A Method to Improve Age Determination of Male Bobolinks in Alternate Plumage

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ABSTRACT

No reliable molt and plumage criteria have been developed for determining the age of Bobolinks (*Dolichonyx oryzivorus*) in alternate plumage. Because this species has two complete molts per year, it is reasonable to assume that variation may be found in plumage traits. I, therefore, assessed the crown and nape plumage of the male Bobolink to see if it would provide an indicator of age. I assessed this trait along with more direct measures of body size: back patch width / length and standard wing chord. I developed a discriminant function using the distance between the posterior edge of the exposed culmen and the anterior edge of the nape that could classify 17% of unknown-age birds into age categories. Contrary to my expectations, this distance tended to increase with age. I posit several possible mechanisms for this trend and provide the cutoff values for aging second-year male Bobolinks when the nape to culmen distance is <14.6 mm and for after-second-year when it is >25.5 mm. Although there is a great degree of overlap in this measure, individuals at the extremes are able to be aged, and the function increases our reliability of aging from "<5%" (Pyle 1997) to within "5-25%". This method should serve as a stepping-stone to further necessary research on age determination of Bobolinks.

INTRODUCTION

Age determination of individuals in a population is essential to precise studies of avian life history and demography. Aside from rare long-term research projects on marked individuals, measurement and assessment in-hand (particularly when banding) is currently the best tool for reliable age estimation of live birds. Several methods for in-hand age estimation are commonly used, such as examination of certain biochemical parameters (Chaney et al. 2003), body morphometrics (Prince and Rodwell 1994, Mather and Esler 1999), and molt and plumage criteria (Pyle 1997), which has certainly become the most widely applied technique.

Despite these major advances, certain species defy our ability to estimate age accurately. For instance, no reliable molt or plumage criteria have been developed for Bobolink (*Dolichonyx oryzivorus*) (i.e., <5% reliability to age individuals in alternate plumage; Pyle 1997). Bobolinks undergo two complete molts per year and achieve part of their breeding plumage coloration through wearing of buff tips off alternate feathers (Chapman 1890). Therefore, molt limits have not been observed commonly in this species. This presents a major limitation to our ability to study this species and its ecology appropriately.

In lieu of using molt limits to estimate age, it is possible to use other plumage traits that may vary with age. Examples of such plumage traits are dominance signals like badges, epaulets, or bright patches, which can become enlarged and/or brightened over time. Change in these status symbols is expected as an animal becomes older, more experienced, and/or reproductively fit. This phenomenon has been documented well in species such as House Sparrow (*Passer domesticus*; Veiga 1993), Red-winged Blackbirds (*Agelaius phoeniceus*; Johnsen et al. 1996), and Blue Grosbeaks (*Guiraca caerulea*; Keyser and Hill 1999). However, such forms of plumage variation that might allow age estimation have not been reported for Bobolinks, and no alternative method has yet been described.

Bobolinks have a buff nuchal collar (which I hereafter refer to as the 'nape') that may vary with age and possibly serve as a dominance signal.

Therefore, I predicted that estimating age in alternate-plumaged male Bobolinks could be possible by monitoring nape patch extent. Although I expected there to be great overlap, I reasoned that some birds might present extreme values allowing for age estimation reliability greater than 5%. To do this, I performed a discriminant function analysis (DFA) on plumage and morphometric data from a set of known-age wild Bobolinks, including the distance between the culmen and nape patch as a measure of patch extent. To determine if this measurement was simply correlated with body size, I also included wing chord and back patch width and length as variables in the analysis.

METHODS

Study site and banding - This study was conducted in hayfields of the western Annapolis Valley of Nova Scotia, Canada. Four study sites totaling 648 ha, centered around 44°45'N, 65°31'W, were used as part of a larger research project. During May-September of 2002-2004, adult male Bobolinks were captured on their territories using standard 36-mm nylon mesh mist nets. For this study, a total of 66 adult males were banded with a standard metal Canadian Wildlife Service leg band and a unique combination of colored celluloid bands. Each individual, when captured or recaptured, was measured for wing chord, nape-to-culmen distance, and back patch width and length (see below).

Ageing criteria and measurements - All acronyms referring to age follow Pyle (1997) where HY = hatch year, AHY = after-hatch-year (i.e., unknown age adult), SY = second-year, and ASY = after-second-year. I used plumage and skull ossification criteria for aging Bobolinks in-hand (Pyle 1997) to determine if a bird was HY or AHY during July-September. Beyond these coarse age classes, Pyle does offer that some (<5%) individuals show "...brown-tipped pp covs on SY♂♂ vs uniformly black covs on ASY♂♂, and occasional retained middle ss (among s3-s6) on both sexes...that may indicate SY; more study is needed." Assuming that these criteria were applicable, I was able to further separate 10 birds as probably-SY. I also classified 10 birds as ASY based on their known-age banding histories.

