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Aberrations in Plumage Coloration in Birds

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Summary

Plumage aberrations are not uncommon in birds, but there is some confusion in the literature, especially in relation to albinos. Plumage aberrations in birds are better known in Europe and North America than in Australia, where, however, several reports have been published recently. In this paper, we review the various types and causes of plumage aberrations, focussing on those that arise from abnormal incorporation of pigments in growing feathers and thus result in aberrant coloration of the plumage.

Plumage coloration in birds

Plumage coloration in birds is the result of the deposition of a combination of pigments in the feathers. The most common pigments are melanins that give rise to black and brown colours (McGraw 2006a). Two types of melanin have been described in birds: eumelanin (black) and phaeomelanin (brown) (McGraw 2006a). Carotenoids, other common pigments, give rise to yellows, oranges and reds (McGraw 2006b). Parrots (Psittacidae) are unique in that they do not incorporate carotenoids into their plumage but synthesise a different type of yellow, orange and red pigments called psittacofulvins (Völker 1937; Stradi *et al.* 2001). Turacos (Musophagidae) also produce some unique red (turacins) and green (turacoverdin) pigments (Auber 1957). In contrast with all these colours, blues result from the scattering of light by structural properties of the feathers, and greens (except in Turacos) result from a combination of pigment and structural properties of the feathers (Dyck 1976). If, for some reason, either pigment or structural components are not incorporated properly as the feathers develop, plumage aberration will result.

Types of aberrations in plumage coloration

Plumage aberrations are not uncommon in wild birds (e.g. Deane 1876; Michener & Michener 1936; Sage 1963; Hosner & Lebbin 2006). Although extensive work has been conducted in Europe and North America on the frequency and cause of such aberrations (e.g. Sage 1962, 1963; Gross 1965), little has been done in Australia with the exception of reports on single species (e.g. White 1916; Hindwood 1950; Cleere 2002; Morrison 2006) and compilations of such reports (Lepschi 1990). Interestingly, multiple reports of aberrant plumage have been published over the last two years in the ornithological literature (Guay & Potvin 2010; Frith & McCollum 2011; Guay 2011; Hosken 2011; Frith & Murphy 2012) and popular print media (Anonymous 2010; Perkin 2011), suggesting a renewed interest in the issue in Australia. This increased interest in plumage aberrations has prompted us to review the different types of plumage aberrations and their causes, for the benefit of Australian professional ornithologists and birdwatchers.

Various processes can result in aberrant plumage, including feather staining (e.g. Cooch & Cooch 2005), hybridisation (e.g. Bonhote 1907) and hormonal imbalances (e.g. Summers & Kostecke 2004), but in this review we focus on aberrations caused by abnormal pigment incorporation in growing feathers. Such plumage aberrations are generally classified in six broad categories: albinism, leucism, schizochroism, melanism, carotenism and dilution (Buckley 1969).

Albinism

Albinism (Plate 4) results from the complete lack of all melanin in both plumage and skin. Albinistic birds thus have completely white plumage, pinkish-red eyes and pale skin, but they do retain carotenoid plumage (e.g. Northern Mockingbird *Mimus polyglottos*: McIlhenny 1940; Australian Magpie *Gymnorhina tibicen*: Hosken 2011). Historically, any bird with aberrant white feathers was described as albino (van Grouw 2006). For instance, birds with completely white plumage were called albinos irrespective of the colour of their bare parts, whereas birds presenting only a patch of white feathers were said to be partial albinos (Sage 1963). In some cases, birds with pale plumage characteristic of schizochroism (see below) were also classified as albino (Reilly 1964). It is thus difficult to verify historical records unless the colour of the skin and eyes was described. Albinism has also been associated with poor vision and hypo-activity in birds (Lee & Keeler 1951), which may explain why it is so rare in adults birds in the wild.

