Aberrant Colouration in the Atlantic Puffin (*Fratercula arctica*), the Common Murre (*Uria aalge*), and the Thick-billed Murre (*U. lomvia*) from Atlantic Canada

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The colour of birds' plumage and bare parts is an important feature in choice of mate, camouflage, thermoregulation, species recognition, and flight mechanics. Abnormalities in colouration occur in a variety of species and can have important consequences for an individual's survival and fitness. We present 7 new cases of colouration abnormalities in 3 species of auk (Alcidae) and review previous reports to correctly assign the proper form of abnormality to specimens in museums or photographs. Of the 53 reported colouration abnormalities, we reclassified 42, progressive greying being the most common (18 or 19 cases out of 42, 43–45%), followed by brown (10/42 cases, 24%), in addition to 6 cases of melanism, 4 of dilution, 2 of partial leucism, and 1 likely somatic mutation. Properly describing the form of colour abnormality improves our understanding of the frequency, causes, and consequences of aberrant colouration.

Key Words: Atlantic Puffin; *Fratercula arctica*; Common Murre; *Uria aalge*; Thick-billed Murre; *Uria lomvia*; plumage; colouration; colour aberration; Atlantic Canada

Introduction

The colour of birds' plumage and bare parts (bill and legs) plays many important functional roles in flight, thermoregulation, mate choice, camouflage from predators, and species recognition (Hamilton and Heppner 1967; Barrowclough and Sibley 1980; Cairns 1986; Jones 1990; Andersson *et al.* 1998; Murphy and Pham 2012). However, a variety of colouration abnormalities of feathers and bare parts occur, albeit at very low frequencies (Sage 1962, 1963; Ross 1964; Gross 1965; Forrest and Naveen 2000; McCardle 2012). There is a long history of documenting abnormal colouration in a variety of birds (Krüper 1857; Deane 1876; Newton 1877), but only recently has the physiological basis for the varying conditions been understood (Summers 2009). Historically, many individuals with any sort of lack of plumage colouration were termed "albino," despite this term having a very specific meaning and the condition being very rare in wild populations (van Grouw 2010, 2013).

The most extreme lack of colouration, albinism, is a complete lack of eumelanin and phaeomelanin and is extremely rare (McCardle 2012). More common are cases of partial under-expression of pigments (leucism, progressive greying, brown, dilution, and ino), and these can exhibit a wide range of phenotypes from light or dark patches, to an overall dilution of pigment (van Grouw *et al.* 2011; Jakubas and Wojczulanis-Jakubas 2012; van Grouw 2013). Cases of extreme melanism, where the bird appears entirely black, are rare (Clarke 1913; Loomis 1918).

There has been a fair degree of interest and a long history of documenting plumage aberrations in seabirds (e.g., Newton 1877), including the Procellariiformes (Mancini *et al.* 2010), and Sphenisciformes (Forrest and Naveen 2000). In the auks (Charadriiformes, family Alcidae), plumage abnormalities have been described for many species (Deane 1876; Newton 1877; Arnold 1950; Lockley 1953; Tuck 1961; Sealy 1969; Reinsch 1983; Leopold *et al.* 2010; van Grouw *et al.* 2011; Jakubas and Wojczulanis-Jakubas 2012). Here, we describe five additional cases of plumage abnormalities in 3 species of Atlantic alcid: Thick-billed Murre (*Uria lomvia*), Common Murre (*U. aalge*), and Atlantic Puffin (*Fratercula arctica*), and we use current terminology to clarify the particular mutation in several museum specimens described previously.

Methods

We used the system described by van Grouw (2013) for assigning colour aberrations in 7 categories (Table 1). We made regular notes on abnormal plumages dur-

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TABLE 1. The physiological and genetic basis for colour aberrations and their phenotypic effect.

