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Source: Waterbirds, 39(2) : 156-164

Published By: The Waterbird Society

URL: https://doi.org/10.1675/063.039.0206

# A Comparison of the Origins of Yellow Rails (*Coturnicops noveboracensis*) Wintering in Oklahoma and Texas, USA

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**Abstract.**—Numbers, densities, and sex ratios of Yellow Rails (*Coturnicops noveboracensis*) wintering at Red Slough Wildlife Management Area in McCurtain County, Oklahoma, USA, were approximated and compared to estimates from birds wintering in coastal Texas, USA. Deuterium (δD) and sulfur ($\delta^{34}$S) values from rectrices of birds wintering in Oklahoma and in Texas were also examined to determine where the birds bred. Yellow Rails in Oklahoma from October 2009 through April 2010 were banded. Fifty-six Yellow Rails were captured, and the population was estimated to consist of 90.3 ± 25.5 birds, or 5.3 ± 1.5 rails * $ha^{-1}$, which is similar to the published density of Yellow Rails in coastal Texas. Sex ratios did not differ from an expected 1:1 male:female ratio and did not differ between Oklahoma and Texas. Rectrices from Texas ($n = 40$) and Oklahoma ($n = 32$) had similar δD values and were broadly consistent with published δD values from southeastern Alberta to James Bay in Ontario and Quebec, Canada. The $\delta^{34}$S analysis from Texas ($n$ = 4) and Oklahoma ($n$ = 35) showed only two birds, both from Texas, with enriched $\delta^{34}$S values, suggesting that most birds from Texas and Oklahoma bred in interior Canadian marshes. Although the sample size was small, these results suggest interior overwintering sites contain similar densities to coastal sites.
*Received 26 May 2015, accepted 23 November 2015.*

**Key words.**—*Coturnicops noveboracensis*, density, deuterium, population estimate, stable isotope, sulfur, winter, Yellow Rail.

Waterbirds 39(2): 156-164, 2016

Yellow Rails (*Coturnicops noveboracensis*) are nocturnal marsh-dwelling birds that breed in North America, from Nova Scotia and New Brunswick west to Montana, Alberta and northeastern British Columbia (Bookhout 1995; Phinney 2014). There are also isolated populations in south-central Oregon and northern California (Popper and Stern 2000; Sterling 2008). They winter along the coast from Texas to North Carolina (Bookhout 1995) and have recently been discovered overwintering in southeastern Oklahoma (Butler *et al.* 2010). While there have been several studies about the biology of Yellow Rails on their breeding grounds (Bookhout and Stenzel 1987; Robert and Laporte 1999; Austin and Buhl 2013), many other aspects of their biology are poorly studied (Bookhout 1995), including the relatively few studies about their winter ecology (Bookhout 1995).

Based on specimens collected from 1903 to 1918 in Charleston County, South Carolina, Post (2008) described the wintering habitat of Yellow Rails as damp, freshwater fields, and suggested that they were often found with LeConte's Sparrows (*Ammodramus leconteii*). Butler *et al.* (2010) found that Yellow Rails overwintering in McCurtain County, Oklahoma, used damp, grassy fields dominated by *Sporobolus* sp. Post (2008) also noted that there was a female bias in specimens that were collected in South Carolina and suggested that males and females may overwinter in different habitats or at different latitudes. Butler *et al.* (2014) found that 55.9% of the Yellow Rails banded at San Bernard National Wildlife Refuge (NWR) in Brazoria County, Texas, were male, but did not suggest that there was a male bias at this location. Butler *et al.* (2014) also estimated that the population overwintering in sampled marshes consisted of 1,170 ± 300 individuals, or approximately 5.2 ± 1.3 rails/ha.

We know little about the ecology of Yellow Rails in Oklahoma, which lies at the extreme northwestern edge of the winter range. Heck and Arbour (2008) summarized published dates of occurrence for the 20th century. They reported one record from the 1960s, three records from the 1970s, no records during the 1980s and four records from the 1990s. Beginning in 2001, Oklahoma Department of Wildlife Conservation staff conducted regular rope drags to flush Yellow Rails during October and early November at Red Slough Wildlife Management Area (WMA), McCurtain County, Oklahoma. Heck and Arbour (2008) observed Yellow Rails annually from 2001-2008 during the autumn. In addition, Butler *et al.* (2010) recently documented overwintering Yellow Rails at this location. However, to date, no estimates exist of the number of rails overwintering or the sex ratios present.