Anterior nape extent was measured with calipers (to the nearest mm) as the distance between the posterior edge of the exposed culmen and the anterior edge of the nape patch (Figure 1). This distance (hereafter called "nape-to-culmen distance") was used because the absolute length of the nape patch varies widely due to position of the head and neck, becoming broader as the bill is moved downward (e.g., as if the bird were to be 'skulled'). By contrast, the distance between culmen and nape varies little. Numerous recaptures within a season showed that nape-to-culmen distance suffered little inter-observer measurement error and did not change over the course of the season.

Fig. 1. Profile of an alternate plumaged male Bobolink in-hand, with measurement between posterior edge of the exposed culmen and anterior edge of nuchal collar (nape) indicaed. The photo demonstrates why the nape was not measured directly, as with head upright (shown) it might vary little, but with bill-under-thumb could conceivably vary widely due to stretching.

To address any confounding correlation with body size, back patch width and length were also measured, at their widest extents, with calipers while the bird was in an upright position. An unflattened wing chord was measured with a flat-end wing-rule as an additional body size metric.

Analysis - I performed a DFA on all metrics taken for ASY and probable-SY birds. Analysis of variance was first used to determine which variables significantly ($p < 0.05$) contributed to the DFA. The DFA was then generated using multiple regression (Sokal and Rohlf 1995) and the resultant equation identified the least-squares best predictor of age-class membership. Because the ultimate goal is to establish a field-usable criterion, I present the DFA equation *and* 95% confidence interval cutoffs.

RESULTS

Although a great proportion of banded birds were re-observed subsequently, many for multiple years, only 10 male Bobolinks were recaptured in subsequent years so that I could obtain inter-annual plumage measurements. These data show that there was a mean *increase* in nape-to-culmen distance, by ~1.9 mm per year. Wing chord and back patch measurements were not as inter-annually variable. Initial analysis of variance showed that back patch width ($F_{1,19}$ = 1.75, p = 0.21), length ($F_{1,19}$ = 1.43, p = 0.31), and wing chord ($F_{1,19}$ = 1.83, p = 0.20) did not contribute significantly to the model, but nape-to-culmen distance did ($F_{1,19}$ = 5.01, p = 0.04). The DFA was thus run for nape-to-culmen distance of known ASY and presumed-SY birds and resulted in a least-squares regression (Figure 2) equation of:

*Age = -3.500 + (0.1745 * nape-to-culmen distance)*

Figure 2 shows the regression line for this equation with associated 95% confidence limits of the moving average, plotted on the data that generated the function. It indicates that 30% of ASY, and 40% of SY birds, would have been aged correctly according to this function alone.

The 95% confidence limits of this function are 14.6 - 25.5 mm nape-to-culmen distance, where individuals with measurements below this range can be estimated safely as SY birds, and those above as ASY. Alternatively, if a nape-to-culmen distance measurement is entered into the function above, a result of 0.95 or greater would indicate an ASY bird, whereas –0.95 or less would indicate an SY bird.

Figure 3 shows the 95% confidence limits (as cutoff points rather than a moving average as in

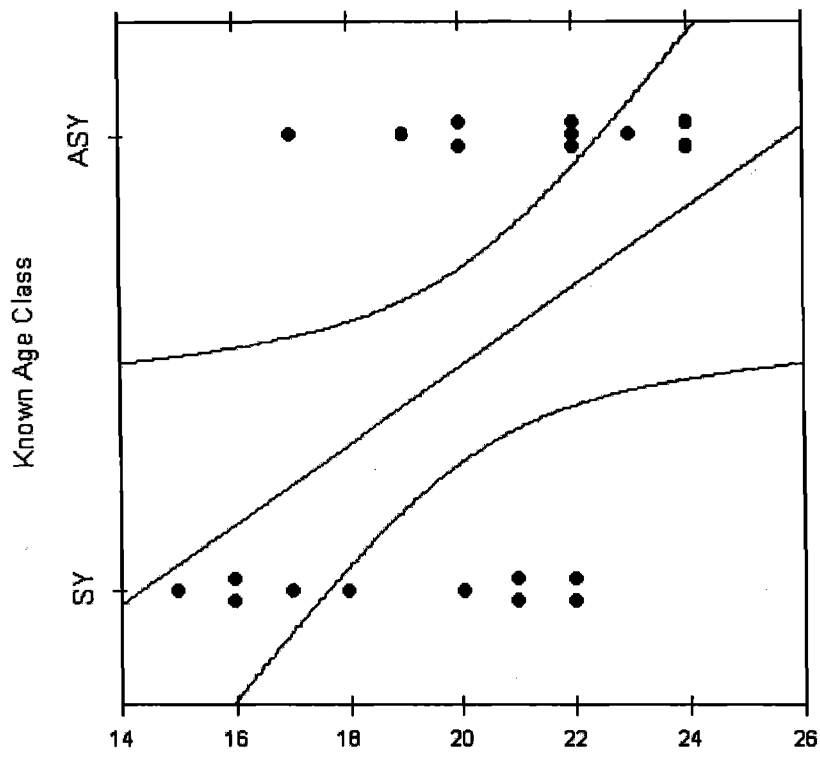

Fig. 2. Discriminant function for classifying second-year (SY) and after-second-year (ASY) male Bobolinks in alternate plumage using the distance (in mm) between the posterior edge of the exposed culmen and the anterior edge of the nuchal collar (nape). Data used in generating this function were from known ASY birds (determined by previous banding records), or from SY birds (presumed from occasional retention of brown tipped primary coverts). The function is depicted as a least-squares best-fit regression, with 95% confidence intervals of the moving average, that has a slope of: Age = -3,500 + (0.1745 * nape-to-culmen distance).