Colour aberration	Physiological or genetic basis	Phenotypic effect
Albinism	Complete absence of eumelanin and phaeomelanin in all tissues, caused by inherited lack of tyrosinase	All white feathers, red eyes, pink feet and bill
Brown	Reduction in the expression of eumelanin molecules caused by incomplete oxidation	Typically black tissues become brown, and rufous/yellow/brown tissues are unaffected
Dilution – isabel	Reduced number of eumelanin molecules (but not their expression)	Typically black tissues become silver/grey, and rufous/yellow/brown tissues are unaffected
Dilution – pastel	Reduced number of eumelanin and phaeomelanin molecules (but not their expression)	Typically black tissues become silver/grey, and rufous/yellow/brown tissues become buff/cream
Ino – dark	Strong reduction in the expression of both eumelanin and phaeomelanin caused by incomplete oxidation	Typically black tissues are light brown, and rufous/yellow/brown tissues are buff/cream; bill and feet pink
Ino – light	Mild reduction in the expression of both eumelanin and phaeomelanin caused by incomplete oxidation	Typically black tissues are very pale brown/cream, and rufous/yellow/brown tones are hardly present; eyes, bill, and feet pink
Leucism	Partial or total lack of eumelanin and phaeomelanin in feathers/skin caused by inherited lack of pigment cells	Plumage all white or all-white feathers mixed with normally coloured feathers. Bill and feet can be pink or unaffected; normally coloured eyes
Melanism	Increased melanin deposits	Increase in black or darker red/brown pigments
Progressive greying	Partial or total loss of eumelanin and phaeomelanin in feathers/skin caused by gradual loss of pigment cells with age	Plumage all white or all-white feathers mixed with normally coloured feathers. Bill and feet can be pink or unaffected; normally coloured eyes

Source: Adapted from van Grouw (2013).

ing our research in eastern Canada and, where possible, documented cases of abnormal plumage with photographs. We also searched published and unpublished articles, including government reports, monographs, and journal articles for mention of plumage or colouration abnormalities in our 3 species of interest. Finally, we contacted curators at several museums known to house specimens with abnormal colouration (see Acknowledgements) and obtained photographs of the specimens in question to allow further examination and reclassification where possible.

Results

Thick-billed Murre, CMNAV 37719

This is a previously undescribed case of dilution in a bird collected by L. M. Tuck in Hants Harbour, Newfoundland and Labrador, on 12 March 1951 (Figure 1), now in the Canadian Museum of Nature (CMNAV). The normally dark brown back, neck, head, and wings are a silvery grey. Tuck (1961) also described 3 "full albinos" and 3 "partial albinos." This is almost certainly incorrect, and the latter, whose black feathers appeared grey were likely cases of dilution (van Grouw 2013) and could include CMNAV 38151 (see below); the true status of the 3 "albinos" is unknown (Table S1).

Thick-billed Murre, CMNAV 38151

This is a melanistic bird described by Tuck (1961) as being shot in Trinity Bay, Newfoundland and Labrador, on 31 January 1952 (Figure 2); its destination was listed only as the "National Museum of Canada" (now the Canadian Museum of Nature). It is uniformly dark brown/black above, and dark grey below, rather than white.

Common Murre, Cabot Island, Newfoundland and Labrador

On 2 August 2011, 1 bird among 100 adult breeding Common Murres banded on Cabot Island (49°17'N, 53°36'W) lacked pigment in parts of its bill, and in its feet (a form of progressive greying; Figure 3). On the Isle of May, Scotland, this occurs in about 1 in 1000 Common Murres (M. P. Harris, personal communication). A single Thick-billed Murre with yellow feet was seen on Coats Island in the 1980s (A. J. Gaston, personal communication).

Atlantic Puffin, Gull Island, Witless Bay, Newfoundland and Labrador

In May and June 2012, 91 adult Atlantic Puffins were banded on Gull Island (47°15'N, 52°12'W). One bird's black head feathers were grey, flecked with white (Figure 4). The bird was a breeding adult, with more than