Some avian species stratify by age and sex across their winter range, with young males wintering the farthest north, adult males wintering further south, young females wintering still further south, and adult females wintering the farthest south (Nolan and Ketterson 1990). Post (2008) found a female bias in Yellow Rail specimens from South Carolina, but Butler *et al.* (2014) did not find a sex-related bias in Yellow Rails from Texas.

Other avian species stratify themselves on the winter range based upon where they bred and thus exhibit strong migratory connectivity. Salomonsen (1955) and Boulet and Norris (2006) summarized four types of migration that may lead to strong migratory connectivity. Some species (e.g., Rock Sandpiper (*Calidris ptilocnemis*)) engage in a leapfrog migration, where individuals breeding further north tend to winter further south (Boland 1990). Other species, such as Red Knot (*Calidris canutus*), engage in longitudinal migration and stratify themselves along a north/south gradient, with individuals that breed further north tending to winter further north, and individuals that breed further south tending to winter further south (Piersma *et al.* 2005). Still other species engage in parallel migration and stratify themselves along an east/west gradient, with individuals from the western portion of the breeding range tending to winter in the western portion of the winter range (Norris *et al.* 2006). Finally, some subspecies of Canada Goose (*Branta canadensis*) engage in crosswise migration, with western birds wintering further east (Mowbray *et al.* 2002).

The extent of migratory connectivity in Yellow Rails has not been investigated, and it is unknown whether rails wintering in Oklahoma breed in the same region as other rail species wintering in Texas. Although records through 2015 show that 1,835 individual Yellow Rails have been captured and marked throughout Canada and the USA, there has been only a single recovery (Bird Banding Laboratory 2015). Consequently, stable isotope analysis can help clarify the extent of migratory connectivity in birds (Boulet and Norris 2006). Isotopes are elements with different numbers of neutrons in the nucleus (McMurray and Fay 1995). Isotope ratios vary across the landscape in a predictable fashion. For example, deuterium ($\delta D$) is heavier than protium (ordinary hydrogen) (McMurray and Fay 1995). This means that $\delta D$ precipitates more readily than protium (Merlivat and Jouzel 1979) and so maps of stable H isotope ratios can be derived from maps of precipitation (Bowen *et al.* 2005; Boulet and Norris 2006). Isotope ratios in an organism's tissues reflect the local isoscape (Webster *et al.* 2002). Since feathers are metabolically inert, the isotopic ratio is "locked in" after a feather stops growing (Hobson 2005). Consequently, comparing $\delta D$ values from feathers to $\delta D$ maps enables investigators to determine feather origins (Bowen *et al.* 2005). Sulfur is another widely used stable isotope, as the stable isotope ratio of sulfur ($\delta^{34}S$) differs among saltwater and freshwater habitats (Lott *et al.* 2003). Yellow Rails grow new rectrices (tail feathers) on their breeding grounds (Pyle 2008), so it should be possible to collect a single rectrix from a Yellow Rail wintering at Red Slough WMA, subject the feather to a stable isotope analysis, and identify where the individual bred.

The objectives of this study were threefold: 1) create population estimates for Yellow Rails wintering at Red Slough WMA; 2) examine the sex ratios of Yellow Rails at Red Slough WMA and compare them to published sex ratios of Yellow Rails at San Bernard NWR; and 3) use stable isotope analysis to determine whether Yellow Rails at Red Slough WMA and San Bernard NWR bred in the same region.

## METHODS

### Study Area

We banded Yellow Rails at Red Slough Wildlife Management Area (33° 38' 20.04" N, 94° 33' 14.04" W; Fig. 1), an area cooperatively managed by the Oklahoma Department of Wildlife Conservation, the U.S. Forest Service, and the Natural Resources Conservation Service (U.S. Forest Service 2009). Red Slough WMA is located in McCurtain County, Oklahoma, where the 1981-2010 average January high temperature is 11.7 °C and the average January low temperature is -1.5 °C (Oklahoma Climatological Survey 2014). Red Slough WMA consists of 971 ha of wetlands, 647 ha of shrub/scrub habitat, 445 ha of (reforested) bottomland hardwoods, 168 ha of reservoirs, and 121 ha of woodlands (U.S. Forest Service 2016). Although Yellow Rails were captured in three fields during 2008-2009 (a total of 23 ha; Butler *et al.* 2010), they were found in only two fields during 2009-2010 (a total of 17 ha). Grasses, predominantly *Sporobolus* spp., dominated these fields (Butler *et al.* 2010).

