Why So Many White Eared Grebes?

Possible interactions among leucism, molt, and pollutants

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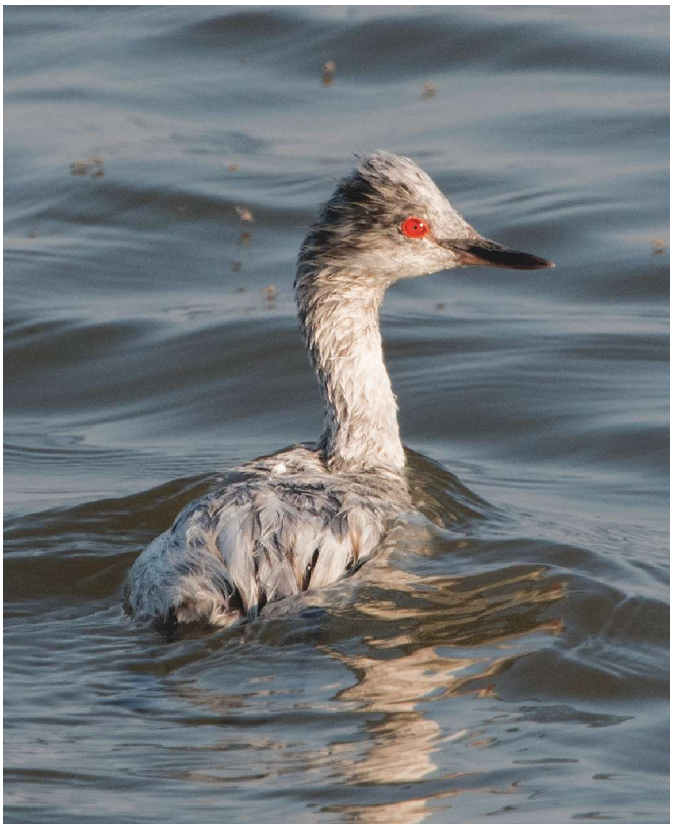
On July 21, 2017, McPherson was photographing birds at the west end of the causeway at Antelope Island State Park, Great Salt Lake, Utah, when she noticed an abnormally white-plumaged Eared Grebe (*Podiceps nigricollis*), and then another, and then another… By the time McPherson had traveled a couple of kilometers along the causeway, she had photographed at least 10 different white or mostly white individuals (Figs. 1a–j), and had probably seen a few more. She estimated the proportion of white-plumaged to normal-plumaged birds around one in 500, far more than is typically found in any wild bird population. Why so many white Eared Grebes at one location?



Featured Photo–leucistic Eared Grebe. This leucistic individual can be identified as an Eared Grebe rather than a Horned Grebe by its peaked head, long neck, and upturned bill; see Blumin (2007) for more on identifying leucistic grebes. *Antelope Island Causeway, Great Salt Lake, Davis County, Utah; July 21, 2017. Photo by © Mia McPherson.*

White Feathers

Leucism

Several mechanisms appear to produce abnormal white feathers. In some cases, intense exposure to the sun can result in feathers so severely bleached as to appear essentially white, but this isn't what we are talking about. Completely white birds may be albinos, although "pure" (or "clinical") albinism, as expressed in mammals, appears to be very rare in wild birds observed in the field—perhaps because birds are less able to survive the weak eyesight that typically afflicts albino mammals. The terms "dilute," "ino," "hypomelanism," and "progressive graying" have been applied to such feather conditions (van Grouw 2006, 2012; Davis 2007). The most common disorder involves one, a few, or many—but not all—feathers that are partially or completely white. Here we use the popular term "leucism" (Buckley 1982) for such birds while recognizing that this word may apply to several different conditions resulting from varying mechanisms (Davis 2007, van Grouw 2012). As birders are well aware, avian leucism appears to occur at low levels across a wide taxonomic spectrum.