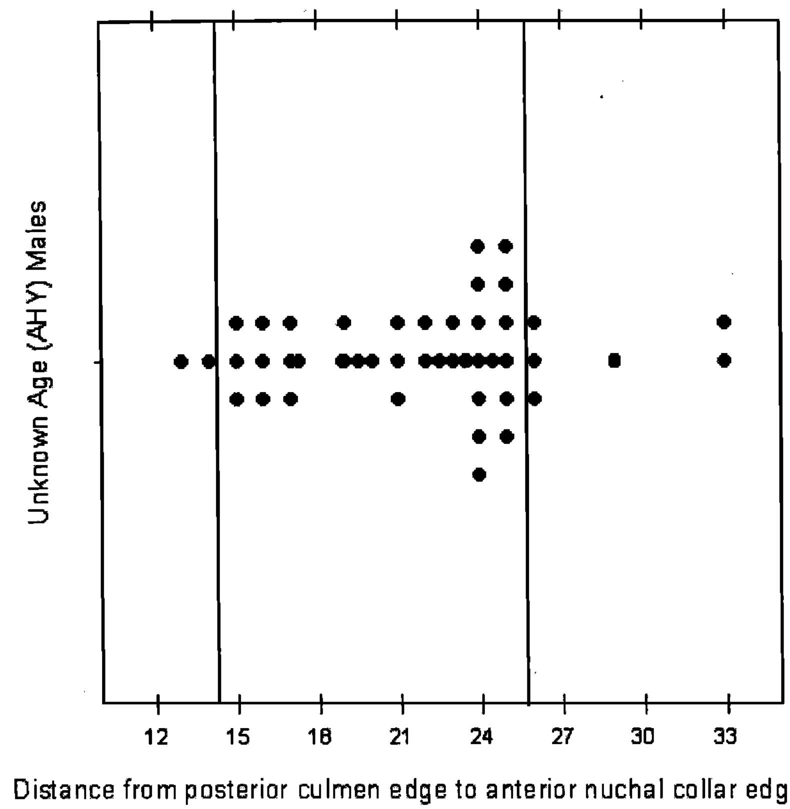

Fig. 3. Application of 95% confidence limit cutoffs for a function discriminating second-year (SY) and after-second-year (ASY) male Bobolinks in alternate plumage using the distance (in mm) between posterior edge of the exposed culmen and the anterior edge of the nuchal collar (nape). The function is applied to a population of 46 unknown age adult (AHY) males for which the nape-to-culmen distance was measured. This plot demonstrates that 17% (8 individuals) could be aged within the confidence limits of the function, where distance <14.6 mm indicates SY birds, and >25.5 mm indicates ASY birds.

Figure 2) applied to a set of unknown age (AHY) birds from the same population for which nape-to-culmen distance was measured. In this plot, a further 17% (eight individuals) of birds could be aged within the confidence limits of the function.

DISCUSSION

The DFA showed that nape-to-culmen distance was a statistically significant predictor of age, while measures more related to body size, such as back patch size and wing chord were not. The function was able to discriminate 17% of birds of unknown age into SY or ASY age classes.

The trend that nape-to-culmen distance increased with age was counter to what I predicted. If the nape does function as a social dominance signal, perhaps it does so by some other measure of area, such as width, or by changes in hue or brightness (none of which were measured in this study, but have been shown to be important in other species, e.g. Fitzpatrick 1998, Pryke et al. 2002).

Conversely, the real dominance signal may instead be a narrower nape patch and/or more black on the head.

Alternatively, variation in nape patch metrics may not be a selective trait at all, although that is unlikely as I did find some variation with age However, if this were true, then I predict that pairing success and dominance would not be related to nape patch size. There is a basis for this prediction, as social dominance was not observed to covary with epaulet size in Red-winged Blackbirds (Weatherhead and Boag 1995) or forehead badge size in Pied Flycatchers (*Ficedula hypoleuca*; Dale et al. 1999). Further, in House Finches (*Carpodacus mexicanus*), it has been shown that selection for ornament size is strongest in those males that did *not* have mates the year before, thus reducing selection for ornament quality for older males (Badyaev and Duckworth 2003).

In combination with seldom-usable molt criteria for Bobolinks, the function derived in this paper has provided a stepping-stone to increase the Bobolink's age estimation reliability category (Pyle 1997) from "<5%" to a slightly more reliable "5-25%". But, I strongly encourage that more plumage criteria need to be examined. Other patches, or plumage traits such as border regularity (i.e., immaculateness) or ultraviolet reflectance patterns, may hold further clues to improve our ability to determine age of male Bobolinks in summer. Although annual reduction in nape distance poses an intriguing mechanism for further study in itself, future examinations may determine that other criteria far exceed the power of the function generated here, or augment it.

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