We also banded Yellow Rails at San Bernard National Wildlife Refuge (29° 4' 59.88" N, 95° 15' 00.00" W) in Brazoria and Matagorda Counties, Texas. San Bernard NWR consists of 11,100 ha of salt marsh habitat, of which 5,058 ha are similar *Spartina* marshes as described below. The mean high temperature of nearby Galveston during winter is 17.4 °C and the mean low temperature was 10.0 °C (Office of the Texas State Climatologist 2014). Galveston receives 128.9 cm of rain each year, of which 26.1 cm (20.3%) falls during the winter (Office of the Texas State Climatologist 2014). We banded Yellow Rails at the Cedar Lake Creek unit, a 224.6-ha salty prairie marsh dominated by Gulf cordgrass (*Spartina spartinae*), saltmeadow cordgrass (*Spartina patens*) and eastern baccharis (*Baccharis halimifolia*).

Butler *et al.* (2014) presented details about banding Yellow Rails in Texas. Banding occurred between 10 November 2009 and 20 April 2010, including two occasions in November 2009, two in January 2010, three in February 2010, and five in April 2010. Similar to Perkins *et al.* (2010), two observers used a utility task vehicle (UTV) at San Bernard NWR to flush the rails. Sampling began at 18:00 hr and concluded by 01:00 hr.

We banded Yellow Rails once per month at Red Slough WMA from 23 October 2009 to 9 April 2010. The procedure outlined by Butler *et al.* (2010) was used to catch Yellow Rails (i.e., a 12-m rope weighted with bottles (filled with rocks) was dragged through each field at night and birds were captured using handheld nets). Sampling began ~30 min after the sunset and lasted for 3 hr. The number of people participating ranged from four to 17, although only three individuals had nets. Two people held the ends of the rope, while the remainder spaced themselves evenly behind the rope, maintaining a distance of 2-4 m from the rope. We used adjacent transects to sample for Yellow Rails, covering the fields from edge to edge. Lanterns were placed on opposite ends of the field to ensure that transects were straight.

Given that this study spanned several months, permanent immigration or emigration of individuals to the

