Origins of Late-Breeding Nomadic Sedge Wrens in North America: Limitations and Potential of Hydrogen-Isotope Analyses of Soft Tissue

Authors: Keith A. Hobson, and Mark B. Robbins
Source: The Condor, 111(1) : 188-192
Published By: American Ornithological Society
URL: https://doi.org/10.1525/cond.2009.080001

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne’s Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.
ORIGINS OF LATE-BREEDING NOMADIC SEDGE WRENS IN NORTH AMERICA: LIMITATIONS AND POTENTIAL OF HYDROGEN-ISOTOPE ANALYSES OF SOFT TISSUE

KEITH A. HOBSON1,3 AND MARK B. ROBBINS2

1Environment Canada, 11 Innovation Blvd., Saskatoon, SK, Canada S7N 3H5
2Division of Birds, University of Kansas Natural History Museum and Biodiversity Research Center, 1345 Jayhawk Boulevard, Lawrence, KS 66045

Abstract. The nomadic Sedge Wren (Cistothorus platensis) breeds primarily in mesic grasslands in north-central North America. Following breeding in these regions from late May to early July, however, the species then “appears” en masse in the tallgrass prairie region farther south (e.g., Missouri and Kansas) and to the east to breed again from mid-July to early August (Herkert et al. 2001). The provenance of birds appearing in late summer to breed in these areas remains unknown because of problems inherent in mark–recapture surveys. Recent studies have shown how endogenous markers may be used to infer origins of individual birds. We analyzed levels of the stable hydrogen isotope 2H (δD) from liver, muscle, and claws of Sedge Wrens from known northern breeding locations first to establish the relationships between δD in the wrens’ tissue and mean δD in precipitation during the growing season (δDp). From these relationships we derived expected values (mean and 95% CI) for three sites in Kansas and Missouri where late breeders colonized. The observed values of δD in these late breeders were primarily within the range expected for those locations, but more individuals than expected had δD values higher than expected. In addition, in birds apparently originating from north or south of Kansas and Missouri, the values of δD in claws were positively correlated with those in other tissues, in contrast to those with the “local” signal. This supports the idea that the isotopic outliers at these sites were more recent arrivals. For small-bodied birds like the Sedge Wren, however, the isotopic approach based on soft tissues is limited to a very narrow temporal window of inference because of rapid elemental turnover. This greatly restricts the use of this technique in inferring origins of small nomadic species.

Key words: Cistothorus platensis, determining origins, deuterium, nomadism, stable isotopes.

Origenes de la Población Nómade de Cistothorus platensis

Resumen. La especie nómade Cistothorus platensis cria principalmente en pastizales húmedos en el norte y centro de Norte América. Sin embargo, después de reproducirse en estas regiones entre fines de mayo y principios de julio, la especie “aparece” en masa en la región de praderas de pastos altos más hacia el sur (e.g., Missouri y Kansas) y hacia el este, en donde cría nuevamente desde mediados de julio hasta principios de agosto (Herkert et al. 2001). La proveniencia de las aves que aparecen a finales del verano para criar en estas áreas es incierta.
Las aves individuales. Analizamos los niveles del isótopo de hidrógeno estable ²H (δD) de los tejidos y la garras de *C. platensis* de localidades de cría conocidas del norte para establecer inicialmente las relaciones entre δD en los tejidos de las aves y el promedio de δD en las precipitaciones durante la estación de crecimiento (δDₚ). A partir de estas relaciones derivamos los valores esperados (media e IC del 95%) de tres sitios en Kansas y Missouri poblados por aves reproductivas tardías. Los valores observados de δD en estas aves estuvieron principalmente dentro del rango esperado para estas localidades, pero más individuos que los esperados tuvieron valores de δD mayores que los esperados. Además, en las que se originaron aparentemente en el norte o sur de Kansas y Missouri, los valores de δD de las garras estuvieron positivamente correlacionados con los de otras tejidos, en contraste con aquellos con la “señal” local. Esto apoya la idea de que los individuos que se encontraban por fuera de los rangos en estos sitios arribaron más recientemente. Para las aves de tamaño corporal pequeño como *C. platensis*, sin embargo, el enfoque isotópico basado en tejidos blandos está limitado a una ventana temporal angosta de inferencia, debido al recambio rápido de elementos. Esto restringe enormemente el uso de esta técnica para inferir el origen de aves pequeñas nómadas.