It has largely been assumed that leucism has a genetic basis (Gross 1965; van Grouw 2006, 2012). Nonhereditary causes have also been proposed, however, and have been invoked in birds that replace white with normally pigmented feathers, or vice versa, during molt. For example, a Steller's Jay photographed in Colorado was observed to molt from "normal" plumage into a leucistic plumage (Shawkey and Hill 2006, Davis 2007; see Figs. 2a–c), and a leucistic male Northern Harrier in Florida (Wilson 2017) appeared to be replacing white with normally pigmented, brownish-gray inner primaries and black-tipped secondaries. Environmental—as opposed to genetic—factors that might affect feather pigmentation in birds include nutritional stress, injury, and metabolic dysfunction. Toxins and pollutants have also been implicated as causative agents for disrupting normal

pigment-deposition processes in feathers; however, ecotoxicological studies have focused almost exclusively on effects related to carotenoids in red feathers (Hill 2006, Møller et al. 2007, Eeva et al. 2008), rather than on the various melanins that result in most feather pigmentation.

Leucistic Eared Grebes

None of the Eared Grebes photographed by McPherson on July 21 were pure white, with all showing at least a few grayish or partly gray or black feathers (Figs. 1a–j). Eye color in these birds was redder (less pinkish) than appears in albinos—normal for adult Eared Grebes—and these birds' bills were typically dark, suggesting that clinical albinism was not part of the equation. Thus, these birds can be regarded as leucistic. Seemingly high proportions of leucistic Eared Grebes have also been noted in Spain (Konter 2015) and at Mono Lake, California, where Jehl (1985, 2007) has recorded up to 24 leucistic individuals in a day. At the Great Salt Lake, leucistic Eared Grebes have been noted anecdotally at least since 2003 (M. Moody, personal communication), but we are not aware of any published studies of the phenomenon at the site.

Jehl (1985) documented higher proportions of leucistic grebes in summer than in other months, and, based on examination of collected individuals, found that most were older pre-breeding individuals as opposed to first-year birds or breeding adults. Both Jehl (1985, 2007) and Konter (2015) posited a hereditary mechanism for leucism in Eared Grebes, and discussed possible reasons for the genetic expression of anomalous and presumably maladaptive white plumages.

A few Eared Grebes breed at the Great Salt Lake, but the majority arrive there after the breeding season to undergo their complete prebasic molt (Behle 1985). Most depart to winter farther south, but some remain at the lake through winter and spring, undergoing their partial prealternate molt at the site. If the grebes observed by McPherson at Antelope Island State Park were not drawn from a relatively small and geographically restricted breeding population there, then the high concentration of leucistic birds is unlikely to have a genetic explanation. The same reasoning applies at Mono Lake where, similarly, few grebes breed but millions molt (Jehl 1985).

Could non-hereditary factors be involved? It seems reasonable to speculate that something in the grebe's diet (such as brine flies and brine shrimp, their favored food at these molting locations) or toxins in the water might account for the increased incidence of white feathering. Eared Grebes at the Great Salt Lake have been found with high levels of selenium and mercury in their tissues, and the concentration of these pollutants appears to increase with a bird's age (Conover and Vest 2009). Could these or other toxins in the water have resulted in leucism? Recent investigations, suggesting that pollutants can impede the expression of both carotenoids and melanins in birds and fish (see Lifshitz and St. Clair 2016), indicate this as a possibility in Eared Grebe physiology.

Molts and Plumages of the Eared Grebe

A bit of terminology

Adult Eared Grebes undergo their complete, annual, **prebasic** molt in July–October, largely at staging areas such as Great Salt and Mono lakes, and they undergo a second, partial, **prealternate** molt in February–May, primarily on the wintering grounds (Pyle 2008). Note that the prealternate molt includes body feathers and some, but not all, upper-wing secondary coverts. First-year birds have a partial, **preformative** molt in late summer and fall, and a more limited, **first-prealternate** molt in early spring before undergoing the prebasic molt in May–September.

A role for pollutants?

