Abnormal Coloration in *Sciurus carolinensis* Gmelin (Eastern Gray Squirrel): Albinism, Leucism, or Isabellinism?

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Abstract - Abnormal coloration occurs frequently among mammals but seldom is described in terms that are complete, accurate, or clear, and such reports often lack details necessary to allow readers to assess causation. I describe here an abnormally colored *Sciurus carolinensis* Gmelin (Eastern Gray Squirrel), review potential causation, and discuss the infrequent occurrence of abnormal coloration of squirrels in rural areas when compared to that sometimes observed in populations occupying urban areas that largely are isolated from immigration and, thus, are less subject to natural—or 'unnatural'—selection.

Abnormal coloration occurs frequently among mammals and most often manifests as white (leucisistic or albinistic) or dark (melanistic) pelage; grayish-yellow coloration (isabellinism) has been reported only infrequently. Isabelline coloration, despite being described occasionally as partial albinism, is not a partially albinistic variant; instead, isabellinism is a type of pigment dilution involving a substantial—albeit not complete—reduction in melanin (van Grouw 2006). In a condition termed piebaldism, there is a lack of pigmentation (Abreu et al. 2013) in some parts of the body but other areas exhibit normal coloration; piebald individuals are characterized by eyes of normal (or sometimes blue) coloration (Acevedo and Aguayo 2008, Fertl and Rosel 2002). Investigators (Baumgartner 1943, Harrison 1963, Jones 1920, van Grouw 2021) have repeatedly noted that many descriptions or reports of abnormal coloration in mammals or birds have lacked detail, clarity, or consistency of interpretation with respect to such aberrations; in part, such incomplete accounts provided the stimulus for this note.

On 29 June and 22 July 2023, I observed and photographed an unusual and strikingly colored *Sciurus carolinensis* Gmelin (Eastern Gray Squirrel); although I cannot be certain these were the same individual, I estimated both to be of adult size according to Koprowski (1994) and Seabloom et al. (2020). On 29 June, the abnormally colored individual was seen along with at least 7 other conspecifics of normal coloration also appearing to be of adult size at Spirit Lake, Ottertail County, Minnesota, USA. It was viewed several times near dawn through a 12×50 binocular, as well as under a variety of daytime conditions including intense shade, indirect sunlight, and full sunlight. The eight squirrels were foraging at bird feeders in a rural neighborhood (46.621° N, 95.853° W), but the individual of interest possessed a completely white, or near-white, tail, and the dorsum of the rump also was white. Eye color was normal and, aside from its unique coloration, the squirrel otherwise was unremarkable in form or behavior. On 22 July, what appeared to be the same abnormally colored individual was seen alone in broken shade at the same location. I recorded several images of the subject squirrel with my cellular phone, but they are of very poor resolution and are not included.

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While observing hundreds of Eastern Gray Squirrels in the 'lakes region' of western Minnesota from May to October over the past seven years, these are the only observations of an abnormally colored squirrel I have recorded. Albinism and leucism often are used interchangeably, albeit erroneously, to describe 'white' color morphs (Curatolo 1979, McCardle 2012). Albinistic individuals lack pigmentation in the skin and hair and have pink eyes; however, leucistic individuals are deficient in pigmentation and can be white in color but exhibit pigmented skin and eyes (see Abreu et al. 2013 for review). Isabellinism is characterized by a uniform dilution of pigment involving a reduction in melanin and is the result of a genetic mutation (van Grouw 2006). Isabelline coloration is not a partially albinistic variant (Banfield 1974, but see Everitt and Miskelly 2003) and instead presents as normally dark coloration appearing "grayish-yellow" (Everitt and Miskelly 2003), entirely "yellow" (as Schorger [1973] described an apparently isabellinistic Eastern Gray Squirrel), or uniformly "washed out" (as illustrated by Jung and Slough [2012]).

The individual described herein did not exhibit a complete lack of melanin and, thus, was not albinistic. Normal coloration of the eyes, white coloration of only the tail and rump, and the absence of uniformly 'washed-out' coloration that is typical of isabellinism are consistent with piebaldism, a condition that involves a lack of pigmentation (Abreu et al. 2013) in some parts of the body, and pigmented eyes (Acevedo and Aguayo 2008, Fertl and Rosel 2002). As has been the case with erroneous references to isabellinism, piebaldism also has been referred to as partial albinism by some investigators (Miller 2005), whereas others have not distinguished between piebaldism and leucism. As a result of such indeterminate assessments, terminology associated with published reports of abnormally pigmented animals has been compounded by a lack of detail or clarity regarding causation (Abreu et al. 2013; Baumgartner 1943; Everitt and Miskelly 2003; Jones 1920; van Grouw 2006, 2021).

Leucism is a double-recessive trait (Cruickshank and Robinson 1997), and normally colored parents have the potential to produce leucistic offspring; however, the genetics of leucism should not be confused with the genetics of albinism (Searle 1968), which involve gene mutations (Pruthi 2022). Leucism often manifests in the form of piebaldism, and entirely white or piebald individuals can become prevalent in populations that are isolated from conspecific immigration, unusually low populations of predators that may more readily detect leucistic individuals, or human selection against non-leucistic individuals, all of which frequently are associated with large, urban areas (Nelson 2023). Under natural conditions, leucism can persist at low frequencies in some species and across broad geographic areas, as is the case among the numerous subpopulations of *Ovis canadensis* Shaw (Bighorn Sheep) comprising a metapopulation in the eastern Mojave Desert of California and Nevada (Bleich 2017a, 2017b).

Eastern Gray Squirrels are native to much of the eastern United States, but their distribution has expanded, either naturally or through intentional introductions, across North America where they occupy wildlands and urban areas with adequate food supplies (Hibbard 1956, Palmer et al. 2007, Seabloom et al. 2020), including suitable habitat in the northern Great Plains (Hibbard 1956, Seabloom et al. 2020). The species can be an agricultural pest (Palmer et al. 2007) or otherwise damage property (Koprowski 1991); however, it is also a popular game animal (Koprowski 1994) and harvest of squirrels is legal year-round in parts of its current range (Minnesota Department of Natural Resources 2023). Thus, strong selection against squirrels of normal coloration likely is common in this rural area of western Minnesota. Although the extent to which anthropogenic removal occurs is unknown, the rate of removal likely is far greater in this rural area than in some highly urbanized areas wherein the proportion of abnormally colored tree squirrels can be substantial, if not com-

plete (Cosentino and Gibbs 2022, Nelson 2023). Thus, anthropogenic removal of squirrels deemed to be pests may be a factor in the apparent lack of reports of leucism in rural areas, as could the increased removal by natural predators that, in turn, may portend some not-yet-recognized environmental change (Brito and Valdivieso-Bermeo 2016).

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