Determination of Sex Using Wing Chord in Southern Vancouver Island Populations of Bewick's Wren and "Puget Sound" White-crowned Sparrow

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Abstract

Sex determination is difficult in sexually monochromatic passerines outside of the breeding season. Bewick's Wrens (Thryomanes bewickii) *and White-crowned Sparrows* (Zonotrichia leucophrys) *are two such species. The objective of this study was to examine wing chord differences between males and females of southern Vancouver Island populations of both species, and to explore whether the wing chord ranges listed in Pyle (1997) could be used to determine sex. Using data from birds sexed by breeding characteristics at the Rocky Point Bird Observatory and the Monitoring Avian Productivity and Survivorship sites on southern Vancouver Island, and exact binomial tests, I showed that wing chord values can be used to correctly determine sex in mature individuals of these populations of both species with >95% confidence. This information allows researchers in the region to definitively sex 53% of adult* calophonus *Bewick's Wrens and 22% of adult* pugetensis *White-crowned Sparrows with 95% confidence of correct assignment. There is potential for these percentages to be improved through the use of discriminant functions, increasing their utility for avian ecologists.*

Introduction

Many ecological studies rely on accurate sex determination of birds, but this can be difficult in sexually monochromatic species even when an individual is captured (Gill and Vonhof 2006, Ellrich et al. 2010, Jahn et al. 2010). During the breeding season, characteristics such as an alternate plumage, a brood patch (in females) or a cloacal protuberance (in males) are usually reliable indicators of sex (Svensson 1992, Pyle 1997). Outside of breeding season, prebasic molts often result in similar plumages in male and female passerines, and breeding characteristics such as brood patches and cloacal protuberances are lost. Invasive sexing methods such as laparotomies and less invasive methods such as blood sampling work well but are subject to ethical issues, can be time-consuming, and are not practical for all birds captured at banding stations (Griffiths et al. 1998, Ellrich et al. 2010).

Invasive methods may not be necessary when careful measurements are taken. Many species which are monochromatic in plumage are dimorphic in size, with males averaging larger than females (Piper and Wiley 1991, Svensson 1992, Pyle 1997, Twedt 2004, Gill and Vonhof 2006, Murphy 2007, Ellrich et al. 2010). Due in part to this sexual size dimorphism, bird banders usually measure wing chord and sometimes tail, tarsus and/or bill lengths (Gosler et al. 1998, Twedt 2004, Gill and Vonhof 2006, Frey et al. 2008, Covino 2015, French et al. 2016). These measurements are then compared to known ranges for the species or subspecies, listed in Pyle (1997) for North America and Svensson (1992) for Europe. Males are generally at the higher end of the range of measurements, and females at the lower end, with a few species showing little to no overlap in measurements between sexes (Pyle 1997). For sexually monochromatic species with considerable overlap in these measurements, many individuals are left as "sex unknown" outside of the breeding season because their measurements fall within the overlap zone (Pyle 1997).

Many bird banders are wary of using the measurements listed in Pyle (1997) as the sole

indicator of sex (French et al. 2016). Factors such as museum specimen shrinkage due to preparation technique and desiccation, migration distance of the population, sample size, geographic variations in individual size, age of the individual, and feather wear could all contribute to differences in wing chord ranges between Pyle (1997) and live birds (Stewart 1963, Alatalo et al. 1984, Jenni and Winkler 1989, Svensson 1992, Fielder 2005, Green et al. 2009, Jahn et al. 2010, Zaniewicz 2012, Covino 2015). Some of these issues are addressed in Pyle (1997), with measurements of subspecies included for most species, and a note in the introduction that wing chord in younger birds averages 1-3 mm shorter than adults.