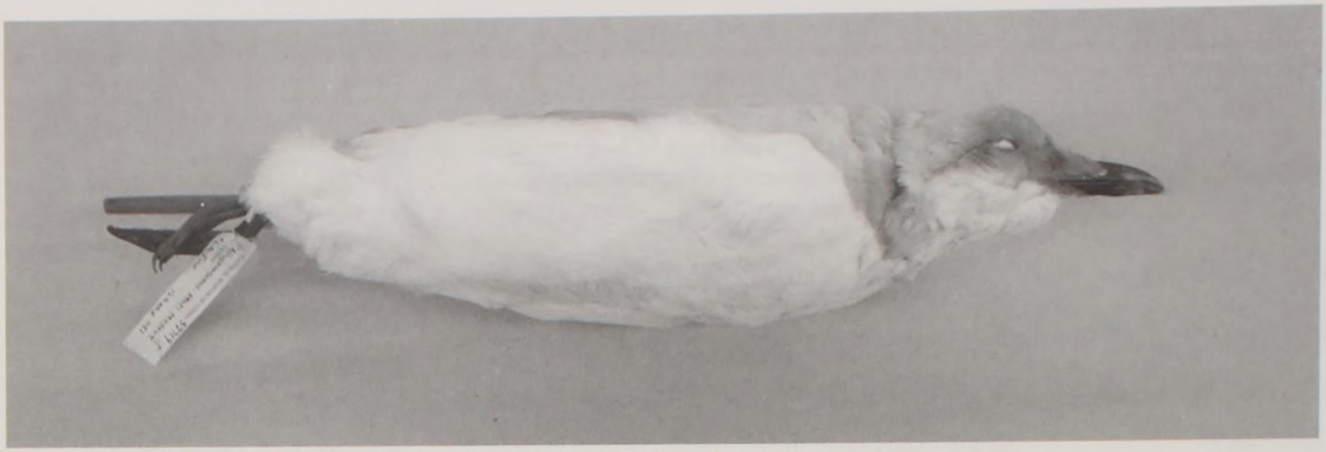

FIGURE 1. Thick-billed Murre (CMNAV 37719) showing dilution. Photo: M. Gosselin.

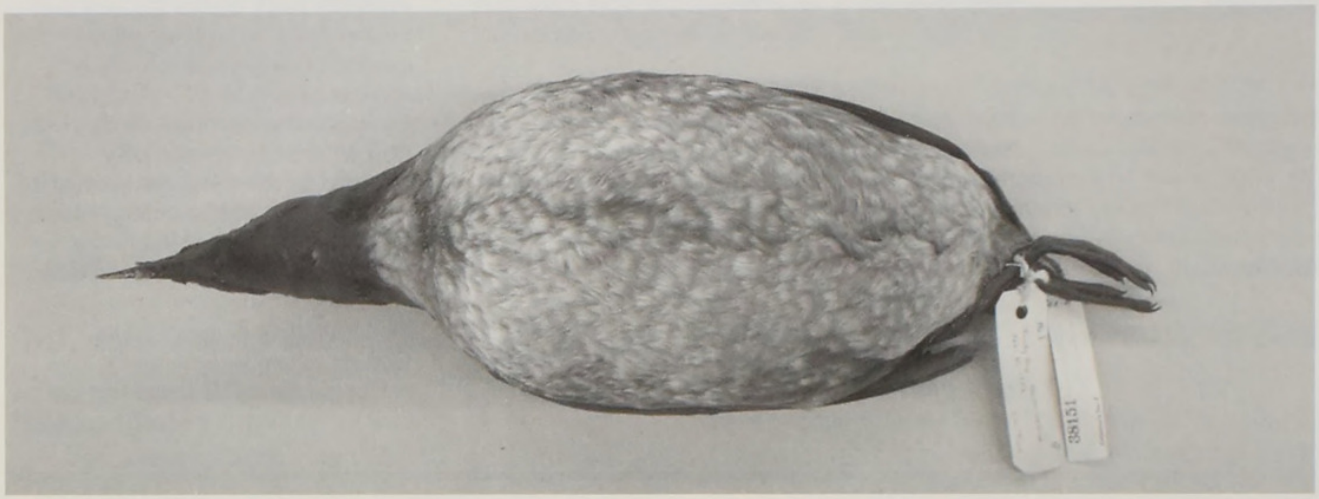

FIGURE 2. Melanistic Thick-billed Murre (CMNAV 38151). Photo: M. Gosselin.

FIGURE 3. Common Murre on Cabot Island, Newfoundland, showing progressive greying in the legs and bill. Photo: A. Lang.

FIGURE 4. Atlantic Puffin on Gull Island, Newfoundland, showing a likely somatic mutation, as other dark plumage appeared normal. Photo: A. Bond.