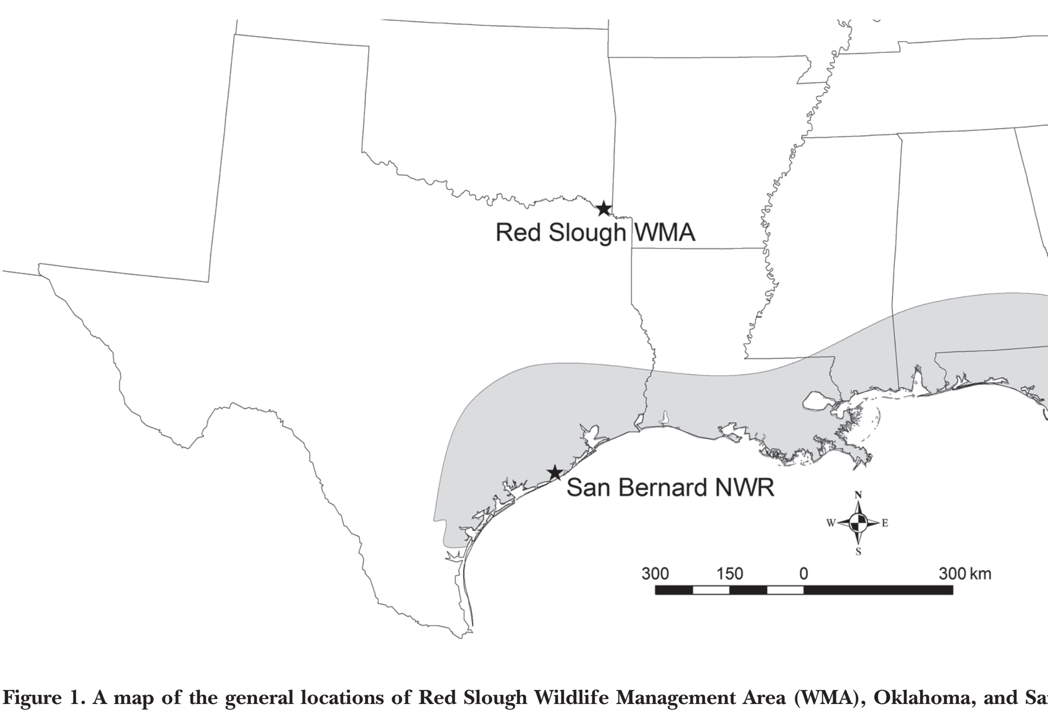


**Figure 1. A map of the general locations of Red Slough Wildlife Management Area (WMA), Oklahoma, and San Bernard National Wildlife Refuge (NWR), Texas.**

population may have occurred, so we chose to use the open population model POPAN to estimate population size. POPAN is a modified Jolly-Seber model and uses mark-recapture rates to derive population estimates (Arnason and Schwarz 1999). We entered the encounter history of each bird for the period November 2009 to March 2010 into program MARK to estimate population sizes using the POPAN model (White and Burnham 1999; Cooch and White 2010). We excluded birds captured in October and April from the analysis as they may have been migrants. Population sizes were estimated only for the locations where we banded birds (i.e., 17 ha at Red Slough WMA).

The assumptions of POPAN include that the marks are not lost, that there is homogeneity of capture probability between marked and unmarked animals, and that there is homogenous survival of marked and unmarked animals (Cooch and White 2010). Although we used different methods to capture Yellow Rails in Texas and Oklahoma, the method of capture was consistent at each site. Consequently, while capture probabilities may differ in Oklahoma and Texas, capture probabilities for each location should be homogenous.

We pulled two rectrices from each bird captured during November through March and subjected them to a stable isotope analysis using protocol details in Kelly *et al.* (2008). In addition, feathers from rails banded in Oklahoma during November 2008 through March 2009 were also included in the analysis. For the δD analysis, we removed approximately 0.15 mg of feather and then wrapped this sample in a silver capsule. These samples were then loaded into an autosampler and put into a high temperature (1,450 °C) reduction furnace interfaced with an isotope ratio mass spectrometer. To account for the exchange of hydrogen in the feather with hydrogen in the atmosphere, we employed the protocol outlined by Wassenaar and Hobson (2003), which uses "working standards" (i.e., samples with known hydrogen values) to correct for the effects of atmospheric hydrogen. The analysis procedure for $\delta^{34}S$ was similar although different capsules were used (tin instead of silver) and analyses used a Carlo Erba elementary analyzer at 800 °C linked to an isotope ratio mass spectrometer. To help identify the δD offset, we also obtained δD values from two Yellow Rail rectrices from Manitoba, Canada. One feather sample came from Oak Hammock Marsh (50° 10' 9.01" N, 97° 7' 9.01" W) while the other sample came from a bog near Sundown (49° 7' 3" N, 96° 22' 5.99" W). The University of Oklahoma Stable Isotope Lab carried out the stable isotope analysis.

Sex was determined by extracting DNA from the quill of the rectrix using a Qiagen DNEasy kit (QIAGEN Inc.) following the manufacturer's recommendations. We amplified sex-linked alleles using the 2550F and 2718R primers (Fridolfsson and Ellegren 1999). Amplification volumes totaled 10 µl and included 50-250 ng genomic DNA, 3.0 mM $MgCl_2$, 200µM dNTP's, 2 pmol of each primer and 0.25 U Taq. We denatured reactions for 1 min at 94 °C followed by 35 cycles of 94 °C denaturing for 30 sec, 50 °C annealing for 30 sec and 72 °C extension for 40 sec. A final 5-min extension at 72 °C completed the PCR profile. We visualized 10 µl of each PCR sample on a 2% agarose gel containing 0.025 µg ethidium bromide per ml. Gels were photographed under UV light and assigned sex by counting the number of bands (two bands for females, one band for males).