Leucism

Leucism (Plates 5–6) results from the complete lack of melanin from all or part of the plumage but not necessarily from the soft parts. Leucistic birds have a varying proportion of white feathers, but have normally coloured eyes (e.g. Eared Grebe *Podiceps nigricollis*: Jehl 1985; Superb Fairy-wren *Malurus cyaneus*: Hosken 2011); the skin and the beak may also be normal (van Grouw 2006). In a sense, leucism is thus similar to vitiligo in mammals (Weller *et al.* 2008). There is confusion in the literature between albinism and leucism, with the latter often referred to as partial albinism (e.g. Sage 1963). Leucism seems to have been selected during domestication, as many domestic birds, including chickens, ducks, pigeons, geese and turkeys, have leucistic breeds (Crawford 1990). It is the commonest plumage aberration in wild birds, but its frequency varies, being very common in some species (e.g. >40% in Brewer's Blackbird *Euphagus cyanocephalus*: Edson 1928) but rare in others (e.g. 1:146,000 in the Chinstrap Penguin *Pygoscelis antarcticus*: Forrest & Naveen 2000). Within a species, important variation can also occur between populations (Enders & Post 1971; Bensch *et al.* 2000), and leucism seems to be more frequent in urban than in rural populations (Rollin 1953) and in small, potentially inbred, populations (Bensch *et al.* 2000).

Schizochroism

Schizochroism (Plate 7) is characterised by the lack of a single pigment from part or all of the plumage. It is usually named from the pigment that is absent. Thus a non-eumelanic schizochroistic bird has no eumelanin (black pigment) and thus has fawn plumage (Harrison 1963a); lack of phaeomelanin (a brownish pigment) gives rise to grey plumage. Since the skin and eyes contain only eumelanin, non-eumelanin schizochroistic birds have red eyes and pink skin (van Grouw 2006). Schizochroism is well known to bird-breeders, having been described in aviary species like the Budgerigar *Melopsittacus undulatus*, Island Canary *Serinus canaria*,

American Wood Duck *Aix sponsa* and White-cheeked Pintail *Anas bahamensis* (Delacour 1956, 1959; Harrison 1963b). In contrast, it is rarer in wild birds, but has been reported in e.g. Northern Mallard *A. platyrhynchos* (Harrison 1963a), Australian Wood Duck *Chenonetta jubata* (Guay & Potvin 2010) and Peregrine Falcon *Falco peregrinu*s (e.g. Ellis *et al.* 2002).

Melanism

Melanism (Plate 8) occurs when either an abnormally high level of melanin is deposited in feathers or melanin replaces carotenoids in part or all of the plumage. As a result, melanistic birds are darker overall (e.g. Blue-winged Kookaburra *Dacelo leachii*: Frith & McCollum 2011) or lose some light-coloured patches (e.g. Canada Goose *Branta canadensis*: Kennard 1912).

Carotenism

Carotenism is an abnormality of carotenoid pigments caused either by changes in the amount, distribution or composition of pigments deposited or by the substitution of melanin by carotenoids. The colour of carotenistic birds' plumage shifts toward either red or yellow, depending on the cause of the aberration (e.g. Bananaquit *Coereba flaveola*: Hudon *et al.* 1996).

Dilution

Finally, dilution is characterised by an overall decrease in deposition of all pigment in feathers over the whole body, resulting in a faded appearance (e.g. Mourning Dove *Zenaida macroura*: Graefe & Hollander 1945; Purple Swamphen *Porphyrio porphyrio*: Morrison 2006).

Causes of plumage aberrations

A wide variety of factors has been suggested to contribute to plumage aberration in birds, including genetic mutation, diet, age, disease, parasites, and injury. Here we detail evidence for each of those factors.

Mutation

Genetic mutations have long been associated with plumage aberrations, and indeed have been exploited by breeders to preserve desirable plumage colorations in captive populations. Albinism, for example, is caused by a genetic mutation resulting in the absence of the enzyme tyrosinase, which is essential for the synthesis of both eumelanin and phaeomelanin (Fox & Vevers 1960). As early as 1941, experiments linked complete albinistic plumage with a single autosomal recessive gene (Sage 1962). In contrast, leucism may be caused by a dominant genetic trait, usually affecting one or more distinct parts of a bird's plumage (Sage 1962). Interestingly, some distinct leucistic patterns may be observed among a number of separate but related species (e.g. white neck-rings in waterfowl: Guay 2011) and may be considered an atavistic phenotype that reappears in certain species (Harrison & Harrison 1963). Although in most cases the origin of the mutation causing leucism is unknown, Ellegren *et al.* (1997) found that a population of Barn Swallows *Hirundo rustica* exposed to high levels of radioactivity at their breeding site around Chernobyl, Ukraine, in the years following the nuclear catastrophe there in 1987 had an unusually high frequency of leucism.