2 bill grooves (Harris 1981), and all other aspects of plumage and colouration of bare parts were typical, including the black feathers on the back and proximal region of the breast. Although this might appear to be a case of dilution, the genetic mechanism (a heritable mutation affecting the number of pigment molecules, but not their colour) would result in all black plumage appearing grey. Therefore, this is likely the result of a somatic mutation, rather than a heritable plumage abnormality.

Atlantic Puffin, Machias Seal Island, New Brunswick

In May 2013, an adult Atlantic Puffin with more than 2 bill grooves was photographed on Machias Seal Island (44°3'N, 67°06'W). It had white feathers speckled throughout the black contour feathers on its neck and back (Figure 5), showing characteristics of progressive greying. Colouration of all other aspects of plumage and bare parts appeared normal.

FIGURE 5. Atlantic Puffin on Machias Seal Island, New Brunswick, with progressive greying expressed as white feathers around the neck. Photo: T. Einfeldt.

Atlantic Puffin, Machias Seal Island, and Grand Manan basin, New Brunswick

In 2002, 2004, and 2009, a "white puffin" was observed at sea around Machias Seal Island or in the Grand Manan basin (Figure 6). The bare parts were unaffected, as were portions of the feathers (e.g., tips of primary feathers), making this an extreme case of progressive greying. Other "white puffins" have been recorded at the Isles of Scilly, United Kingdom, in May 2009 (Harris and Wanless 2011) and at the Faroe Islands in the late 1800s (Lockley 1953; see below).

FIGURE 6. A "white puffin" in the Grand Manan basin, New Brunswick, in 2009, showing an extreme case of progressive greying. Photo: New England Aquarium.

These 3 records may or may not pertain to a single individual.

Reclassification of museum specimens and previous records

We located 10 reported cases of plumage abnormalities in Atlantic Puffins, 23 in Common Murres, and 18 in Thick-billed Murres. Of these, we determined the precise form of colouration abnormality from the description, original specimen, or photographs and reclassified 10, 16, and 12 specimens of each species, respectively (Table S1). Most of these were originally described as "albino," "partial albino," or "melanistic," the most extreme forms of plumage colouration anomalies, and all were reclassified as a milder form. Among live and museum specimens combined, progressive greying was the most common abnormality (16 or 17 cases out of 41), followed by brown (10 of 41 cases), with 6 cases each of dilution and melanism (Table S1). Partial leucism was the least common abnormality and occurred in only 2 Common Murres (Table S1).

Discussion

Of the 52 cases of colour abnormalities in these 3 species, we were able to reclassify 40 (80%) and add an additional 4 cases, including rarer abnormalities affecting bare parts (Table S1). Previous classifications tended to adopt one of the extremes (albinism/melanism) rather than the underlying mechanistic explanation, which masks the root cause for the colouration abnormality and artificially groups abnormalities that have no common mechanism. This greater understanding of the mechanisms of colour aberrations has received more attention only recently (van Grouw 2010, 2013). Abnormalities of bare parts are less commonly reported than those of plumage, despite being noted in auks since the 19th century (Krüper 1857; Newton 1877). This may be because birds with abnormal plumage are easier to identify in large colonies, such as cliff-nesting murres, whereas birds with abnormally coloured bare parts would not stand out so clearly.

In the Southern Giant Petrel (*Macronectes giganteus*), there is a "white morph" with asymmetrical black feathers scattered throughout otherwise white plumage; this pattern is controlled genetically (Shaughnessy 1970). This is particularly notable, as it could be easily mistaken for a plumage abnormality (likely progressive greying). Indeed, the control of plumage colour polymorphism has a strong genetic influence across multiple species, driven by mate choice and sometimes assortative mating (but see Cooke and McNally 1975; Roulin 2004). Given that the plumage abnormalities described here are also under genetic control (van Grouw 2013), they may ultimately contribute to the formation of various colour morphs, although at the frequencies we observed in the auks, they are likely too rare to become established.

Increased participation by citizen scientists and decreased costs of digital photographic equipment will increase the chances of birds with abnormal colouration coming to light and provide us with a better sense of the frequency and consequences of such abnormalities.

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SUPPLEMENTARY MATERIAL:

TABLE S1. Summary of colouration abnormalities in Atlantic Puffins (ATPU), Common Murres (COMU), and Thick-billed Murres (TBMU). Terminology follows van Grouw (2013).

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