All statistical tests comparing sex ratios and stable isotope values used statistical program R (R Development Core Team 2015). δD stable isotope residuals were non-normally distributed so we used a Mann-Whitney test, while $\delta^{34}S$ stable isotope residuals were normally distributed so we used an independent two-tailed *t*-test. Due to the small sample sizes in the study, we also calculated effect size (Cohen's *d*; Cohen 1988; Rosnow and Rosenthal 1996). We present results as mean ± SE for parametric data and medians with 95% confidence intervals for non-parametric data.

## Results

The POPAN model included the capture histories of the 39 rails banded at Red Slough WMA between 20 November 2009 and 26 March 2010. All 10 recaptures occurred during this period, with one recapture in December, one in January, three in February and five in March (Table 1). We recaptured six individuals once, and recaptured two individuals twice. POPAN estimated that 90.3 ± 25.5 individuals, or 5.3 ± 1.5 rails * $ha^{-1}$, overwintered at Red Slough WMA during this period. The best POPAN model indicated that recapture probability and survivorship did not change with time, but there was time-dependence in the probability of entering the population (Table 2). The probability of entering the population was lowest during the period 15 January to 25 February 2010 (Table 3).

**Table 1. Summary of Yellow Rails (*Coturnicops noveboracensis*) captured and recaptured at Red Slough Wildlife Management Area, Oklahoma, 2009-2010. Birds captured in October and April were excluded from the POPAN analysis.**

| Date | New | Recaptures |
|---|---|---|
| 23 October 2009 | 16 | 0 |
| 20 November 2009 | 10 | 0 |
| 11 December 2009 | 3 | 1 |
| 15 January 2010 | 4 | 1 |
| 26 February 2010 | 6 | 3 |
| 26 March 2010 | 14 | 5 |
| 9 April 2010 | 1 | 0 |
| Total | 56 | 10 |

**Table 2. Summary of the POPAN models with an Akaike Information Criterion corrected for small sample sizes ($AIC_c$) for Yellow Rails (*Coturnicops noveboracensis*) captured and recaptured at Red Slough Wildlife Management Area, Oklahoma, 2009-2010. Models shown include probability of survival ($\theta$), probability of recapture ($p$), and probability of entering the population ($\beta$). Models were either time-dependent ($t$) or time-independent (.). Models with $AIC_c$ < 0.00001 included $\theta(.)p(.)\beta(.)$, $\theta(.)p(t)\beta(.)$, $\theta(t)p(.)\beta(.)$, and $\theta(t)p(t)\beta(.)$.**

| Model | $\Delta AIC_c$ | $AIC_c$ Weight | Model Likelihood | Number of Parameters |
|---|---|---|---|---|
| $\theta(.)p(.)\beta(t)$ | 0.00 | 0.86 | 1.00 | 6 |
| $\theta(.)p(t)\beta(t)$ | 4.06 | 0.11 | 0.13 | 10 |
| $\theta(t)p(.)\beta(t)$ | 6.85 | 0.03 | 0.03 | 9 |
| $\theta(t)p(t)\beta(t)$ | 13.01 | 0.00 | 0.00 | 13 |

During the period November through March, we were able to determine the sex of 28 birds from Red Slough WMA. Eighteen of these birds were male, while 10 were female, but the ratio of male:female did not differ significantly from 1:1 ($\chi^2_1$= 2.29, $P$ = 0.13), although the effect size was large ($d$ = 0.59). For the same time at San Bernard NWR, 33 of the 59 known-sex birds were male (Butler *et al.* 2014). The differences between the two regions was not significant (Fisher's exact test, $P$ = 0.49).

We obtained δD values from 72 birds, including 40 from Texas and 32 from Oklahoma (15 from 2008/2009 and 17 from 2009/2010). There was no significant difference in δD values from Oklahoma Yellow Rails between 2008/2009 and 2009/2010 (Mann-Whitney $U$ =148, $P$ = 0.46). Likewise, there was no significant difference in δD values between Oklahoma and Texas (Mann-Whitney $U$ = 516, $P$ = 0.15). However, 16 of the 40 Yellow Rails from Texas and three of the 32 birds from Oklahoma had δD values consistent with areas south of the breeding range (including six feathers with δD values consistent with Oklahoma and Texas), suggesting that these feathers were not molted on the breeding grounds. Excluding these individuals from the analysis, Yellow Rails banded in Texas had a median δD of -139.6 (95% CI: -156.8, -132.7) while birds banded in Oklahoma had a median δD of -130.7 (95% CI: -150.7, -122.2) indicating that Yellow Rails wintering in Oklahoma may have bred further south than Yellow Rails wintering in Texas. However, there was no significant difference in δD values (Mann-Whitney, $U$ = 418, $P$ = 0.22), although the effect size was moderate ($d$ = 0.47). The δD values from the two birds from Manitoba (-93.2 and -113.2) suggest that a δD offset of approximately 20 is required for geographic assignment. Thus, range of the δD values is broadly consistent with the area extending from southeastern Alberta northeast to James Bay.

