Not every white bird is an albino: sense and nonsense about colour aberrations in birds

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In the birding world, general confusion seems to exist about colour mutations in wild birds and the correct naming of these aberrations. Almost all whitish aberrations are called '(partial) albino'. However, most of these are not albino and 'partial albinism' is – by definition – not even possible. Some mutations are hard to distinguish in the field (and in museum collections) because the colour of feathers with a pigment reduction is easily bleached by sunlight and can even become almost white. For the correct identification and naming of colour mutations, it is necessary to know which changes have occurred in the original pigmentation. But first of all, it is necessary to understand which pigments determine the normal colours of feathers and how these pigments are formed. All colour aberrations described here have a genetic basis, ie, they are caused by a mutation.

There are more possible colour mutations in birds than those described below. However, the ones dealt with here are those occurring most frequently and are more or less clearly recognizable, either in the field or in museum specimens.

The aim of this paper is to present clear definitions of the most common types of colour mutations in birds and to give a basic insight into the genetic or food-related mechanisms that cause or influence these mutations. The paper is based on the study of colour mutation genetics and the study of many 1000s of bird skins and live birds during the course of 15 years of working with cage birds and as bird collection manager and taxidermist of the Nationaal Natuurhistorisch Museum Naturalis at Leiden, Zuid-Holland, the Netherlands, as well as in other European natural history museums (van Grouw 1997, 2000ab).

Pigmentation

The most important pigments that determine plumage coloration in birds are melanines and carotenoids. Carotenoids vary in colour from pale yellow to scarlet red. They are taken in with food and transformed into colour pigments by enzymes. The deposition of the pigments takes place directly at the start of feather growth.

Aberrations in this pigmentation are mostly caused by a food problem and usually do not have a genetic cause. Well-known examples are flamingos Phoenicopteridae and Scarlet Ibis *Eudocimus ruber*, which owe their respective pink and red colours to the presence of red carotenoids in their natural food. When these carotenoids are in short supply, these birds will appear white after the next moult. In the past, this happened frequently in captive individuals of these species before caretakers understood this relation between food and coloration.

In several European passerines, part of their colours are caused by yellow and red carotenoids, eg, Blue-headed Wagtail *Motacilla flava*, Willow Warbler *Phylloscopus trochilus*, European Blue Tit *Cyanistes caeruleus*, Great Tit *Parus major*, Eurasian Golden Oriole *Oriolus oriolus*, Common Chaffinch *Fringilla coelebs*, European Greenfinch *Chloris chloris*, European Goldfinch *Carduelis carduelis*, Eurasian Siskin *C spinus* and Common Crossbill *Loxia curvirostra*. But also the red in spotted woodpeckers *Dendrocopos* and the yellow-green in green woodpeckers *Picus* are caused by carotenoids. However, not every reddish coloration is a result of carotenoids; for instance, the red underwing-coverts and flanks of Redwing *Turdus iliacus* and the orange-brown breast in European Robin *Erithacus rubecula* are caused by a melanin (see below). Mutations causing changes in carotenoid-based colour pigments are rare but melanine mutations occur far more often.

Melanins

Two types of melanin are present in birds: eumelanin and phaeomelanin. Depending on concentration and distribution within the feather, eumelanin is responsible for black, grey and dark brown feathers. In a high concentration, phaeomelanin is responsible for reddish-brown feath-