Close examination of the plumage patterns among the leucistic grebes in Fig. 1 indicates repeated themes to the white and dark coloration. Note, for example, the dark remaining in the larger scapulars (covering the wing) and certain nape feathers on several individuals (Figs. 1a, b, c, d, f, g, h, j). If the condition producing the white feathers is ephemeral, these patterns could result from "molt–plumage interactions" (Pyle 2013), whereby dark coloration appears in some of the later

Fig. 1a

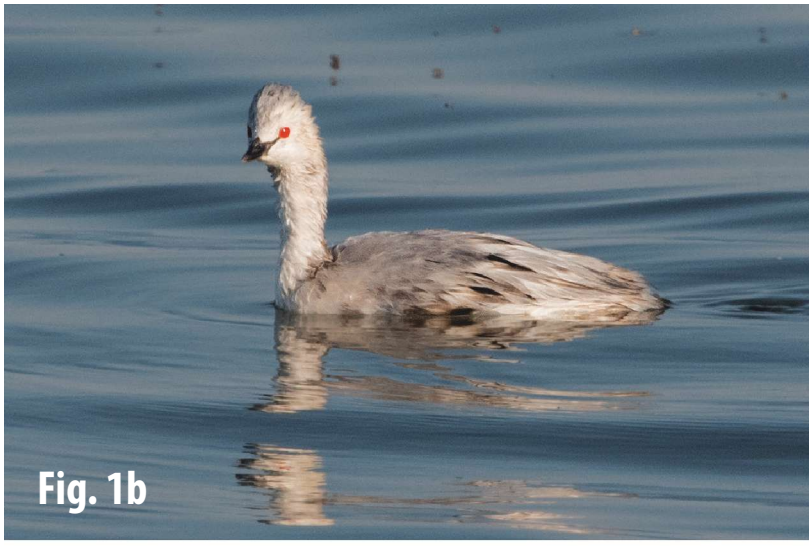
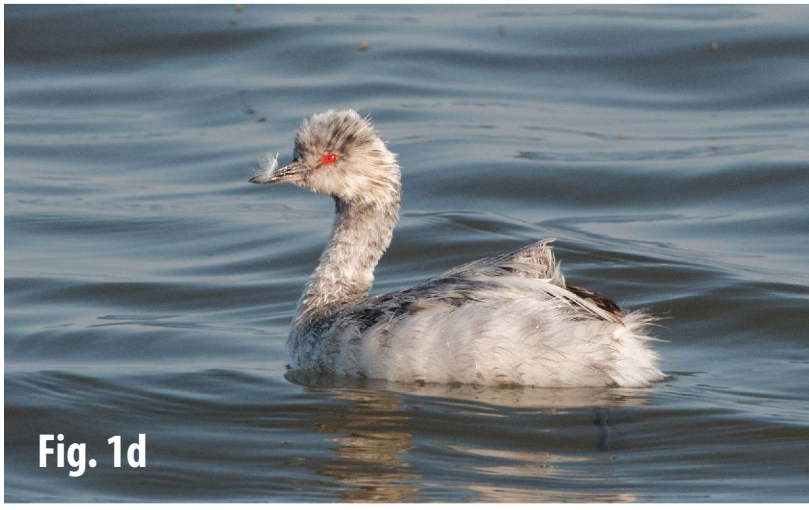


