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# A Carolina Chickadee (*Poecile carolinensis*) with 'Brown' Mutation

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A coauthor (NT) discovered a pale Carolina Chickadee (*Poecile carolinensis*) within the sunflower (*Helianthus* L. sp. [Asteraceae]) field at the Chesapeake & Ohio Canal – Sycamore Landing eBird hotspot on 2 January 2021. Initial observation (Figure 1) seemed to show, in addition to the overall paleness, a brown cap and black bib, although the right panel seems to show brown in the upper part of the bib.

**Figure 1. Two initial photos of a Carolina Chickadee (*Poecile carolinensis*) showing a brown cap and partially brown bib (especially evident in the right panel).** Photos by Stella Tea.

The other coauthor (WSY) visited the same location on 15 February 2021 and relocated this pale Carolina Chickadee. Photos with more even illumination indicated that the bib was similarly brown as the cap (Figure 2). All photos clearly show that the normal grey back and tail feathers are much paler, nearly white, with a hint of tan remaining.

First, we justify our identification of this bird as a Carolina Chickadee, and not a Black-capped Chickadee (*Poecile atricapillus*), based on these characteristics: the bib margin along the bottom edge is smooth, not rough, and the bird seemed

**Figure 2. Carolina Chickadee with the 'brown' mutation.** The bib is more clearly brown in these photos, especially in the right the panel, more closely matching the cap color. The grey feathers on the back and tail are extremely pale with some light tan remaining. Photos by WSY.

less plump and daintier, with a slightly shorter tail than one would expect with a Black-capped Chickadee.

Second, we conclude that this bird expresses the 'brown' mutation in the tyrosinase-related protein 1 gene (*TYRP1*$^{b}$; see below) based on the review by van Grouw (2013). This mutation leads to a reduced level of oxidation and less black eumelanin and more brown eumelanin in feathers (Krishnan 2016; see further discussion below). We are not concerned in our case with any remaining yellowish-brown to reddish-brown pheomelanins as it is not believed to be produced to any extent in this species (D'Alba et al. 2014; van Grouw, in litt.). Thus, areas normally containing high amounts of black eumelanin (i.e., cap and bib) become brown while other plumage with less eumelanin becomes very light brown or white. 'Albinism' due to the absence of functional tyrosinase would lead to a totally white bird, including the cap and bib (and pink eyes), and 'leucism' to partially or totally white plumage throughout the bird (and normal colored eyes). We also considered the 'ino' mutation. That affects the level of both melanins leading to a lighter brown cap and bib than we see here as well as a pink bill and feet which this bird does not have.

A brief search online revealed other Carolina or Black-capped Chickadees with brown caps and bibs, almost always mistakenly considered examples of 'leucism', revealing a fundamental misunderstanding of 'leucism'. An example of a 'brown' mutation is shown by Faintich (2015). 'Leucism' arises from the reduction of the migration of melanocytes from the neural crest to the skin and feather follicles. The absence of melanocytes leads to the absence of melanins in the feather which is thus white. This cannot lead to the brown color of the cap and bib nor the pale other plumage as noted above in our bird. Instead, the 'brown' mutation phenotype is known to arise from a decrease in tyrosinase activity through an increase in *TYRP1* expression (Xu et al. 2013, Domyan et al. 2014, Wang et al. 2014) leading to a decrease in further oxidation of the brown eumelanin to black eumelanin.[3]

[3] The generation of colors in birds is immensely complex (Domyan et al. 2014, Sly 2019). For the interested reader, the process of melanin synthesis is stimulated by activation of the melanocortin-1 receptor (MC1R) by melanocortin (as well as inhibited by agouti-signaling protein that instead activates pheomelanin production). This activation leads to increased expression of the gene for the protein, microphthalmia-associated transcription factor, that regulates tyrosinase expression and is also implicated in the 'brown' mutation (Wang 2014). In addition, MC1R stimulates expression of dopachrome tautomerase (*TYRP2*) and 5,6-dihydroxyindole-2-carboxylic acid (DHICA) oxidase (*TYRP1*), necessary for eumelanin production (Galván and Solano 2016). Not only does the normal color in feathers arise from the proper generation of the melanin pigments, but also from their proper transfer within specifically-shaped melanosomes (also dependent on MC1R) from the melanocytes to the keratinocytes of the feathers. In addition, the eumelanin granules need to be properly embedded into the keratin sheets (Galván and Solano 2016, D'Alba and Shawkey 2019).

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