El Sedge Wren (*Cistothorus platensis*) tiene una fiel fenología compartida por otros aves norteamERICANAS. Se reproduce principalmente en praderas mesic en el centro de la mesocontinenté, donde es el único comportamiento de cría en las regiones norteñas de las distintas partes del año. La creación de aves en el norte de septiembre a octubre, luego apareciendo en masa para el invierno en los lugares de cría conocidos del norte para establecer inicialmente las relaciones entre δD en los tejidos de las aves y el promedio de δD en las precipitaciones durante la estación de crecimiento (δDₚ). A partir de estas relaciones derivamos los valores esperados (media e IC del 95%) de tres sitios en Kansas y Missouri, que los esperados tuvieron valores de δD mayores que los esperados. Además, en las que se originaron aparentemente en el norte o sur de Kansas y Missouri, los valores de δD de las garras estuvieron positivamente correlacionados con los de otros tejidos, en contraste con aquellos con la “señal” local. Esto apoya la idea de que los individuos que se encontraban por fuera de los rangos en estos sitios arribaron más recientemente. Para las aves de tamaño corporal pequeño como *C. platensis*, sin embargo, el enfoque isotópico basado en tejidos blandos está limitado a una ventana temporal angosta de inferencia, debido al recambio rápido de elementos. Esto restringe enormemente el uso de esta técnica para inferir el origen de aves pequeñas nómadas.

**METHODS**

**FIELD COLLECTIONS**

DeSoto National Wildlife Refuge en el Missouri River near Blair, Nebraska, as the southernmost point of the transect. The central Manitoba site is near the northern terminus of this species’ breeding range (Godfrey 1986). On the basis of the anticipated latitudinal resolution deuterium permits, we spaced sampling sites a minimum of 150 km apart. Collecting localities: Iowa/Nebraska: (1) DeSoto National Wildlife Refuge, Harrison/Washington counties (41° 30.6′ N, 95° 59.8′ W). Minnesota: (2) Nobles County, south of Worthington (43° 33.4′ N, 95° 35.6′ W); (3) Traverse County, east of Lake Shore Valley (45° 36.1′ N, 96° 45.6′ W); (4) Polk County, southeast of Crookston (47° 36.6′ N, 96° 23.2′ W). Manitoba: (5) southwest Lake Francis (50° 14.1′ N, 97° 56.6′ W); (6) west-northwest of St. Martin Junction (51° 44.4′ N, 98° 50.1′ W).
Birds arriving to breed in July–August were collected at the following localities and dates: Missouri: Holt County, Bob Brown Conservation Area (39° 58.8’ N, 95° 14.3’ W; 22 July–11 August 2005; n = 23); Missouri: Vernon County, Bushwacker Conservation Area (37° 39.0’ N, 94° 26.9’ W; 28 July 2005; n = 5); Missouri: Barton County, Prairie State Park (37° 30.5’ N, 94° 31.6’ W; 28 July 2005; n = 7), given the close proximity of the latter two localities they are treated as a single site in the text and in Fig. 1; Kansas: Stafford County, Quivira National Wildlife Refuge (38° 11.8’ N, 98° 29.4’ W; 5 August 2005; n = 4).

Upon collection, each specimen was immediately frozen on dry ice. Liver and muscle were preserved from each specimen when voucher specimens were prepared at KUMNH (catalog numbers 96631–96672). After deuterium results were obtained from liver and muscle, toe nails were clipped from voucher specimens.

**STABLE-ISOTOPE ANALYSIS**

Prior to analysis, soft tissues were first freeze-dried, then lipid-extracted by means of a 2:1 chloroform:methanol solvent rinse, and then air dried for several days in a fume hood. Claws were similarly cleaned of surface oils with this solvent rinse. Tissues were then ground and prepared for analysis of stable hydrogen isotopes at the Environment Canada stable-isotope laboratory in Saskatoon, Saskatchewan. Analyses followed the comparative-equilibration method described in detail by Wassenaar and Hobson (2003) and used isotope-reference materials calibrated for keratin. No equivalent standards are available for soft tissues and so were run against the keratin standards. Stable hydrogen isotopes were measured by continuous-flow isotope-ratio mass spectrometry in H$_2$, derived from high-temperature flash pyrolysis of feathers and nails. All deuterium results are expressed in parts per thousand (‰) and normalized on the Vienna Standard Mean Ocean Water–Standard Light Antarctic Precipitation (VSMOW-SLAP) standard scale. Repeated analyses of hydrogen isotope inter-comparison material IAEA-CH-7 (~100 ‰) and keratin references yielded an external repeatability of better than ±2 ‰ based on the distribution of residuals within autoruns for three keratin references.