Fig. 1b

Fig. 1c



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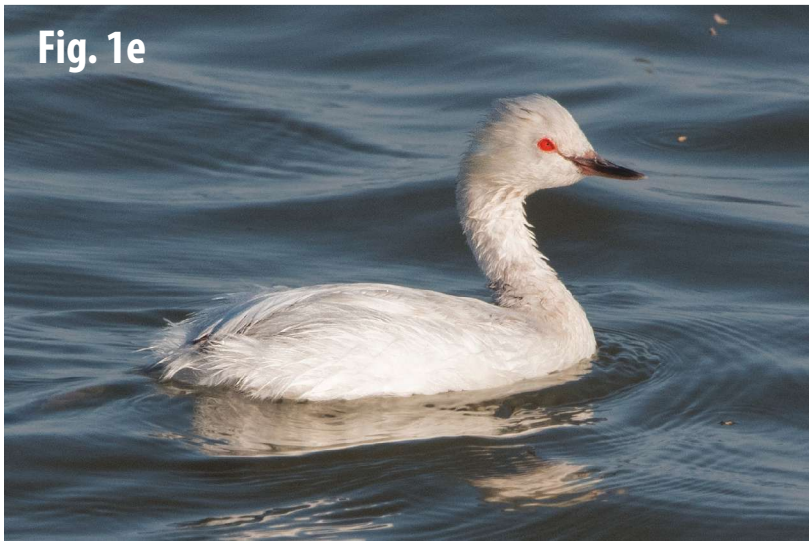
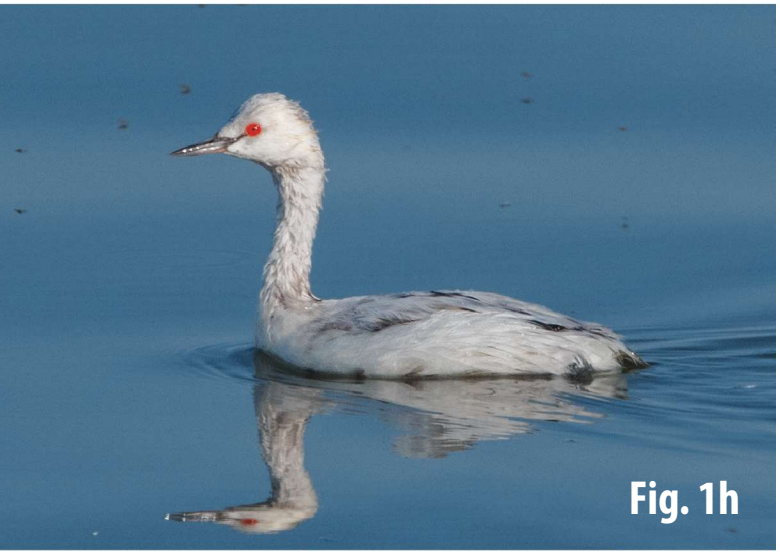
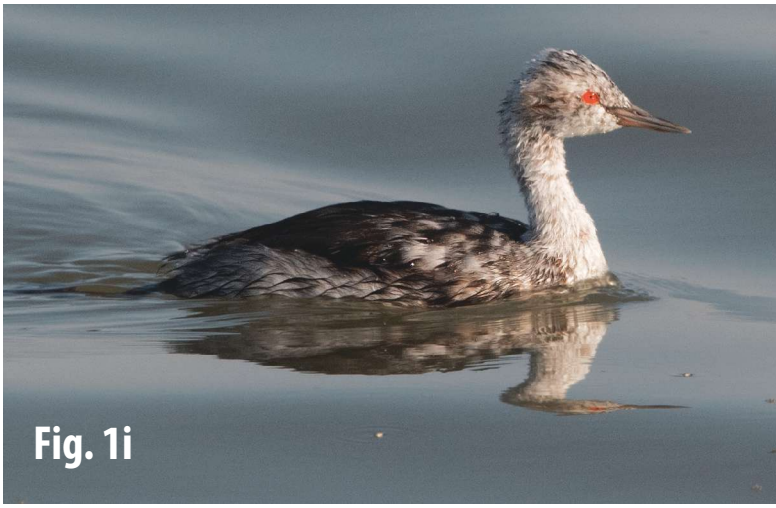