99 Carrion Crow / Zwarte Kraai *Corvus corone*, Heeze, Noord-Brabant, Netherlands, 12 June 2005 *(Rob G Bouwman)*. Albino, juvenile wild bird. Complete absence of melanins in plumage, skin and eyes caused by genetically determined absence of enzyme tyrosinase. Because Carrion Crow has no carotenoid-based colours, whole plumage is colourless (white), as well as skin and eyes. Red of eyes is caused by blood shining through. In nature, survival chances of such birds are very low because of bad eyesight of albinos.
100 Common Blackbird / Merel *Turdus merula (Pieter van den Hooven)*. Albino, adult in captivity. Complete absence of melanins in plumage, skin and eyes caused by genetically determined absence of enzyme tyrosinase. Because Common Blackbird has no carotenoid-based colours, whole plumage is colourless (white), as well as skin and eyes. Red eyes are caused by blood shining through.
101 European Goldfinch / Putter *Carduelis carduelis (Pieter van den Hooven)*. Albino, adult in captivity. Complete absence of melanins in plumage, skin and eyes caused by genetically determined absence of enzyme tyrosinase. Carotenoid-based colours are still present.
102 European Goldfinch / Putter *Carduelis carduelis (Pieter van den Hooven)*. 100% leucistic. Total absence of melanins in all feathers but melanins are still present in skin and iris. Carotenoid-based colours are still present.
103 European Goldfinch / Putter *Carduelis carduelis (Pieter van den Hooven)*. Diluted (isabel). Reduction in eumelanin concentration, phaeomelanin is unaffected. Normally black plumage parts have turned grey. Because this bird remained in captivity, there has been no further bleaching by weather and sunlight and visible colour is result of mutation only.
104 European Goldfinch / Putter *Carduelis carduelis (Pieter van den Hooven)*. Ino. Strong reduction of both melanins: phaeomelanin (back) is almost absent, while there is hardly any oxidation of eumelanin. Normally black plumage parts have turned pale brown. Carotenoid-based colours are still present. Because this bird remained in captivity, there has been no further bleaching by weather and sunlight and visible colour is result of mutation only.

ers. In lower concentrations, the colour will appear as yellow-brown to almost white. Both melanins together can give combination colours such as greyish-brown. In skin and eyes, only eumelanin is present.

In some species, the colour is completely caused by eumelanin, eg, Common Murre *Uria aalge*, Razorbill *Alca torda*, Western Jackdaw *Corvus monedula*, Rook *C frugilegus* and Carrion Crow *C corone*. In most species, however, both types of melanin are present. As far as currently known, there are no wild bird species in which only phaeomelanin occurs. In feathers that contain both types of melanin, the eumelanin is mainly found in the central part of the feather while the phaeomelanin is mainly located in the feather edges.

Most of the basic knowledge on biochemistry and development of melanins already originates from studies in the first half of the 20th century (eg, Frank 1939, Mason 1953, Rawles 1953, Lubnow 1963). The normal formation of melanins starts after the first cell divisions of the fertilized egg. Already in this early stage of embryonal development, basic colour cells are formed which soon migrate to the so-called pigmentation centres. From these pigmentation centres, the basic colour cells spread to, amongst others, the feather follicles. The basic colour cells contain the amino acid tyrosine. Controlled by the enzyme tyrosinase, the basic colour cells can produce melanins during feather development; the basic colour cells are now called the colour cells.

Melanin formation involves a series of chemical reactions, starting with the oxidation of tyrosine, katalysed by tyrosinase. The melanin itself is a polymere molecule which is also subject to oxidation. The amount of oxidation varies: black is the strongest oxidation form, brown a weaker form. The colour cells deposit the pigments into the feather cells through 'extensions'.

The melanin formation process is determined genetically. Any aberration in the process has a potential influence on the colours of a bird. A mutation in the formation of the enzyme tyrosinase may (partially) inhibit the formation of melanin. Also a mutation causing a change in intracellular conditions may have an effect on the eventual outcome of melanin formation, eg, causing a reduction in either phaeomelanin or eumelanin. Changes may also occur in the distribution of the basic colour cells which may result in reduction or complete absence of coloration in some feather tracts. And when a mutation blocks the formation of extensions, the feathers will also remain devoid of colours.

In summary, eumelanin is responsible for the colours black and brown, depending on the amount of oxidation. Differences in shade are mainly caused by the concentration of pigments. For example, the amount of oxidation of the eumelanin in grey and black feathers is similar but the concentration of eumelanin pigment granules is much lower in grey feathers.

