Spectral Plumage Reflectance of Breeding Gray Catbirds in Northeastern Pennsylvania

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Introduction

Many bird species are capable of perceiving wavelengths both within (400 – 700 nm) and beyond (315 – 400 nm) the human visible spectrum. This is because these birds are tetrachromatic, possessing four retinal cone types whereas humans are trichromatic. Different cones are tuned to different wavebands of light and the extra cone birds have detects ultra violet (UV) wavelengths. There is a rich history of the study of avian color, however until recently researchers have only been able to examine wavelengths visible to the human eye. Recent technological advances have lead to the development of portable spectrometers, instruments used to assess reflectance in both the visible and UV spectrum. Consequently, an increasing number of studies are demonstrating that UV reflectance and other plumage color attributes play roles in the behavioral ecology of birds.

Objectives

The purpose of this study was to 1) look for UV reflectance and 2) assess visible reflectance differences by age and sex in rectrices and body contour feathers collected from Gray Catbirds (*Dumetella carolinensis*) captured at study sites in northeastern Pennsylvania.

Methods

We collected feather samples from two study sites - one located in Lackawanna State Park and the other on private property immediately adjacent to the Park, Lackawanna County, northeastern Pennsylvania (Figure 1). We collected one rectrix and no more than four body contour feathers from each individual during the breeding seasons of 2005 and 2006 (June 1st through August 15th). Birds were aged as Second Year (SY) or After Second Year (ASY) using the plumage criteria outlined in Pyle (1997). Because catbirds are monomorphic, we used morphological evidence associated with breeding, e.g., the presence of an obvious cloacal protruberance (male) or a brood patch (female) to determine sex.

We used an Ocean Optics spectrometer to collect reflectance data and interpreted our results using Spectra Suite (Ocean Optics 2007) and CLR: Colour Analysis Programs v1.02 software (Montgomerie 2008). For each bird we measured reflectance from one rectrix at two points 7.0 cm and 4.5 cm from the tip of the calamus and averaged the readings. For each body contour feather we also collected and averaged two readings at 5.0 cm and 3.0 cm from the calamus tip. Finally, because we measured multiple body contour feathers from each bird we calculated an overall body contour feather average for each bird. We examined reflectance spectra graphs for evidence of reflectance in the UV and compared the three major color attributes, brightness, hue, and saturation by age and sex looking at the range of 300nm to 700nm. We used non-parametric General Linear Models (GLMs on ranked data; Zar 1996) to assess age and sex related variation in our reflection measurements and Spearman's nonparametric correlations to assess relationships between brightness and hue.

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

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

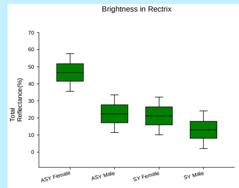

Figure 3. Brightness in rectrices according to total reflectance (%).

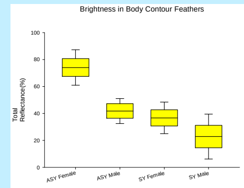

Figure 7. Brightness in body contour feathers according to total reflectance (%).

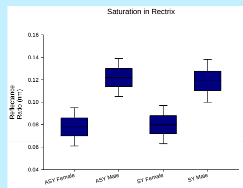

Figure 4. Saturation in rectrices according to the reflectance ratio in nanometers.

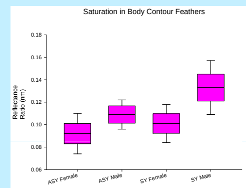

Figure 8. Saturation in body contour feathers according to the reflectance ratio in nanometers.

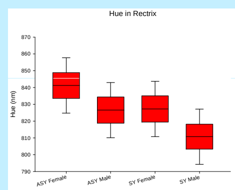

Figure 5. Hue in rectrices measured in nanometers.

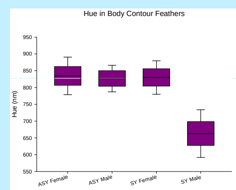

Figure 9. Hue in body contour feathers measured in nanometers.

