

Revisiting cultural evolution and variation of song in an isolated population of Mountain White-crowned Sparrows (*Zonotrichia leucophrys oriantha*)

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INTRODUCTION

- Songs are culturally inherited, and as a result geographically isolated populations may become culturally isolated over time, developing a distinct population-wide dialect (Marler & Tamura 1962)
- This may be the case for the dialect of the White-crowned Sparrows (WCSP) population isolated in Cypress Hills Provincial Park (CHPP), whose next closest population is separated by ~ 300km of unsuitable prairie habitat (**Fig. 1**)

WHITE-CROWNED SPARROW SONG DIALECTS

- White-crowned Sparrows (*Zonotrichia leucophrys*) are the model system for investigation of learned song dialects in birds
- First described by Barbara Blanchard DeWolfe (Blanchard 1941)
- Seminal studies demonstrated that dialects are learned from local tutors in the first months of life (pre-dispersal) (Marler & Tamura 1962)

CYPRESS HILLS PARK GEOGRAPHY

- CHPP is an island of montane forests similar to the Rocky Mountains; the higher elevation allowed it to remain unglaciated by the Wisconsin Glaciation (~10,000 yra), and could explain why the Rocky Mountains and the CHPP share similar boreal ecosystems while the intervening area between the two is prairie (Thompson and Kuijt, 1976)
- The geographic isolation of CHPP may provide total population isolation, which could allow for cultural and genetic evolution in White-crowned Sparrows (Chilton, 2002)



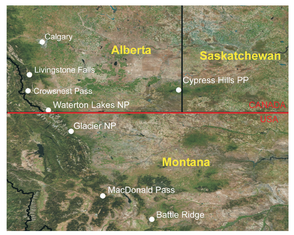


Figure 1. View from the Cypress Hills looking out onto the surrounding prairies, and a map of Cypress Hills location and some of the closest WCSP sites in Alberta and Montana.

CHPP WCSP DIALECT – HISTORICAL

- Three separate studies have explored White-crowned Sparrow songs in CHPP – 1978, 1984, and 1999 (Lein, 1979, O'Malley, 1987, Chilton, 2002)
- In each of these studies, males from the disjunct CHPP population all sang the same dialect. However, between each study, the structure of the song had changed

OBJECTIVE

- Revisiting the exploration of the CHPP White-crowned Sparrow population to determine if the local dialect has continued to change or had become stable.

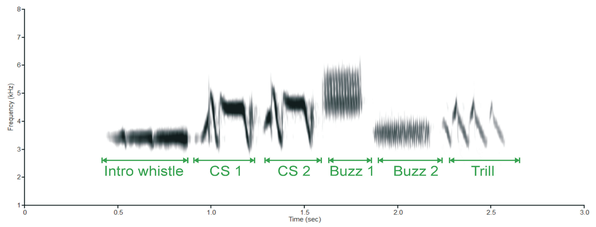


Figure 2. Audiospectrogram of a White-crowned Sparrow song indicating the syllables that comprise the song. CS = complex syllable. Time and frequency variables were taken from each syllable.

METHODS

- Singing male WCSP were recorded in 1978 by MRL (n = 14) and in 2018 by CMS (n = 23)
- Twelve temporal and six frequency variables measured for each song (**Fig. 2**)
- Data set: The mean of five song measurements for each variable from individual WCSPs
- Principal Component Analysis (PCA) on significant variables was used to reduce variables and eliminate colinearity
- Discriminant Function Analysis (DFA) of PC scores of songs was used to determine whether songs could be distinguished reliably to correct year

RESULTS

- Songs of Cypress Hills birds were visually and qualitatively different between years (**Fig. 3**)
- Songs from 2018 were shorter, had a lower mean minimum frequency, fewer terminal trill syllables, and covered a larger frequency range compared to songs from 1978.The structure of the complex syllables has changed, and harmonic notes not present in 1978 are now present
- Univariate analyses showed significant differences between years for five temporal, seven frequency, and one syllable variables (13 of 18 variables, all P<0.005)
- PCA generated four PCs with eigenvalues > 1.0, explaining 74% of the variance in the original measurements
- PC1 and PC2 separate the songs of the two years moderately well (**Fig. 4**)
- Multivariate means differed significantly between years (MANOVA: $F_{4,32}$ = 26.8; P<0.0001
- DFA jack-knifed classification correctly assigned 36 of the 37 (97%) songs to correct year (**Table 1**)

Table 1. Jack-knifed classification of the DFA, showing the number of songs correctly identified to year.

	Jack-knifed Classification Matrix		
	1978	2018	% correct
1978	23	0	100
2018	1	13	93
Total	24	13	97

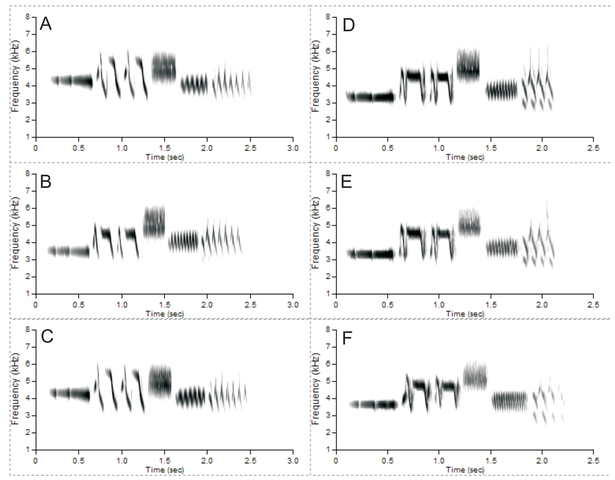


Figure 3. Audiospectrograms of White-crowned Sparrow songs from Cypress Hills PP. Songs A - C are from 1978; Songs D-F are from 2018.

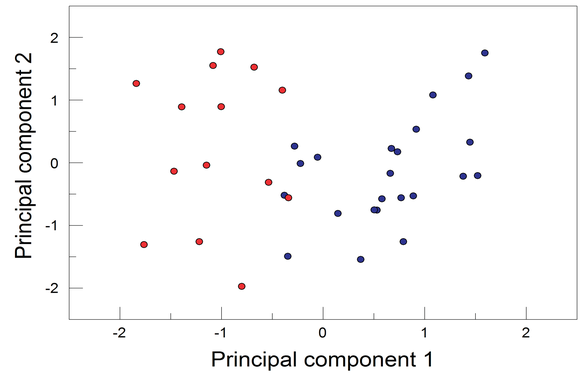


Figure 4. Plot of scores of individual songs on PC1 vs. PC2 of White-crowned Sparrow from Cypress Hills: (●) = 2018 and (●) = 1979.

DISCUSSION

- Songs of WCSP from CHPP are significantly different in terms of time, frequency, and syllable characteristics when comparing 1978 to 2018 songs
- Songs from 2018 are less complex than songs from 1978.This is expected, as songs from isolated populations are typically less complex than "mainland" populations due to lack of new or modified phrases (O'Malley, 1987)
- Jack-knifed classifications correctly identifying all but one male to the correct year demonstrates that songs from 1978 and 2018 are different enough to be distinguished from each other
- Conformity of song characteristics throughout the population suggest that there are no new song types being introduced into the population
- Further study is needed to explore if the population is also genetically isolated from other "mainland" populations

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