Phaeomelanin is responsible for red-brown pigments. Probably, phaeomelanin is also an oxi-

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105 Eurasian Coot / Meerkoet *Fulica atra*, Capelle aan den IJssel, Zuid-Holland, Netherlands, 28 February 2004 *(Chris van Rijswijk)*. 100% leucistic. Total absence of melanins in all feathers but melanins are still present in skin and iris. In this almost completely white bird, virtually all feathers lack melanins.
106 Snow Bunting / Sneeuwgors *Plectrophenax nivalis*, Vlieland, Friesland, Netherlands, 15 November 2004 *(Menno van Straaten)*. 100% leucistic. Total absence of melanins in all feathers but melanins are still present in skin and iris.
107 Eurasian Oystercatcher / Scholekster *Haematopus ostralegus (Pieter van den Hooven)*. 50% leucistic. Total absence of melanins in some (random) feather tracts but melanins are still present in skin and iris. Note that deposition of melanins in affected feathers is blocked, not development of melanins itself. Therefore, unaffected feathers have their normal colours.
108 Eurasian Oystercatcher / Scholekster *Haematopus ostralegus*, Texel, Noord-Holland, Netherlands, May 1974 *(René Pop)*. Probably 100% leucistic. This white bird lived for many years on Texel, which makes an albino very unlikely. Colour of eye and down layer have to be studied to identify it as a certain 100% leucistic bird and not a bleached ino. In an ino, the down layer would be cream-coloured and the pupil 'dark red' (see main text). In a leucistic bird, the down layer would be pure white and the eye would be normal (red iris with 'black' pupil). These features can not be properly judged from this single photograph but considering the pure white plumage, a 100% leucistic bird is the most likely identification.
109 Eurasian Coot / Meerkoet *Fulica atra*, Rotterdam-Ommoord, Zuid-Holland, Netherlands, 2 March 2003 *(Chris van Rijswijk)*. Diluted. Reduction of melanin concentration. Because Eurasian Coot only has eumelanin in its plumage, no distinction can be made in 'pastel' or 'isabel'. Normally black plumage parts have turned grey, normally grey parts are now paler grey.
110 Eurasian Jay / Gaai *Garrulus glandarius (Pieter van den Hooven)*. Diluted (pastel). Strong reduction of concentration of both melanins, but they are still present. This results in very pale plumage but skin remains unaffected. Same mutation as in House Sparrow *Passer domesticus* of plate 111. Because this bird remained in captivity, there has been no further bleaching by weather and sunlight and visible colour is result of mutation only.

dation product of eumelanin. The different shades of this pigment as the human eyes see it, from deep red-brown to yellowish-cream, also depend on the concentration.

Albinism

Albinism is defined as a total lack of both melanins in feathers, eyes and skin as a result of an inherited absence of tyrosinase (Fox & Vevers 1960). It is probably one of the most frequently mentioned colour mutations whereas it is, in fact, one of the least frequently observed mutations (especially in adult birds) in the field. Due to a mutation, an albino completely lacks the enzyme tyrosinase in its body. Tyrosinase is necessary for the chemical process that produces melanin pigments in vertebrates. Because of the absence of tyrosinase, an albino cannot produce melanin at all. The result usually is a completely colourless bird (but see below the remark on albinos with carotenoid pigments). Also, the eyes and skin are colourless. The red or pinkish 'colour' of these parts is caused by the blood that can be seen through the colourless tissue of eye and skin. A mostly white bird which nevertheless shows some form of melanin pigmentation is *never* an albino, by definition. 'Partial albinism' does *not* exist and is a 'contradictio in terminis', even if it is often used in the birding literature (eg, Ogilvie 2001). It is simply impossible, just like being 'partially pregnant'.

Tyrosinase has no influence on the formation of carotenoids. In an albino of a species with carotenoids as additional colour, these pigments remain present. Such a bird will remain completely or partially yellow (or red), dependent on the natural location of the carotenoids in the plumage. These birds do have red eyes and a colourless skin. Contrary to popular belief, albinos are therefore not necessarily all-white.