Given that accurate sex identification during the non-breeding season is beneficial to studies controlling for sex, wing chord ranges specific to age, sex and geographic location are highly desirable. Here, working with Beack's Wrens of the Pacific Northwest subspecies (*Thryomanes bewickii calophonus*) and "Puget Sound" White-crowned Sparrows (*Zonotrichia leucophrys pugetensis*), I compared the wing chords of birds sexed by breeding characteristics with the wing chord ranges given in Pyle (1997). My goal was to determine whether measurements can be used to accurately identify the sex of these two subspecies in southwestern British Columbia

Methods

The study subspecies, *calophonus* Bewick's Wren and "Puget Sound" White-crowned Sparrow, were chosen for their high capture rates in the study area and status as year-round residents, eliminating the possibility that individuals could be from a population with a different average wing length. The Rocky Point Bird Observatory (RPBO) on southern Vancouver Island, British Columbia and the Monitoring Avian Productivity and Survivorship (MAPS) program provided raw data collected during April to August in the Capital Regional District.

RPBO operates migration monitoring stations at two sites: one on Department of National Defense land at Rocky Point (48° 19' 12" N, 123° 32' 52" W), and the other at the Pedder Bay Marina (48° 21' 7" N, 123° 34' 40" W). At both sites, birds were captured passively using mist nets. Data collection occurred from 1994 to 2006 and 2008 to 2018 at the Rocky Point site and from 2012 to 2018 at the Pedder Bay site, in accordance with the Canadian Migration Monitoring Network Protocol (North American Banding Council 2001a, 2001b, Hussell and Ralph 2005).

Data collection for the MAPS program occurred from 2003 to 2006 and 2008 to 2017 using the MAPS protocol (DeSante et al. 2014). This program included four stations: Rocky Point, at RPBO (2003-2006, 2008-2011), Royal Roads University in Colwood (48° 25' 40" N, 123° 28' 45" W; 2003-2006, 2008-2009), Witty's Lagoon in Metchosin (48° 23' 3" N, 123° 30' 55" W; 2009-2017) and Madrona Farm, north of Victoria (48° 29' 16" N, 123° 210" W; 2011-2017). Birds were captured passively with mist nets at each station.

In both the RPBO migration monitoring and MAPS programs, the unflattened wing chord was measured in accordance with the North American Banding Council (2001a, 2001b) and guidelines in Pyle (1997). A small (~1 mm) variance in average wing chord measurements among recaptured individuals indicated that banders' measurements were reliable within 1 mm and that feather wear had minimal impact on measured wing chord. The age of each bird was determined using feather and breeding characteristics, and sex determined using breeding characteristics if possible (Pyle 1997). Combining newly banded birds and recaptures from all stations across all years yielded 2,410 records of Bewick's Wrens and 5,943 records of White-crowned Sparrows ("Puget Sound" and unknown subspecies, excluding individuals known to be of the "Gambel's" subspecies).

Of these, only individuals aged as After Hatch Year or After Second Year were included, as younger birds average shorter and more worn wings (Alatalo et al. 1984, Covino 2015, French et al. 2016). Birds of unknown sex and birds sexed using characteristics other than brood patch or cloacal protuberance were also removed. By removing birds lacking breeding characteristics, other subspecies of White-crowned Sparrow were

removed because they do not breed in or near the region (Chilton et al. 1995). Duplicate captures were removed by comparing band numbers of individuals; in cases where a bird was caught in multiple years, the record where the bird was the oldest was used, if wing chord was recorded; otherwise the first capture record where wing chord was recorded was used. This resulted in sample sizes of 66 female and 28 male Bewick's Wrens, and 70 female and 25 male "Puget Sound" White-crowned Sparrows.

Using these data, the percentage of birds in each species and sex correctly identified as male or female by wing chord ranges in Pyle (1997) was determined. Birds were counted as definitively sexed by wing chord if their wing chord fell outside of the female-male overlap range given in Pyle (1997) and within the range of their sex as determined using breeding characteristics. Birds were considered incorrectly sexed by measurements if their wing chord fell outside the overlap range outlined in Pyle (1997) and within the range of the opposite sex. Birds were counted as correctly sexed if they were assigned as definitively sexed or unknown (i.e., not incorrectly sexed) using the wing chord ranges in Pyle (1997). To test the success of sexing known-sex individuals by wing chord, a series of exact binomial tests was performed by species and sex (Conover 1971). The hypothesized success rate was set to 95%, the cutoff listed as acceptable by the Bird Banding Laboratory (BBL) and the Canadian Wildlife Service (CWS) (Pyle 1997).