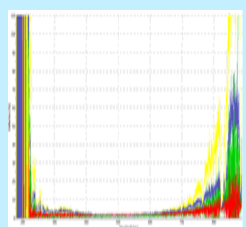

Figure 2. Spectra of UV, visible and IR reflection in rectrix feathers.

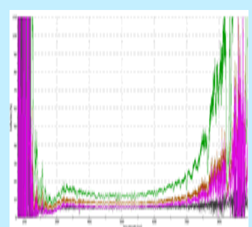

Figure 6. Spectra of UV, visible and IR reflectance in body contour feathers.

Results

Rectrices:

UV – Examination of reflectance spectra of all birds suggest catbird rectrices do reflect in the UV, though not to any great extent (see Figure 2).

Infrared – While we did not quantify IR reflectance, it is clear that catbird rectrices reflect strongly in the near IR (Figure 2).

Brightness – We found a sex ($F_{1,44}$=16.997, p<0.001) and age effect ($F_{1,44}$=26.712, p<0.001); interestingly, females were brighter than males and older birds were brighter than younger birds (Figure 3).

Saturation – We found no age effect in saturation ($F_{1,44}$=0.026, p=0.873), however we did find a sex effect ($F_{1,44}$=77.224, p<0.001). Males were more saturated than females (Figure 4).

Hue – Our results suggest that there was both a sex ($F_{1,44}$=18.601, p<0.001) and age effect ($F_{1,44}$=17.851, p<0.001). Females had a significantly greater hue value than males and older birds had higher hue values than younger (Figure 5). Further, there was a strong correlation between brightness and hue (r = 0.660, n = 49, p<0.001).

Body Contour Feathers:

UV – Examination of reflectance spectra of all birds suggest catbird body contour feathers also reflect in the UV, though not to any great extent (see Figure 6).

Infrared – Similar reflectance patterns were present in body contour feathers as in rectrices (Figure 6).

Brightness – We found both a sex ($F_{1,27}$=28.262, p<0.001) and age effect ($F_{1,27}$=37.135, p<0.001) in brightness of body contour feathers. Females were brighter than males and older birds were brighter then younger (see Figure 7).

Saturation – There was both an age ($F_{1,27}$=4.461, p=0.044) and sex effect ($F_{1,27}$=13.286, p=0.001) in saturation level. Male coloration was more saturated than females and younger birds were more saturated than older (see Figure 8).

Hue – Hue varied by sex ($F_{1,27}$=10.480, p=0.003) and age ($F_{1,27}$=5.182, p=0.031); Females had a higher hue value than males and older birds had a higher hue value than younger birds (see Figure 9). Finally, there was a positive relationship between brightness and hue (r = 0.431, n = 31, p=0.016).

Conclusion

- While it appears that catbird plumage reflects in the UV range, total reflectance is low, suggesting that UV reflectance plays little, if any, role in mate choice.
- Female hue values were higher than males, indicating that females were lighter in coloration. This likely reflects a difference in plumage melanin deposition by sex [melanin is the predominant pigment in catbird feathers (McGraw 2006)]. There is some suggestion of a positive relationship between testosterone and melanin deposition during feather development, along with a negative relationship between estrogen and melanin deposition (see review by McGraw 2006).
- Our finding that females were brighter was interesting. Further investigation of this effect revealed positive relationships between hue and brightness – lighter birds were brighter. These relationships suggest female brightness may have been a consequence of the sex-based differences in hue.
- Saturation is a measure of the degree to which a color appears to be pure (Andersson and Prager 2006). The sex-based differences in saturation may reflect increased melanin deposition in male plumage – males were more saturated than females.
- The near IR reflectance is interesting and warrants further study. Possible explanations include 1) a nonadaptive consequence of melanin reflectance, 2) reducing thermal loading, as in plants (Gates 1970) or 3) reducing heat loss by reflecting near IR radiation back to the body.

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