In all animal species, the mutation albino is inherited through an autosomal recessive gene. This gene is not rare and occurs in most populations. Albinos are born more frequently than one would expect, given the rarity with which they are observed. The reason that (adult) albinos are observed so infrequently is related to their bad eyesight. Due to the absence of pigments in the eye, albinos are very light-sensitive and they have difficulties in observing depth. As a result, they are an easier prey for predators than normal birds and also more readily fall victim to traffic and other hazards. Most of them die soon after the start of their independence, at fledging.

Leucism

Leucism is defined as a partial or total lack of eumelanin and phaeomelanin in the feathers as a result of inherited disorder of the deposition of these pigments in the feathers. It is probably the most frequently occurring inheritable colour aberration in birds and it is most often – errone-

111 House Sparrow / Huismus *Passer domesticus*, Camperduin, Noord-Holland, Netherlands, May 2000 *(René Pop)*. Diluted (pastel). Strong reduction of concentration of both melanins, but they are still present. This results in very pale plumage but skin remains unaffected. There are many gradations of dilution but this is one of the more extreme examples. Weather and sunlight have caused further bleaching. So, visible colour is result of mutation in combination with bleaching by sunlight.
112 Common Starling / Spreeuw *Sturnus vulgaris (Pieter van den Hooven)*. 'Brown'. Incomplete oxidation of eumelanin. Normally black plumage parts have turned dark brown. Phaeomelanin is unaffected. Incompletely oxidised eumelanin is very light-sensitive and, in nature, 'brown' plumage will soon strongly bleach. However, bleached 'brown' Common Starlings in adult-type plumage will not become as white as juveniles because of still rather dark 'starting point' of adult-type feathers. Because this bird remained in captivity, there has been no further bleaching by weather and sunlight and visible colour is result of mutation only.
113 European Greenfinch / Groenling *Chloris chloris (Pieter van den Hooven)*. 'Brown'. Incomplete oxidation of eumelanin. Normally black plumage parts have turned dark brown. Phaeomelanin is unaffected. Dark (melanine) ground colour of green parts is paler than normal. Incompletely oxidised eumelanin is very light-sensitive and, in nature, 'brown' plumage will soon strongly bleach. Because carotenoids are unaffected, a bleached European Greenfinch will gradually appear more yellow. Because this bird remained in captivity, there has been no further bleaching by weather and sunlight and visible colour is result of mutation only.

ously – called albinism or 'partial albinism'. In leucistic birds, the enzyme tyrosinase is normally present and the production of melanin in the *basic colour cells* and the transformation into *colour cells* is normal. However, the deposition of melanin in the feather cells does not occur due to an inherited disturbance disorder of the pigment transfer. As a result, more or less colourless (white) feathers occur at random anywhere in the plumage.

Different forms of leucism are known and can vary from only a few white feathers (<25%) to totally white individuals (100%). White feathers of leucistic birds are fully without melanin, with no coloured patches (however, similar to what has been described above under albinism, if colours are present that are caused by carotenoids, these remain visible). In certain forms, only feathers become colourless while eyes, skin and horny bare parts are normally coloured. In other forms, these parts can become colourless as well. Nevertheless, even birds with the latter form of leucism still have dark eyes. The reason for this is that only the pigments of the iris are missing. The pigments in the back of the eyeball remain present and therefore the eyes look dark.

So, leucistic birds always have coloured eyes which distinguishes them from albinos. In all forms of leucism, the eyesight is normal. Such birds are not hampered by reduced eyesight, and thus do not have reduced chances of survival. Consequently, leucistic birds are observed rather frequently.

Partly coloured feathers are very unusual in leucism. Individual feathers that are partly coloured usually indicate a bad condition of the bird during feather growth and is not an inheritable character (ie, is not leucism). This is often seen in, eg, Carrion Crows, especially those eating junk food in cities.