We obtained $\delta^{34}S$ values from 31 individuals from Texas ($n$ = 4) and Oklahoma ($n$ = 27). Yellow Rails wintering in Oklahoma had a mean $\delta^{34}S$ of 3.6 ± 1.2, while Yellow Rails wintering in Texas had a mean $\delta^{34}S$ of 9.39 ± 1.5, and higher $\delta^{34}S$ values are consistent with birds breeding near a maritime influence such as James Bay. The difference was significant (t-test, $t_{29}$ = -3.03, $P$ = 0.02) with a large effect size ($d$ = -1.62). Only two birds had high $\delta^{34}S$ values, indicating that these two birds bred near a maritime environ-

**Table 3. A summary of the parameters for the top two POPAN models by month for Yellow Rails (*Coturnicops noveboracensis*) captured and recaptured at Red Slough Wildlife Management Area, Oklahoma, 2009-2010. Models shown include probability of survival ($\theta$), probability of recapture ($p$), and probability of entering the population ($\beta$). Models were either time-dependent ($t$) or time-independent (.).**

| | $\theta(.)p(.)\beta(t)$ | | | $\theta(.)p(t)\beta(t)$ | | |
|---|---|---|---|---|---|---|
| Date | $\theta$ | $p$ | $\beta$ | $\theta$ | $P$ | $\beta$ |
| 20 November-10 December 2009 | 0.691 | 0.296 | 0.000 | 0.609 | 0.117 | 0.368 |
| 11 December 2009-14 January 2010 | 0.691 | 0.296 | 0.065 | 0.609 | 0.142 | 0.332 |
| 15 January-25 February 2010 | 0.691 | 0.296 | 0.200 | 0.609 | 0.463 | 0.000 |
| 26 February-26 March 2010 | 0.691 | 0.296 | 0.772 | 0.609 | 0.586 | 0.436 |

ment. δD values and $\delta^{34}S$ values are not correlated (Spearman's S = 4,078, $P = 0.62$).

## Discussion

The number of Yellow Rails wintering at Red Slough WMA in Oklahoma (90.3 ± 25.5 individuals) was surprisingly high given that this location was only recently described (Butler *et al.* 2010). Red Slough WMA is much further inland than their traditional coastal wintering sites, with a colder winter climate, and the Oklahoma study site is dominated by *Sporobolus* spp. (Butler *et al.* 2010) rather than *Spartina* spp. as in Texas (Butler *et al.* 2014).

Wintering Yellow Rails are difficult to document, as the birds rarely flush and seldom vocalize (Bookhout 1995). We used UTVs to flush Yellow Rails in Texas, while we used rope drags to flush Yellow Rails in Oklahoma. Both methods were effective at flushing rails. UTVs required fewer personnel and were more efficient at covering large areas. However, concern exists that vehicles may negatively affect marshes and other wetland areas (Rader *et al.* 2001). Red Slough WMA prohibits UTVs and all-terrain vehicles, but rope drags were very efficient in relatively small areas even though they required greater numbers of personnel.

The density of Yellow Rails at Red Slough was 5.3 ± 1.5 rails * $ha^{-1}$ and was virtually identical to the 5.2 ± 1.3 rails * $ha^{-1}$ at San Bernard NWR in Texas (Butler *et al.* 2014). Grace *et al.* (2005) used radio telemetry on Yellow Rails in Texas and estimated that home range size of this species during winter was 1.16 ha, while Mizell (1998) estimated home range size to be 1.7 ha along the Texas coast. However, both Mizell (1998) and Grace *et al.* (2005) reported that Yellow Rails may be gregarious on their wintering grounds; consequently, the home ranges of Yellow Rails may overlap considerably, and it appears that density in Oklahoma and Texas is approximately five individuals * $ha^{-1}$ in suitable habitat (Butler *et al.* 2014).