Fig. 1e





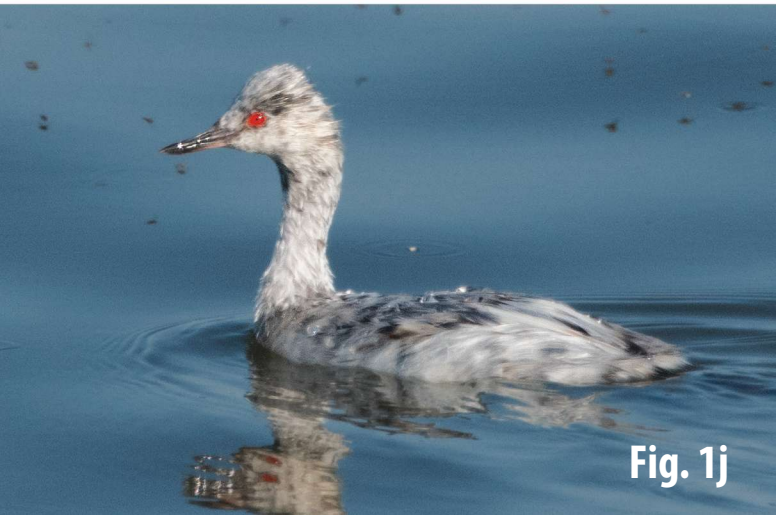


Fig. 1. These 10 leucistic **Eared Grebes** occurred within a two-kilometer stretch of the Great Salt Lake. Close examination indicates that all of them, including the particularly white bird in Fig. 1e, show at least some dark or partially dark feathers; they also have red (not pink) eyes and black bills. Thus, they are not "albinos," but, rather, "leucistic" individuals. Note that many of them are largely white but show black on the scapulars and the feathers of the nape (Figs. 1b, c, d, f, g, h, and j).

This could result from "molt–plumage interactions," wherein normal melanin pigmentation returns toward the end of a body feather molt. If so, leucism may result from an environmental, not a purely hereditary, cause—perhaps related to pollutants. The wing feathers are largely invisible on these resting birds, making it unfeasible to assess the plumage (basic vs. alternate) of the white body feathers (see also Fig. 3). *Antelope Island Causeway, Great Salt Lake, Davis County, Utah; July 21, 2017. Photos by © Mia McPherson.*

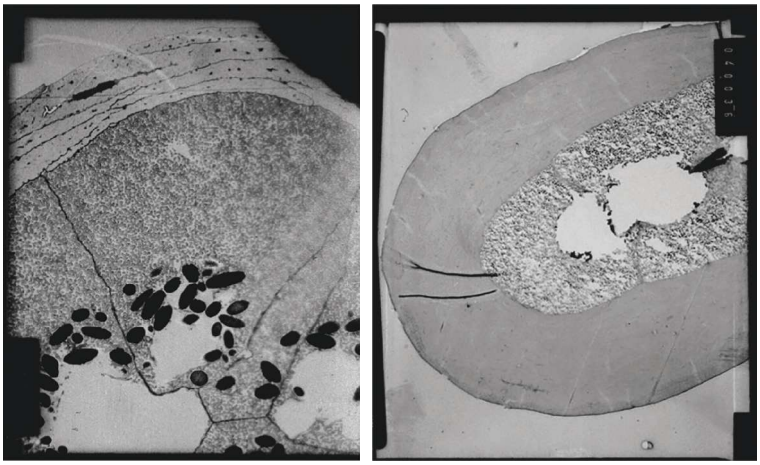
body feathers to be replaced—often including those of the nape and the scapulars. We conjecture that potential disruptive effects of toxins on pigment-deposition processes could subside by the time the last feathers were being replaced, resulting in relatively normal pigment deposition to these feathers.

Factoring in age

The bright red eyes of the Antelope Island State Park birds (Figs. 1a–j) indicate that they are not year-old birds (in their second calendar year), which should have duller orange eyes at that age (Pyle 2008). The white feathers thus appear to be definitive (after-second-year). If they are primarily pre-breeding birds, as Jehl's (1985) data from Mono Lake suggest, one possibility is that they are two-year-old (third-calendar-year) birds that had over-summered or over-wintered at the Great Salt Lake the previous year, and thus had accumulated relatively high levels of toxins by the time they underwent their prebasic (fall) or prealternate (spring) molts, respectively.