Brown

Brown as aberration is defined as a qualitative reduction of eumelanin. In this mutation, the amount of pigment remains unchanged but the appearance of the eumelanin is changed (cf Kopf 1986). As a result of an inherited incomplete oxidation of eumelanin, black feathers will turn dark brown. The phaeomelanin is unaffected.

In bird species in which both melanins occur naturally, this mutation is less obvious than in species which only have eumelanin. So, a 'brown' House Sparrow *Passer domesticus* (both melanins present) appears less aberrant than a 'brown' Carrion Crow (only eumelanin). However, feathers with a qualitative reduction of eumelanin are very sensitive to (sun)light and bleach quickly and strongly. So, old plumage is often almost white because the feathers are bleached by (sun)light. For that reason, this mutation is sometimes hard to distinguish in the field. In the hand, such a bleached 'brown' bird can be recognized by, eg, the colour of the down layer *under the contour feathers* and the colour of those parts of the remiges and rectrices covered by neighbouring feathers (often inner webs). In these parts, sunlight cannot penetrate and reduce the actual coloration.

The mutation 'brown' is widespread and can be encountered regularly. The juvenile 'biscuit-coloured' Common Starling *Sturnus vulgaris* reported from Weerselo, Overijssel, Netherlands (Dutch Birding 18: 244-245, 1996) is also an example of this mutation. Many reports of so-called 'leucistic' birds actually refer to 'brown' birds. For instance, the published photographs of pale Great

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114 Northern Lapwing / Kievit *Vanellus vanellus (Pieter van den Hooven)*. 'Brown'. Incomplete oxidation of eumelanin. Normally black plumage parts have turned dark brown. Phaeomelanin is unaffected. Incompletely oxidised eumelanin is very light-sensitive and, in nature, 'brown' plumage will soon strongly bleach to almost white. In this bird, many old feathers have bleached strongly, a combined effect of the mutation and exposure to sunlight. From a distance, it seems to have white and coloured feathers, and might be taken for a leucistic bird. However, closer view reveals that the pale feathers are not white and the coloured feathers do not show their normal coloration. In the hand, the down layer will be 'brown'.
115 Common Gull / Stormmeeuw *Larus canus canus*, Maasvlakte, Zuid-Holland, Netherlands, May 1981 *(René Pop)*. 'Brown'. Incomplete oxidation of eumelanin. Normally black plumage parts have turned dark brown. Phaeomelanin would have been unaffected but Common Gull does not have phaeomelanin. In first-winter/first-summer Common Gull, normally black colours are restricted to outer primaries and primary coverts and tail-band. Grey of mantle has turned into pale creamy-brown. Remainder of brown feathering (especially wing-coverts) has bleached to almost white. Feathers that are still brown are at rest covered by other feathers, and have been less influenced by sunlight.
116 Song Thrush / Zanglijster *Turdus philomelos (Pieter van den Hooven)*. Ino. Strong reduction of both melanins: phaeomelanin is almost absent, while there is hardly any oxidation of eumelanin. Normally black breast-spots (eumelanin) have turned pale brown and are only faintly visible. Because this bird remained in captivity, there has been no further bleaching by weather and sunlight and visible colour is result of mutation only. In nature, an ino soon will bleach to almost white and may resemble an albino or 100% leucistic bird. Inspection in the hand of the down layer (or other parts covered from sunlight) will reveal that it is the mutation 'ino'.
117 House Sparrow / Huismus *Passer domesticus* (Niedersächsisches Landesmuseum Hannover, Germany) *(Hein van Grouw)*. Schizochroic ('grey') male. Phaeomelanin is completely absent, whilst eumelanin is unaffected. This results in black or grey appearance.
118 House Sparrow / Huismus *Passer domesticus (Pieter van den Hooven)*. Schizochroic (phaeo) male. Eumelanin is completely absent. Phaeomelanin, which is largely restricted to the feather edges, is unaffected and even seems brighter in absence of eumelanin.
119 House Sparrow / Huismus *Passer domesticus (Pieter van den Hooven)*. Schizochroic (phaeo) female. Eumelanin is completely absent. Phaeomelanin, which is largely restricted to the feather edges, is unaffected and even seems brighter in absence of eumelanin.