Wing chord ranges for RPBO data were calculated using the same method outlined in Pyle (1997), calculating the mean plus-or-minus two standard deviations to approximate a 95% confidence interval. The RPBO wing chord ranges were then compared with those in Pyle (1997) for consistency. A proportion distribution comparing the occurrences of discrete wing chord values was used for each species to visualize differences by sex. Welch Two-Sample t-tests were conducted to determine the significance of differences in means between sexes for each species. Analyses were performed using the statistical software package R version 3.4.3 (R Core Team 2017).

Results

The wing chord ranges listed in Pyle (1997) correctly sexed 97.9% of the *calophonus* Bewick's Wrens (98.5% of females and 96.4% of males) and 98.9% of the "Puget Sound" White-crowned Sparrows (98.6% of females and 100% of males) included in this study (Table 1). This met the 95% success rate outlined by the BBL and CWS, as shown by the exact binomial tests ($P > 0.05$) (Table 1). These wing chord ranges definitively sexed 53.2% of *calophonus* Bewick's Wrens (54.5% of females and 50.0% of males) and 22.1% of "Puget Sound" White-crowned Sparrows (22.9% of females and 20.0% of males) (Table 1).

For "Puget Sound" White-crowned Sparrows, wing chord ranges created using RPBO data matched those found in Pyle (1997). Wing chord ranges created using RPBO data for *calophonus* Bewick's Wrens differed slightly from those found in Pyle (1997), with the lower limit of the range 2 mm lower at RPBO for females and 1 mm lower for males (Table 2).

Male *calophonus* Bewick's Wrens averaged 3.1 mm longer wing chords than females (means of 53.4 and 50.3; $t = 8.8$, $df = 51$, $P < 0.001$, 95% CI: 2.4-3.8), while male "Puget Sound" White-crowned Sparrows averaged 3.2 mm longer wing chords than females (means of 71.0 and 67.8; $t = 7.0$, $df = 44$, $P < 0.001$, 95% CI: 2.3-4.2) (Figures 1 and 2).

Discussion

These results suggest that the wing chord ranges in Pyle (1997) can be used to determine the sex of adult "Puget Sound" White-crowned Sparrows and *calophonus* Bewick's Wrens in the study region with >95% accuracy. One possible improvement is that the wing chord range for *calophonus* Bewick's Wrens should be expanded for both sexes, lowering the cutoff for unknown birds from 51 mm to 50 mm. This discrepancy between the wing chord ranges found in Pyle (1997) for Bewick's Wrens and those obtained using RPBO data may be a result of sample size. Pyle (1997) lists a sample size of n = 10 for both sexes, while the RPBO dataset had a sample size of n = 66 females and n = 28 males, allowing for

Table 1. Percent of individual adult, known-sex *calophonus* Bewick's Wren (BEWR) and "Puget Sound" White-crowned Sparrow (PSWS) correctly sexed using wing chord ranges in Pyle (1997). The number definitively sexed refers to those individuals which have a wing length falling within a species' exclusively male or female wing chord range in Pyle (1997). Percent correctly sexed refers to the number of individuals assigned as definitively sexed or unknown vs. those incorrectly sexed.

Species	Sex	Number definitively sexed	Number unknown	Number incorrectly sexed	% Correctly sexed	95% CI	P (probability = 0.95)
BEWR	Female	36	29	1	98.5	91.8-100	0.263
	Male	14	13	1	96.4	81.6-99.9	1
	Total	50	42	2	97.9	92.5-99.7	0.336
PSWS	Female	16	53	1	98.6	92.3-100	0.266
	Male	5	20	0	100	86.3-100	0.635
	Total	21	73	1	98.9	94.3-100	0.094

Table 2. Sex-specific wing chord statistics for adult *calophonus* Bewick's Wren (BEWR) and "Puget Sound" White-crowned Sparrow (PSWS), and for ranges given in Pyle (1997). "SD" represents the standard deviation. Units for all values are in mm.

