Establishing Migratory Connectivity in the Rufous Hummingbird (Selasphorus rufus) Using Plumage δD and Chroma

Jonathan Moran 1, 2, J. Cam Finlay 3, Leonor Wassenaar 4, Susan Wethington 5 & Leigh Anne Isaac 6

1 Royal Roads University, Victoria, BC, Canada (jonathan.moran@royalroads.ca) 2 Rocky Point Bird Observatory, Victoria, BC, Canada (jcamfinlay@gmail.com) 3 Humboldt Project of BC, Victoria, BC, Canada 4 Environment Canada, Sackville, SK, Canada (leonor.wassenaar@environment.gc.ca) 5 University of Victoria, Victoria, BC, Canada

Introduction and Aims

The Rufous hummingbird (Selasphorus rufus Gmelin, Trochilidae) undertakes the longest migration for its size any bird. Breeding as far north as Southeast Alaska, it overwinters in Mexico and the Gulf Coast of the US 1, 2. S. rufus is recognized as a Species of Conservation Importance on the “ Partners in Flight” (PIF) Watchlist 3. In recent years, banders at a number of sites in British Columbia and the US Pacific Northwest have indicated a reduction in the numbers of S. rufus in the spring migration.

Migratory bird species require suitable habitat on both breeding and wintering grounds, as well as on the migration routes that link them. The first step in elucidating the possible causes of decline in S. rufus, therefore, is to investigate the degree of migratory connectivity 4. We sought to address two questions:

1. Does S. rufus exhibit a high degree of migratory connectivity, or do those from one breeding area disperse and merge with others on different wintering grounds?

2. A relatively small but apparently growing population of S. rufus overwinters along the Gulf Coast of the US 5. What is the breeding range of this population?

Materials and Methods (continued)

The rufous coloration from which S. rufus derives its name is due to carbonoid pigments. Thus, birds can be approximately classified into nine chromatic types: Black, Blue, Purple, Green, Blue-green, Yellow, Orange, Red, and Pink (Table 1). Each color type is associated with a unique plumage δD signature (Table 2). Chroma = \( \frac{(Q_L - Q_H)}{Q_H} \) and where Q_L, Q_M, Q_H, and Q_R are the summed reflectances of the red (625-700 nm), green (475-655 nm), yellow (530-625 nm), blue (400-475 nm) and violet (400-700 nm) wavelengths, respectively 6.

Cluster analysis (Ward's, Euclidean Distance 7) was undertaken to differentiate between groups of individuals based on δD and chroma. The optimum number of groups was ascertained using root-mean-square deviation (RMSD) and using a fixed number of clusters (2000-2010) for S. rufus for the months December-February inclusive, based on data collected by the Avian Knowledge Network (AKN) database 8. To each of the right of each map, the proportion of birds from each site present in a given group is represented by a bar graph.

Results

There were significant effects of Site and Sex on both δD and chroma (P<0.05, ANOVA). There were also significant interactions between factors; as a result, further analyses were conducted separately by Sex.

For several sites at which both sexes were sampled, males showed significantly less negative δD values (Figure 2). Males also exhibited higher chroma values than females (Figure 3).

Cluster analyses based on δD and chroma identified four groups per sex (Figures 4 and 5).

To predict wintering range estimates from δD directly onto published δD isoscape maps, we used Reduced Major Axis (RMA) regression to predict the δD values that would result in the observed δD values from feathers of known geographical origin. These included feathers from hatch-year (HY) birds sampled on the breeding range in Western Canada, as well as newly-molted feathers from both HY and AHY birds on the wintering ranges in Mexico and the Gulf of Mexico.

We estimated δD values corresponding to the collection date (month) of the S. rufus feathers of known geographic origin, using OIPC v.2.3 (Online Isotope Calibrator, Colorado). The second isoscape covered Mexico only 9, although at higher sampling resolution (304 sampling sites vs. 4 for the AEA-based isoscape). This isoscape employs temporally-integrated isotopic signatures derived from groundwork. Therefore, we used annual mean OIPC-derived δD values, rather than monthly values for each feather location, in the second RMA regression.

The RMA regressions were undertaken using the RMA v.1.7 software package 10. Finally, we plotted effects of estimates ofS. rufus wintering range by overlaying its RMA-derived δD values (95% C.I.) onto both isoscapes. The RMA-equations are presented in Figure 6a and 6b. Estimates of wintering location (95% C.I.) are presented for each group in Figure 8 (below). The large maps display the 95% C.I.s for each group in the months December-February inclusive, based on the relationship presented by the monthly RMA-regression in Figure 6. The isoscape on which they are overlaid is from Bowen (2010). Waterscapes.org 11.

The inset maps present the 95% C.I.s for each group on an annual basis for Mexico alone, based on the relationship presented by the annual RMA-regression in Figure 7. The isoscape is that of Wassenaar et al. (2009) 12. In each map, the black dots represent reported sightings (2000-2010) for S. rufus for the months December-February inclusive, based on data collected by the Avian Knowledge Network (AKN) database 8. To the right of each map, the proportion of birds from each site present in a given group is represented by a bar graph.

Conclusions

1. Interspecific differences in δD values (males-Females) suggest a degree of allogey on the wintering ranges. This hypothesis is supported by observational evidence from Mexico 2. Other explanations include interspecific differences in discrimination against deuterium uptake (δD), faster molting of males, and interspecific differences in foraging strategy on the wintering grounds resulting in differential access to “exchange” water 13, 14. There is currently no supporting evidence for these alternative hyrdtheses.

2. The results also suggest that migratory connectivity in the populations of S. rufus investigated in this study is not particularly high: each of the groups in Figure 8 comprises individuals from several of the breeding sites.

3. The most likely candidates for populations of S. rufus overwintering on the Gulf Coast of the US are in Groups 2 and 4 for females, and Groups 1 and 3 for males.

Acknowledgements

This work was generously supported financially by Royal Roads University, and by the US Forest Service, under the “Wings Across the Americas” Initiative. We are particularly indebted to the many people who helped with the collection of feathers; the project would not have been possible without their generous support. We thank: S. Acton, J. Bacon, C. Carrothorn, S. Contreras-Martinez, N. Cox, D. Craig, C. Culp, J. Finlay, D. Gellaty, P. Gregory, A. Hall, B. Hawkins, K. Hobson, M. Hoebel, A. Hurley, C. Hutcherson, D. Jims, C. Lively, G. Logan, M. Lynn, S. Maslen, D. Markle, A. Monar, A. Nightingale, M. Noble, K. Poulton, S. Robbins, L. Rogers, J. Schondube, B. Silenes, R. Teo, V. Wilgenburg, S. Walker, and G. West.

Literature Cited