Alternatively, if the toxins bioaccumulate in grebes more persistently with age, perhaps the leucistic individuals are even older birds that have returned annually to undergo the prebasic molt in polluted waters. In this case, the effects of pollutants might be cumulative, resulting in "progressive graying" (see van Grauw 2012). Notably, of eight collected grebes shown in Jehl (1985) and reproduced here as Fig. 3, five show normally pigmented remiges (the primaries and secondaries), and patterns of white body feathers and upper-wing secondary coverts matching the typical extent of the prealternate molt; three others show white remiges, with two of them showing dark upper-wing coverts that may be alternate; and only one shows partially white remiges. This suggests that the white feathering may largely have been produced by either the prealternate molt or the prebasic molt, but not always both. We believe that this provides support for ephemeral and non-hereditary causation for the white feathers in these Eared Grebes.

Fig. 2a. On first glance, this striking **Steller's Jay** might appear to be an albino. The dark eye is inconsistent with albinism, however. Furthermore, this individual, monitored over the course of over a year, started out as a "normal" black, blue, and brown Steller's Jay, and then acquired this white plumage through molt—indicating a possible non-hereditary explanation for the white feathers. *Photo by © Bill Schmoker.*



Figs. 2b, c. Micro-structures in the feather of a blue Steller's Jay (Fig. 2b) and a white Steller's Jay (Fig. 2c) have been shown experimentally to result in striking plumage color differences. Both genetic and environmental factors are likely at play in the cellular physiology of the feathers, which in turn affects a bird's appearance. *Electron micrograms by © Matthew D. Shawkey.*

Other systems and suggestions for further work

There is additional evidence for elevated levels of leucism in polluted areas. For example, Enders and Post (1971) found high proportions of leucism in adult (but not juvenile) marsh sparrows (genus *Ammodramus*) near Jones Beach, Long Island, an area known for pollution at the time. Other studies (cited in

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Davis 2007, van Grouw 2012) have shown that birds in urban areas can express more leucism than those of the same species in nearby rural areas.

We propose more investigation into the possibility that the higher concentrations of leucistic Eared Grebes at Great Salt and Mono lakes are related to toxins in the water, and that the abundance or proportions of such birds could potentially be used to monitor the environmental health of these locations. Determining whether or not white feathers in Eared Grebes change through molts and, if so, which molts produce them, would represent a good start.

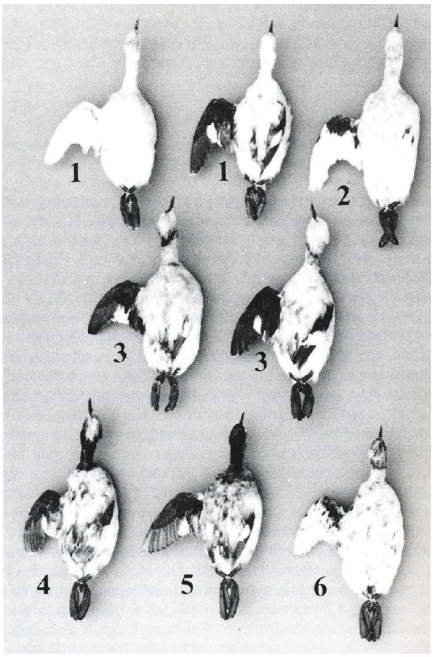

Fig. 3. Shown here are eight leucistic Eared Grebes collected at Mono Lake, California; numbers refer to phenotypes defined by Jehl (1985). Note that some birds have completely or nearly completely white remiges (primaries and secondaries), whereas others exhibit normally pigmented remiges; one bird (bottom, center) shows partially white remiges.

It may be the case that those showing white remiges produced white body feathering during prebasic molts, but those showing normally pigmented remiges produced white feathering during prealternate molts. The dark rump feathers on many of these birds (see Jehl 1985) might have resulted from "molt–plumage interactions," with the rump feathers being among the last replaced during body-feather molts (see Fig. 1). *Photo by © Joseph R. Jehl, reproduced from Jehl (1985) with permission of the American Ornithological Society.*

Acknowledgments

We thank Joseph Jehl for permission to use the image in Fig. 3 and Kathleen Erickson (on behalf of the American Ornithological Society) for permission to reproduce this image. We also thank Matt Shawkey for permission to reproduce his electron micrograms (Figs. 2b, c), and we are grateful to Bill Schmoker and Nick Minor

for help with obtaining the technical images for this article.

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