**STATISTICAL ANALYSES**

Deuterium values for growing-season average precipitation ($\delta$D$_p$) were taken for each collection site from the online tool [http://www.waterisotopes.org](http://www.waterisotopes.org). Regressions of tissue $\delta$D values against $\delta$D$_p$ were performed using SPSS (version 15). We used SigmaPlot (version 10) to portray these regressions with 95% confidence intervals. We used this approach to examine how those $\delta$D values for Sedge Wrens at the two southern collection sites differed from values expected for that location.

**RESULTS**

As expected, in birds of known origin tissue $\delta$D values were most depleted at the northern end of the range and most enriched at the southern end. That is, the relationship between tissue $\delta$D values and estimated $\delta$D$_p$ values was positive (Fig. 2). The relationship for muscle tissue, however, was stronger ($r^2 = 0.62$) than that for liver ($r^2 = 0.28$) and claw ($r^2 = 0.32$). We then plotted the distribution of tissue $\delta$D values for the southern sites of newly arriving birds in Kansas and Missouri. For all tissues, there was a slight tendency for outliers to be more enriched in their $\delta$D values than expected for those sites. We apportioned the values for muscle and claw $\delta$D values from the Missouri sites into three groups (top third, middle third, and lowest third). For the claw values, we found a significant positive relationship for the groups most enriched and most depleted in $\delta$D (enriched: $r^2 = 0.25$, $P < 0.01$; depleted $r^2 = 0.27$, $P = 0.01$) but no relationship for the central group.

**DISCUSSION**

The broad overlap of muscle and claw $\delta$D values of Sedge Wrens arriving later in the breeding season in Kansas and Missouri with values expected for the latitude of those locations is consistent with the notion that those tissues were formed primarily at those locations or at other sites with food webs of similar isotope composition. In liver $\delta$D values more individuals had more enriched values than expected from the extrapolation of the regression of known-source birds. This was surprising since we anticipated these southern breeders to have arrived primarily from the north, where their tissues would have equilibrated with food webs more depleted in $\delta$D. Liver samples in particular were expected to represent very recent locations (i.e., their southern collection sites) in comparison to muscle and claw samples. Within eastern North America, Sedge Wrens are not expected to breed farther south than the locations sampled in Missouri and Kansas.

At each site, variation in tissue $\delta$D values for known breeding birds was considerable. Thus the correlations between claw and liver $\delta$D values and $\delta$D$_p$ values across our north–south transect were weak. In contrast, a moderate ($r^2 = 0.62$) corresponding relationship was found for muscle $\delta$D values. This result suggests that muscle tissue was a more faithful indicator of provenance than liver or claws. Claws from early breeding individuals may have included an isotopic signal from the wintering grounds or migratory stopovers. Claws are also difficult to sample consistently from individual to individual, especially in small birds like wrens. Liver has such a fast turnover rate that it provides only a contemporary signal of local dietary variation in D, and because of Sedge Wren’s small size, muscle extends the signal only a few additional days. Although muscle provided a better match to precipitation data, it was still a poor indicator of where later breeding birds in Kansas and Missouri originated. Ours is the first latitudinal transect of soft-tissue $\delta$D for birds, so we cannot currently compare the results of our regressions of tissue $\delta$D and $\delta$D$_p$ with other published material.

