Spectral Plumage Reflectance of Breeding Common Yellowthroats in Northeastern Pennsylvania

Andrew Wynne and Robert Smith, Department of Biology, The University of Scranton, Scranton, PA, 18510

Introduction
Both humans and birds are able to perceive wavelengths within the visible spectrum (400-700 nm). Many avian species, however, can also recognize wavelengths beyond (315-400 nm) due to an additional cone type within the retina. Each cone type is able to detect a certain range of wavelengths and the tetrachromatic ability of birds allows ultraviolet (UV) detection. Recent technological breakthroughs have allowed scientists and researchers to examine avian coloration patterns beyond the visible spectrum. This is important because now the UV spectrum is able to be analyzed, which provides a better understanding of bird coloration, as well as the role coloration plays in avian behavior and breeding ecology.

Objectives
The purpose of this study was to:
- Analyze feather coloration in Common Yellowthroats breeding in Northeastern Pennsylvania by looking at feather color attributes (brightness, hue, and saturation) relative to both age and sex in rectrices (tail feathers).
- Look for the presence of UV reflectance in Common Yellowthroat rectrices.

Methods
Common Yellowthroat rectrices were collected from two study sites- one located in Lackawanna State Park and the other on private property immediately adjacent to the Park in Lackawanna County in Northeastern Pennsylvania (Figure 1a, b). One rectrix was collected from each bird during the breeding seasons of 2004, 2005, and 2006 (June 1st through August 15th). Sex and age [Second Year (SY) or After Second Year (ASY)] was determined using the plumage criteria outlined in Pyle (1997).

We used an Ocean Optics spectrometer, SpectraSuite (Ocean Optics 2007), and CLR: Colour Analysis Programs v1.02 software (Montgomery 2008) to collect reflectance data. We collected reflectance data from 53 birds, one rectrix from each. From each rectrix we recorded nine different readings, (three each from three random locations). Reflectance graphs were examined for evidence of reflectance in the UV spectrum. We then used a Mixed-model analysis, controlling for individual, to compare brightness, saturation, and hue by age and sex, specifically looking at the 300-700 nm range.

Figure 1a. Aerial photo of our study site taken in 1992. The study site has undergone significant secondary succession since this photo was taken.

Figure 1b. Our study site in northeastern Pennsylvania. An asterisk denotes the location

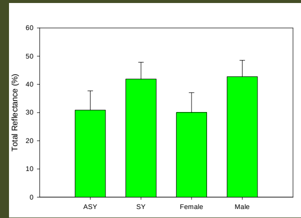

Figure 3. Rectrix brightness by age and sex of Common Yellowthroats collected in Northeastern Pennsylvania, 2004 – 2006.

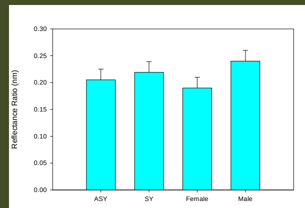

Figure 4. Rectrix saturation by age and sex of Common Yellowthroats collected in Northeastern Pennsylvania, 2004 – 2006.

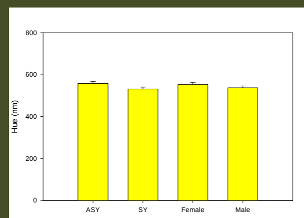

Figure 5. Rectrix hue by age and sex of Common Yellowthroats collected in Northeastern Pennsylvania, 2004 – 2006.

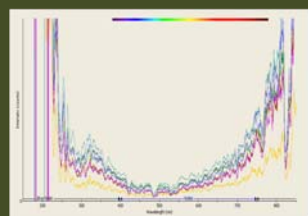

Figure 2. Composite spectra showing UV, visible and IR reflection in rectrix feathers for 6 representative individuals. The instrument's effective measurement range is 200 – 850 nm.

Results
Ultraviolet (UV) - Our results suggest that Common Yellowthroat rectrices do reflect in the UV spectrum (Figure 2).
Infrared (IR) - Although we did not specifically look for IR reflectance, it appears that Common Yellowthroat rectrices strongly reflect in the near IR spectrum (Figure 2).
Brightness- We did not find an age ($F_{1,41}$ = 1.511, P = 0.226) nor sex ($F_{1,41}$ = 1.984, P = 0.167) effect, perhaps due to small sample sizes (Figure 3).
Saturation- Similar to brightness we did not find an age effect ($F_{1,41}$ = 0.295, P = 0.590) though a sex effect ($F_{1,41}$ = 3.462, P = 0.07) approached significance. Males appeared more saturated than females (Figure 4).
Hue- There may have been an age effect ($F_{1,41}$ = 3.569, P = 0.066) such that the rectrices of older Common Yellowthroat reflected at longer wavelengths than younger birds. Hue did not appear to vary by sex ($F_{1,41}$ = 1.204, P = 0.279; Figure 5).

Conclusion
-We found evidence for both IR and UV reflectance in Common Yellowthroat rectrices, with strong reflectance occurring toward the lower end of the UV and IR spectra. More work in needed to evaluate the role IR and UV reflectance plays in the breeding ecology of this species.
-Our results with respect to feather brightness are inconclusive, perhaps due to sample size limitations and a consequent inability to detect statistical differences. We intend to continue data collection to increase statistical testing power.
-The black mask and yellow throat in this species are primary sexually selected traits (Dunn et al. 2008), hence our finding of no significance in brightness may reflect rectrix coloration not playing a major role in Common Yellowthroat mate choice.
-Saturation is a measure of the degree to which a color appears to pure (Andersson and Prager 2006), and most avian yellow coloration is due to carotenoid pigments (McGraw 2006). Sex-based differences in saturation suggest this aspect of feather coloration may play a role in sexual selection, supporting the hypothesis that carotenoid-based ornaments are important in female mate choice (Dunn et al. 2008).
-Age effects in hue may reflect a number of factors. For example, young birds are subordinate, typically holding lower quality territories. Because birds cannot synthesize carotenoids these pigment molecules must be acquired via diet, hence an age effect in hue may reflect age-related differences in territory quality. Further, carotenoids play a critical role in immune function (Ferns and Hinsley, 2008) hence the observed variation may reflect age-related differences in overall health.

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