Is the color of museum mammal specimens an acceptable representation of the color of live animals?

Existing collections in Natural History Museums are often the basis of numerous studies in taxonomy, systematics, ecology, biogeography, management, conservation, etc., and studies based on biological museum specimens are to a large degree the basis of our understanding of the diversity of life on Earth. In discipline-specific research, as well as in broader global issues and public initiatives, resorting to specimens in museum collections has a number of advantages over using field specimens, given the taxonomic, geographic, and temporal range of samples, which is near impossible to achieve by sampling in the wild.

If museum specimens are to be used for studying color, they should accurately represent the color of live animals, or we should understand how they differ. There have been numerous investigations related to temporal changes in coloration of bird specimens in museum collections, and substantial differences in the color of newer and older specimens have been found. Meanwhile, variations of the pelage color of mammal specimens in relation to storage time have not been studied, with few exceptions. Therefore, it seemed reasonable for us to ask research questions related to the extent in which the color of museum mammal specimens may be considered an acceptable representation of the color of live animals.

We applied an objective color measurement methodology to the detection of patterns of changes in the pelage color of specimens of a small rodent species, in relation to the storage time, given the museum specific preparation, preservation and storage conditions, in order to complement previously obtained results for other small mammal species from other museums. For analyses we used skins from 54 adult specimens. We measured the pelage color of five points (neck, upper back, middle back, lower back, and rump) over the dorsal middle line of each specimen, inside a diffuse illumination cabin (where reflected light provided non-directional illumination, free of shadowing), through a spectroradiometer and a specialized software. For calculation of color data it is imperative the use of standard illuminants. We worked with a standard illuminant that represents typical tungsten-filament lighting (Commission Internationale de l'Eclairage, CIE). We matched collection dates (month and year, which ranged from 1970 to 2008), sex, and occurrence localities to each specimen color data. We used Principal Component Analysis and general linear models of Analysis of Variance for data analyses.

In addition to confirming the already reported relationship between the patterns of pelage color change and the season of the year, we also found that there is a relationship between specimen storage antiquity and pelage color: specimens get yellower and redder with storage antiquity. It is likely that the observed color change corresponds to the natural aging of the pelage and its pigments, which is determined by the prevailing storage conditions. The pelage of *Akodon budini* may have suffered breakdown of eumelanin pigment (a dark pigment that predominates in black and brunette hair), which would result in greater proportions of the redder pheomelanin pigment

and a redder overall coat color in older specimens.

Considering our results (even an unpublished more inclusive study with several species from two Argentinean and three Northamerican museums) and previous studies, it seems that there is a relationship between specimen storage antiquity and pelage color that could indicate a universal phenomenon across several mammal species and several storage conditions. It is important to highlight that our study does not intend to take away support from the use of museum specimens to examine intra or inter-specific pelage coloration in mammals. Our results emphasize the importance of considering storage time, among other circumstances, in research studies in which the color of mammal skins is of importance.

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