**FIGURE 1.** Breeding range of the Sedge Wren in North America. Circles enclosing dots, sites of sampling in early summer along a latitudinal transect; stars, sites of sampling in late summer, representing the influx in July and August; dashed line, areas of sporadic breeding. Superimposed, for reference only, are contours of expected values of $\delta$D for feathers, based on Hobson and Wassenaar (1997).
An alternative hypothesis for the origin of late-summer breeders at our Missouri sample sites is that these individuals arrived from more southern wintering locations. Inspecting whether these southern sites would be useful to test for any late-season enrichment in deuterium. However, the four individuals collected at the Kansas site were sampled later than desired (5 August) and without a prior check on their presence in June or July and thus constituted a sample that had likely equilibrated to the local signal, at least for liver and muscle (claws not included for this sub-group). Two individuals were positive outliers for liver and one for muscle (Fig. 2). These presumably locally equilibrated individuals provide weak anecdotal evidence that that Kansas sites were more enriched than expected, undermining the possibility that birds were moving in from more southern locations. Another important factor is the nature of the isotopic contours expected across the Sedge Wren’s range (Fig. 1). Inspection shows that while there is a strong north–south isotopic gradient over much of the range, birds originating from the east and northeast of our Kansas and Missouri sites can have similar or even more positive tissue $\delta^D$ values. Currently, we have no idea if birds move to these southern locations from the east.

Grasslands and wetlands may also be more susceptible to pulsed $\delta^D$ signals related to short-term variation in precipitation. In their study of the Swamp Sparrow (Melospiza georgiana), Greenberg et al. (2007) provided indirect evidence that $\delta^D$ values in winter-grown feathers of coastal plain populations of this species follow winter precipitation $\delta^D_p$. Other studies, however, have shown good agreement between feather $\delta^D$ values and $\delta^D_p$ for wetland or wetland-associated species (Wassenaar and Hobson 2000, Clark et al. 2006, but see Szymanski et al. 2006). We examined the monthly average $\delta^D$ values for precipitation in Barton and Holt counties in Missouri and found that the July averages were more depleted than those for May and June by about 8%. July rainfall tended to be more depleted than the mean annual growing-season average of ~41%. So, if late seasonal rainfall were more important at these sites, the trend is in the direction of...
opposite of that expected from our observation of birds with more enriched claw $\delta D$ values. Thus we have no strong isotopic evidence that seasonal (i.e., May–June) departures in tissue $\delta D$ values from $\delta D_p$ could be responsible for the claw $\delta D$ values more enriched than expected in birds from more northern origins.

Our study reveals the utility of deuterium analyses of soft tissues in addition to those of keratinous tissues such as feathers and claws in investigating the origins of migratory birds and other animals. This approach has some precedence (Hobson et al. 1999, 2004), but more controlled laboratory studies are now needed to work out the influence of body water on soft tissues and the temporal window over which $\delta D$ values for soft tissue represent origins. In our case, the small body size of the Sedge Wren presents, in some respects, a worst-case scenario. All soft tissues in this species will represent a fairly brief interval during which origins can be inferred. These problems are expected to be alleviated with larger-bodied species. Our study also demonstrates an approach that we believe is appropriate in general. Researchers interested in inferring origins of individuals or populations need to attempt, wherever possible, to establish the relationship between tissue $\delta D$ values and expected $\delta D_p$ values or latitude. Such relationships allow researchers to then investigate how origins of birds can be inferred on a species-specific basis. In our case there was no previous information relating claw or muscle tissue to long-term estimates of $\delta D_p$ for sites in North America or elsewhere. This necessitated the verification of a relationship for birds of known origin that could then be used in testing birds of unknown provenance.

The following people helped with locating breeding populations of Sedge Wrens: Bill Busby, Frank Durban, Andy Forbes, Brad Jacobs, Tommie Rodgers, Brett Sandercork, and Spencer Sealy. We thank personnel at DeSoto National Wildlife Refuge for permits and logistical help. The Canadian Wildlife Service, USFWS, and the Iowa and Minnesota Departments of Natural Resources and Missouri Department of Conservation kindly provided collecting permits. Samples were prepared for stable-isotope analysis by Blanca Mora Alvarez, and mass spectrometry conducted by Len Wassenaar at the National Water Research Institute in Saskatoon, SK. Funding for analysis was provided by an operating grant to KAH. Dan L. Reinking and an anonymous reviewer made useful comments on a previous draft of the manuscript.

LITERATURE CITED


Clark, R. G., K. A. Hobson, and L. I. Wassenaar. 2006. Geographic variation in the isotopic ($\delta D$, $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$) composition of feathers and claws from Lesser Scaup and Northern Pintail: Implications for studies of migratory connectivity. Canadian Journal of Zoology 84:1395–1401.