	BEWR		PSWS	
	Female (n=66)	Male (n=28)	Female (n=70)	Male (n=25)
RPBO Range	46-54	49-57	62-73	67-76
RPBO (mean ± 2 SD)	47-53	50-56	64-72	67-75
Pyle (1997)	49-53	51-56	64-72	67-75
Median	50	53.5	68	71
Mean	50.3	53.4	67.8	71.0
SD	1.58	1.57	2.08	1.99

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White-crowned sparrow eastern subspecies Photo R.Pantle

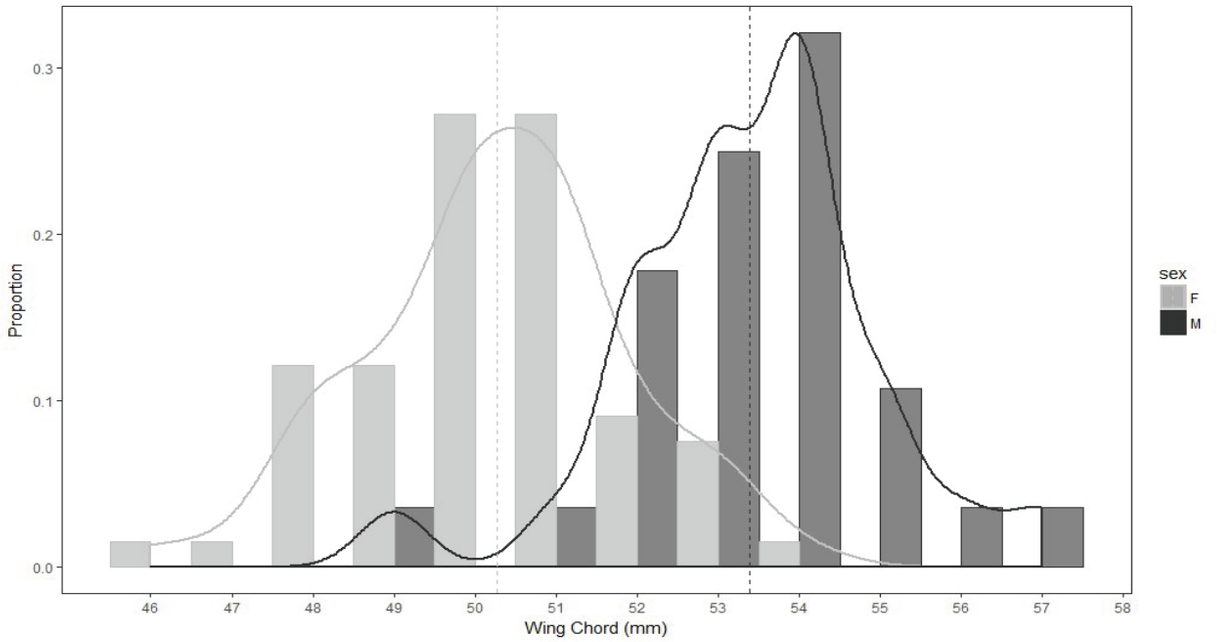

Fig. 1. Proportion histogram of measured wing chords (± 1 mm) for male (dark) and female (light) Bewick's Wrens, with associated density curves. Dashed lines indicate mean wing chord by sex.