Recently, a different genetic mutation has been identified as the cause of certain types of carotenism. In some individuals, certain carotenoids may appear at normal levels, but others may be absent as a result of interrupted metabolic reactions responsible for the integration of carotenoids into the feathers. This condition is thought to be caused by a rare genetic mutation (McGraw *et al.* 2003).

Diet

Deficiency or excess of certain dietary components may also cause abnormalities in plumage coloration. Carotenoids cannot be synthesised by animals and must be present in the diet in order to give colour (yellows, oranges and reds) to plumage. A classical example is the reddish-pink plumage of the flamingo (Phoenicopteridae) (Fox 1975). Therefore, carotenoid-based colour patterns are highly variable and are affected significantly by changes in diet, and it may be difficult to define normal versus aberrant coloration.

Aberrations may follow a diet deficient in protein, e.g. a deficiency in the amino acid lysine has been linked with whitened plumage (Fritz *et al.* 1946). A protein-deficient diet has also been associated with whitened plumage in Common Blackbirds *Turdus merula*, and may cause high levels of whitened plumage in this species in urban areas (Rollin 1959). Cases of white plumage in the Black Noddy *Anous minutus* have also been attributed to diet (Clapp 1974).

Age, disease, parasites and injury

Other life-history traits or events may also induce plumage aberrations. Aging is associated with increased levels of somatic genetic mutation, which can in turn affect plumage patterns, as evidenced by white-spotting in older individuals (Hanson 1949; Warner 1963). Disease, in particular avian pox, has also been implicated as a cause of dull or aberrant plumage, particularly with respect to carotenoids (Thompson *et al.* 1997; Zahn & Rothstein 1999). Pox possibly interferes with the production of pigments, although the exact mechanism is still unknown. Similarly, the mechanism by which internal and external parasites might prevent carotenoids (mainly reds) from being incorporated in growing feathers remains elusive, yet the effect has been identified both observationally and experimentally (Thompson *et al.* 1997; Brawner *et al.* 2000). Certain injuries may also induce local plumage aberrations around the injury, but how this occurs is also undetermined (Phillips 1954). Research into the processes and mechanisms of pigment deposition in these rare cases would therefore be profitable.

We hope this review will clarify imprecision in the literature about the classification of plumage aberrations in birds, and spark interest in this phenomenon in professional ornithologists and birdwatchers around Australia.

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Albinistic Laughing Kookaburra *Dacelo novaeguineae*. **Note the completely white plumage, pinkish-red eyes, and pinkish bill and feet.**

Plate 4 Photo: Cairns Wildlife Dome

Complete leucistic Superb Fairy-wren *Malurus cyaneus*. **Note the completely white plumage, pinkish bill, but black eye.**

Plate 5 Photo: Karen Russell

Incomplete leucistic Australian Wood Duck *Chenonetta jubata*. **Note the white markings in the neck and head region.**

Plate 6 Photo: Graeme Minifie

Schizochroistic Welcome Swallow *Hirundo neoxena*. **Note the lack of black and iridescent plumage on the swallow on the left.**

Plate 7 Photo: Dirk Tomsa

Melanistic Laughing Kookaburra *Dacelo novaeguineae*. **Note the overall dark plumage.**

Plate 8 Photo: Todd Lavis

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Note added in proof. A relevant paper has recently been published:

Dongming Li, Juyong Li & Yuefeng Wu (2011), 'A leucistic Little Grebe *Tachybaptus ruficollis* in Hebei Province and a review of albinistic and leucistic species in China', *BirdingASIA* **16**, 75–77.