distinguished first autumn arrivals and latest spring departures based on the relative abundance per Julian Day. We tested for changes in migratory timing over time by looking at the first and last 10th of arrivals and departures, respectively (e.g., 10th quantile for autumn migrations, 90th quantile for spring migration) in a linear regression for each season. We tested 10th/90th quantiles to account for possible outliers in the earliest arrivers and latest leavers (e.g., rogue birds arriving earlier than the population or leaving later than the population present, respectively; Horton *et al.* 2019).

RESULTS

King Rails arrived first in August, starting in mid-September (September 22nd) followed by Sora (October 5th) and Virginia Rails (October 21st; Table 1). In Spring migration Virginia Rails departed first (March 19th), then King Rails (March 24th) and Sora (April 20th). We did not find any differences in the 90th percentile of spring or autumn migration arrivals across years for any species (Fig. 1, Table 2) or in the 10th percentile of autumn migration arrivals across years for King Rail or Sora (Fig. 2, Table 2). For Virginia Rail, we found that the 10th percentile of autumn migration arrivals became later across time (Table 2).

DISCUSSION

Long term datasets provide insightful inference of past trends that can support robust predictions of future trends. The only change we found in either spring departures or autumn arrivals was for Virginia Rail autumn arrivals. Virginia Rails are arriving later, similar to the autumn migratory shift of other species (Covino *et al.* 2020). Rails are

Table 1. Earliest and latest autumn arrival and spring departure dates of three secretive marsh bird species observed during approximately weekly surveys in the West Jackson County Water Treatment Facility in Ocean Springs, MS, by Mississippi Coastal Audubon Society members 1993–2017.

	Autumn Arrival		Spring Departure	
	Earliest	Latest	Earliest	Latest
King Rail	6 July 2006	17 Dec 1994	8 Jan 2009	30 June 1999
Sora	20 Aug 2004	14 Oct 2016	27 April 1996, 2009, & 2018	4 June 2003
Virginia Rail	9 Sept 2007	4 Dec 1996	1 Feb 2018	23 May 2008

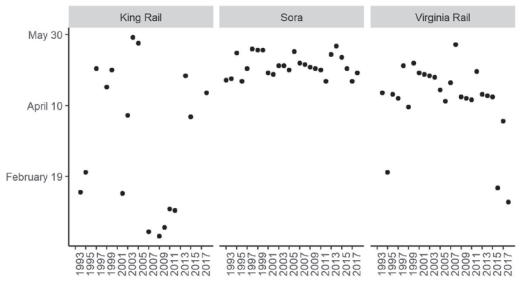


Figure 1 - Ninetieth quantile of autumn migration observations for three rails in each year from observations in Jackson County Mississippi.

short-distance migrants, which could allow them to be more responsive to local weather conditions, as well as continental climate, as opposed to long-distance migrants, who have narrower migration initiation windows to ensure safe arrival times (Brisson-Curadeau *et al.* 2020). Autumn has also been a primary season of migration phenology plasticity, especially for short-distant species which often delay autumn migration due to possible dependence on weather events (e.g., cold fronts and snowstorms; Jenni and Kéry 2003). By delaying autumn migration, Virginia Rails and other secretive marsh bird species can prolong breeding seasons and allow more time for a second or replacement brood (Jenni and Kéry 2003).

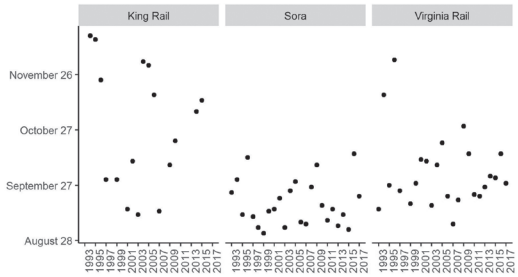
Rails' secretive nature and our small sampling area could have influenced our ability to detect changes in migratory timing (Tryjanowski et al. 2005). In addition, the dataset used was collected over many years by dedicated Mississippi Coastal Audubon Society volunteers on a weekly basis, to better document and understand the diversity of avian species using the sewage lagoons, not necessarily changes in species abundances or migration timing of rails. Because the surveys were conducted weekly, our ability to detect subtle migratory changes occurring daily were greatly limited. The survey was also designed for counting all bird species, not tailored to secretive marsh birds. Therefore, false negatives were likely (i.e., an absence of detection, when the species was actually present) and could have especially impacted our results during the beginning of autumn migration or end of spring migration when fewer individuals were present (Conway 2011). Last, King Rails have been observed as permanent, non-migratory residents at our study site which could confound discerning migration timing for this species.

Other techniques for tracking individual birds could greatly improve our understanding of migration phenology in secretive marsh birds. Call-broad cast surveys (Conway 2011) and aerial surveys for conspicuous species such as waterfowl (Hennig *et al.* 2017) have demonstrated promise for improving abundance estimate precision. Tracking individuals (e.g., color banding, VHF transmitters, GPS and other satellite-based transmitters) should also be considered, to better account for individual variation in migratory arrival/departure decisions (Hagy *et al.* 2014).

While the citizen science data used in this paper has limitations due to its weekly collection, citizen science data collection designed for a particular question can be very powerful. Through citizen science, volunteers can help answer the difficult and important questions about migration ecology in a cost-effective manner, as citizen science data is often collected at larger spatial scales then other methods (Kobori *et al.* 2016; Silvertown 2009). The data collected by citizen science projects (e.g., Breeding Bird Survey,

Table 2. Beta estimates with standard errors and p-values of the year covariate in linear models looking at the tenth quantile of autumn migration or ninetieth quantile of spring migration over a 26-year period in Jackson County Mississippi.

	Autumn			Spring		
	Beta Estimate	Std Error	P-value	Beta Estimate	Std Error	P-value
King Rail	-1.5	2.14	0.49	-1.01	2.11	0.63
Sora	-0.35	0.47	0.45	-0.17	0.68	0.8
Virginia Rail	-1.07	0.46	0.02	-0.02	0.2	0.91



Figures 2 – Tenth quantile of autumn migration observations for three rails in each year from observations in Jackson County Mississippi.

eBird) can then be used by scientists to create species distribution models (Fournier *et al.* 2017a,b), provide estimates of population size and trend (Zimmerman *et al.* 2015; Meehan *et al.* 2019), and build indexes of the integrity of urban greenspaces (Callaghan *et al.* 2019). In addition, citizen science engages and educates members of local areas who are interested and ecologically-minded. (e.g., Mississippi Coastal Audubon Society; Dickinson *et al.* 2010).

Long-term datasets are vital for understanding species responses to environmental and climate changes in addition to other factors. To be able to manage populations, including the rail species mentioned herein, we need to understand their ecology which includes drivers of population change, habitat interactions, emerging threats, and temporal shifts in requirements for survival and reproduction. Citizen science provides a valuable tool for studying the migration of many bird species, and in combination with appropriate sampling techniques can allow for a more holistic, large scale study of avian migration, a vital step to our conservation and management of birds in the face of an uncertain future.

ACKNOWLEDGEMENTS

We would like the thank Mississippi State University's College of Forest Resources' Undergraduate Research Scholars Program and the Mississippi Department of Environmental Quality for sponsoring this research. Thanks again to my parents J. C. and Amy Kitaif for all the support, as well as to my many mentors at the Department of Wildlife, Fisheries, and Aquaculture. Thanks to the Mississippi Coast Audubon Society volunteers who diligently collected these data every week at the sewage lagoons.

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