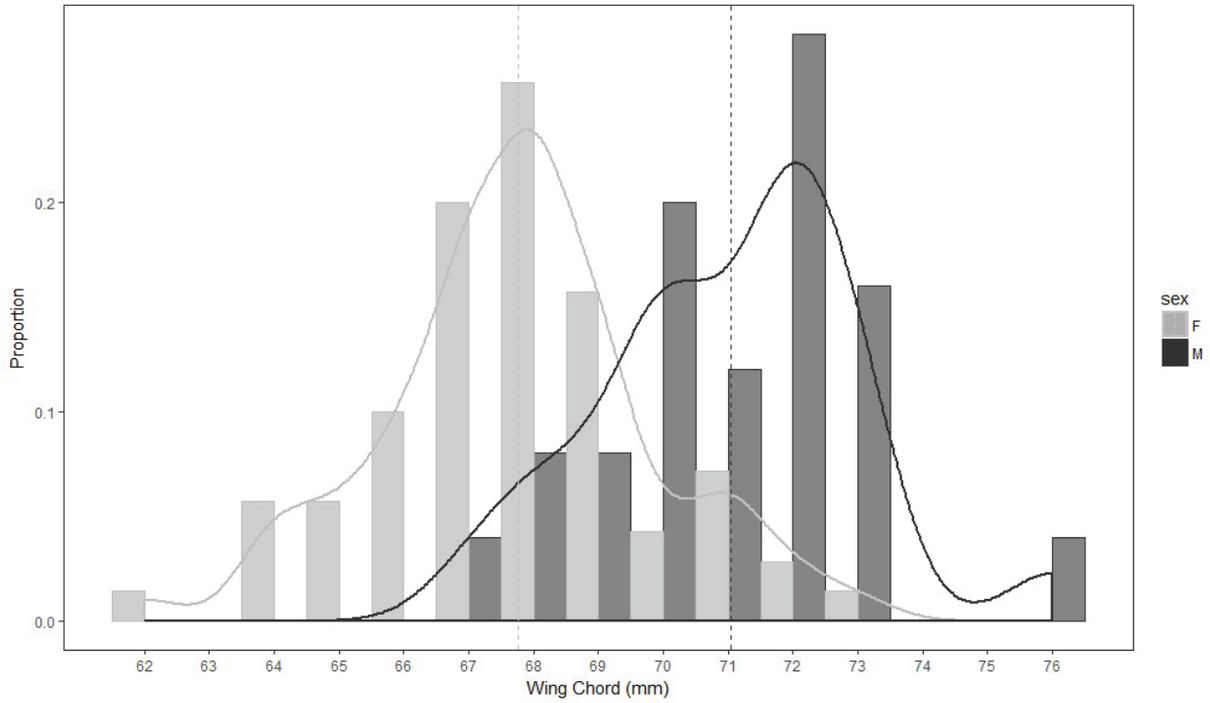

Fig. 2. Proportion histogram of measured wing chords (± 1 mm) for male (dark) and female (light) "Puget Sound" White-crowned Sparrows, with associated density curves. Dashed lines indicate mean wing chord by sex.

more robust ranges. These expanded ranges could be useful to researchers in the region wishing to conduct studies involving sex, and suggest that the use of wing chord for sexing individuals should be explored in other populations of these species.

Age-related variation in wing chord lengths was controlled for by excluding Hatch- and Second-Year birds (Alatalo et al. 1984, Covino 2015, French et al. 2016). It is possible that feather wear or unrecorded primary molt in adult birds could have affected wing chord lengths, especially in females (Merilä and Hemborg 2000). This may account for the few individuals with extremely low wing chord values by species and sex, but is unlikely to have a large effect on the dataset, as individuals with extreme feather wear or obvious molt did not typically have their measurements recorded.

There is potential for the number of definitively sexed individuals to be improved with the use of discriminant function analyses (DFAs) combining multiple morphological measurements, as has been done for other species, including other wrens and sparrows (Hanners and Patton 1985, Sweeney and Tatner 1996, Walton and Walton 1999, Gill and Vonhof 2006, Murphy 2007, Dechaume-Moncharmont et al. 2011, Covino 2015). Using these data and removing individuals with no mass recorded (n = 2 for both species), I performed a test DFA on each subspecies, combining wing chord and mass. Males of both subspecies averaged larger than females for both measurements. Taking into consideration the limits of these data for use in such an analysis (small sample size, only two variables: wing and mass, lopsided sample with n(female) >> n(male) and older records recording mass to the nearest gram), test DFAs for these species were promising and definitively sexed ~80% of "Puget Sound" White-crowned Sparrows and ~87% of *calophonus* Bewick's Wrens that were used to create the formulas. This is a substantial increase over the values of 22.1% and 53.2%, respectively, obtained using wing chord alone.

Future studies should consider taking genetic samples to improve sexing accuracy and sample sizes, and include more morphological measurements (such as bill and tail length) and age classes in order to create more applicable and accurate wing chord ranges and/or DFAs by species, age and region.

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