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Using Feathers to Investigate Cross-Seasonal Effects of Nutrition on Important Winter Traits

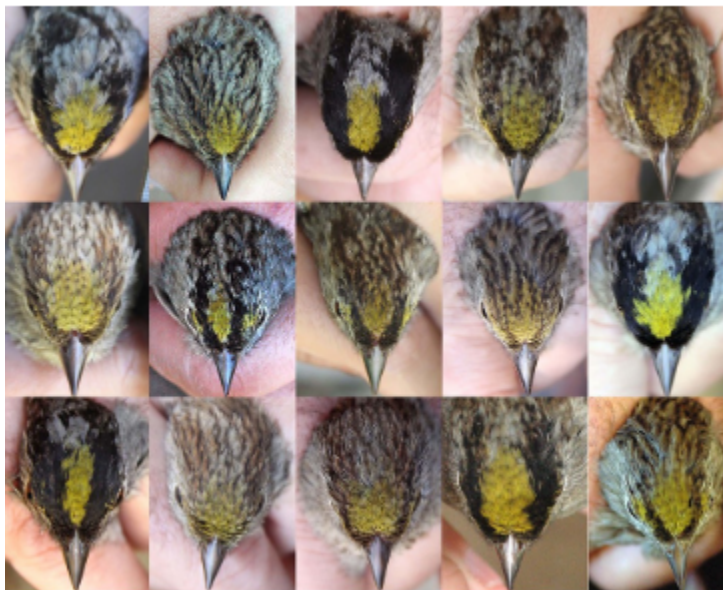
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By Dylan Pereira, Bruce Lyon, and Theadora Block



Golden-Crowned Sparrow showing its black and gold plumage patches. © Photo: Bruce Lyon

Why traits vary among individuals in populations is a fundamental question in evolutionary biology. In some cases, this variation reflects genetic effects. For example, body size has been shown to be a heritable trait in many species. It makes sense that differences in genetics will lead to differences in certain phenotypic traits like body size, but genetic variation between individuals is not the only factor fueling trait variation. Some trait variation is influenced by the differences between individuals in their condition or environment. For example, the nutritional conditions of greater snow geese (*Chen caerulescens*) affect their timing of breeding as well as their physiological ability to produce eggs. Several other studies of birds have found similar relationships between trait variation and nutritional conditions, showing that not all variation is caused by genetics alone.



Gold and black plumage patch variation on the crowns of individual sparrows. © Photo: Bruce Lyon

Clearly, traits are often influenced by both genetic and environmental influences and it can be tricky determining the relative importance of each effect. One approach to this problem is using feathers as a proxy for nutritional health and, particularly, the rate at which the feathers grow. Assessing feather growth rate after the fact is possible because of the way in which feathers grow. When feathers grow, the feather incorporates alternating dark and light bands of pigment in horizontal bands called growth bars (much like in the same way a tree grows a new ring for every year of new growth). Instead of showing a year's worth of growth per band, growth bars show a 24-hour period of growth per band. Previous studies found that manipulating the diet and nutritional condition of individuals affects the growth rate of feathers. Poor diet and nutritional condition slow the rate of feather growth, evidenced by shorter growth bars.

Golden crowned sparrows are migratory birds that breed in the far north and winter in the western USA. UC Santa Cruz Professor Bruce Lyon's long-term study of these sparrows at the UC Santa Cruz Arboretum revealed that variation in certain feather traits serve important social functions in the sparrows' winter societies. For example, the amount of gold and black plumage on golden-crowned sparrows' heads functions as 'badges of status' that are used to signal their relative fighting ability to each other. Other traits that vary between these sparrows include body size, social dominance, and the degree of genetic heterozygosity. Because these traits all show high degrees of variation between individuals, it begs the question as to whether these traits are at least partly condition-dependent.

I used tail feather growth rate of individual golden-crowned sparrows as an indication of their relative



Golden Crowned Sparrow feather with visible growth bars as alternating dark and light horizontal bands. © Photo: Dylan Pereira

nutritional condition during the period when the tail feathers grew (early Fall). In the Winter, I measured the growth bars of feather samples collected from golden-crowned sparrows at the UC Santa Cruz Arboretum. My measurements revealed that feather growth rate varied among birds. However, measuring feather bars from photos is difficult so I wondered if the variation I found truly represented variation among birds or was simply measurement error. To figure this out, I assessed the consistency of my measurements by formally calculating the repeatability of measurements. I measured each feather twice, using a blind test to ensure that measures were consistent. I found that the repeatability of my measurements was very high, indicating that I am able to measure feather growth rates accurately.

I compared feather growth rate with other important traits, like crown patch size and color, body size, dominance and genetic variation. I found a strong correlation between the color intensity of black plumage and feather growth rate, which suggests there is some form of nutritional-dependence in this social trait. I also found a suggestive

relationship between the area of black plumage and feather growth rate. These correlations make sense since the black coloration of this plumage is derived from melanin, which is a pigment that can become restricted or slowed by nutritional condition. Because the sparrow project is a long-term study with 15 years of data, the generality of my findings can easily be assessed by expanding the feather growth study to include a greater sample of year.

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