The ratio of male to females in Oklahoma did not differ significantly from a 1:1 ratio, which mirrors the findings of Butler *et al.* (2014). This suggests that there is no north/south difference in sex ratios for this species wintering in the southern Great Plains. However, males outnumbered females by 1.8:1.0 in Oklahoma. It is possible that a larger sample might reveal a biased sex ratio in Oklahoma, and so there may be an east-west female to male bias consistent with the female dominated sex ratio found by Post (2008) in South Carolina during the early 20th century. It is also conceivable that males and females may segregate by habitat, as has been found with Water Rails (*Rallus aquaticus*; Bravo *et al.* 2014).

Nineteen of the 72 Yellow Rails had δD values consistent with areas south of the breeding range, which may indicate that these rectrices were replacements of lost or damaged feathers or that there may be undocumented variations in molt patterns as described by Pyle (2008). The stable isotope analysis of the remaining birds suggests that Yellow Rails banded at Red Slough WMA and San Bernard NWR bred from southeastern Alberta east to James Bay. Although there was not a significant difference in the δD excess in feathers from Texas and Oklahoma, the effect size was moderate, which suggests that a larger sample size may detect a significant difference in the δD excess between these two locations. Birds caught in Texas had δD excess values that were generally consistent with areas further north than the δD excess values from birds caught in Oklahoma. Only two Yellow Rails had enriched $\delta^{34}S$ values consistent with a marine environment, which suggests that the majority of birds grew rectrices while at interior marshes in Canadian prairies. Robert *et al.* (2004) found that relatively large numbers of Yellow Rails bred at James Bay, and it is conceivable that these two birds bred at this location. However, additional feather samples from the breeding grounds are required before a confident assessment of geographic assignment is possible.

This study relied upon only 1 year of data and a relatively small sample size. As the first study to explore overwintering density, age and sex ratios, and migratory connectivity in wintering Yellow Rails, our results indicate the benefit of further research. A larger, multi-year study would be useful to determine whether the population of Yellow Rails overwintering at Red Slough WMA is increasing, decreasing, or remaining stable. Likewise, it is plausible that a larger, longer-term study may demonstrate a male bias in Oklahoma given the large effect size for the male:female ratio observed. In addition, a greater δD and $\delta^{34}$S excess sample size, more evenly balanced between Oklahoma and Texas, may demonstrate that Yellow Rails wintering in Oklahoma tend to breed in different locations than Yellow Rails wintering in Texas.

Although breeding Yellow Rails are not uncommon in appropriate habitat in the prairie provinces of Canada (Manitoba Avian Research Committee 2003), they are patchy and local in the eastern portion of their range (Gibbs *et al.* 1991; Cadman *et al.* 2009). It is unclear if the relative rarity of Yellow Rails in this area is due to a decline in suitability on the breeding grounds, the wintering grounds or both areas. This study suggests that Yellow Rails overwintering in Oklahoma and Texas breed primarily in the Canadian prairies. It is unclear where birds breeding in Ontario, Quebec, Maine, and other eastern locations winter. Concerted efforts should be made to identify where these individuals winter. This will allow identification of conservation threats and identify whether habitat management on the breeding grounds or the wintering grounds is necessary to increase the population.

The relatively large numbers of Yellow Rails overwintering at Red Slough WMA suggests that Yellow Rails may winter at other inland locations in the southeastern USA. However, documenting their presence during the winter requires substantial effort. High densities of Yellow Rails may be undetected at other refuges or wildlife management areas. As a result, this species may be left out of management planning in areas where it is present. Future efforts should seek to identify other areas in the southeastern USA where concentrations of Yellow Rails may winter.

ACKNOWLEDGMENTS

We thank G. Ritchison, T. A. Sordahl, M. S. Woodrey, and two anonymous reviewers for their helpful reviews of an early draft of this manuscript. We banded under USA permit #23357 and Canada permit #10837 using IACUC #09003. The Office of Research and Grants at the University of Central Oklahoma supported this research.

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