Grey Owls *Strix nebulosa* in Finland (Dutch Birding 17: 19-20, 1995, 20: 296, 1998) do not involve leucistic but bleached 'brown' birds.

In all species, the inheritance of the mutation 'brown' is recessively sex-linked. It is also the only colour mutation that is sex-linked *in all bird species*. This means that a brown mutant with two normally coloured parents is always a female. In nature, 'brown' males are very rare because they can only be born from a 'brown' mother and a normal father that is heterozygotous for this mutation (and of course from parents that are both 'brown'). The chance for this to occur in nature is normally very minute. (Remember that in birds, males have two X chromosomes and females have X and Y.)

Dilution

Dilution is defined as a quantitative reduction of melanins. In this mutation, the amount of pigment is reduced (cf Kopf 1986). The pigment itself is not changed but due to a reduction in pigment concentration, a 'diluted' colour is observed compared with the original coloration. Two forms of dilution can be distinguished.

Pastel

Pastel is defined as a quantitative reduction of both eumelanin and phaeomelanin. Black feathers will turn grey and reddish-brown feathers will turn yellow-brown. The degree of dilution can differ within a single species. But in general, melanin reduction is c 50%. Such a mutant will look like a bleached wild-coloured bird. Several forms of pastel are known to occur within one species, all based on different heritable traits. In pastel birds, old plumage is often almost white because the feathers are bleached by (sun)light (as in the mutation 'brown'). Bleached 'brown' and bleached pastel birds can usually be told apart by examining the colour of the down layer.

Isabel

Isabel is defined as a quantitative reduction of eumelanin only. Black feathers will turn grey. The phaeomelanin is unaffected. In species with only eumelanin in their plumage, such as crows Corvidae, it is difficult to identify a mutant as an isabel or pastel, because both mutations have the same effect: a reduction of the concentration. The difference can only be seen in the phaeomelanin and these species do not have that pigment. Therefore, the general term dilution is used

in these instances, without making a further distinction.

Ino
Ino is defined as a strong qualitative reduction of eumelanin and phaeomelanin. In this mutation, phaeomelanin has (almost) disappeared and there is hardly any oxidation of eumelanin. Black feathers will turn very pale brown (almost white). In fresh plumage, colour and pattern are vaguely visible. Especially in species with a natural amount of white in their plumage, it can be seen that there is some pigmentation left in the remaining non-white plumage. In an ino, the plumage parts with normally the highest pigment concentrations remain the most clearly visible parts, for instance the black cap in Western Jackdaw. Old plumage is almost completely white in an ino because the feathers are bleached by (sun)light.

An ino has reddish eyes because pigments have disappeared there as well. But the eyesight of an ino is much better than that of an albino. It can be stated with great certainty that any adult 'white' bird with red eyes in nature is an ino, not an albino.

In most species, the inheritance of this mutation is recessively sex-linked (see also the mutation 'brown').

Schizochroism
Schizochroism is defined as the absence of only one of both melanins. Two forms of schizochroism can be distinguished.

Phaeo
Phaeo is defined as a complete reduction of eumelanin (non-eumelanin schizochroism). In this mutation, only reddish-brown phaeomelanin is present in the feathers.

Grey
Grey is defined as a complete reduction of phaeomelanin (non-phaeomelanin schizochroism). In this mutation, the plumage only contains the black/grey and brown eumelanin.

These two mutations are rather rare. They can be recognized especially in species with both eumelanin and phaeomelanin in their plumage. In many species, phaeomelanin is mainly located in the feather edges. When eumelanin is absent (phaeo), the darker feather edges result in a scaly pattern. When phaeomelanin is absent (grey), only black-grey and dark brown colours will be visible, the red-brown to yellowish-cream colours having disappeared.

In species with only eumelanin in their plumage, the recognition of a phaeo (non-eumelanin schizochroism) can be difficult, because the feathers of such a bird will be almost completely white (ie, without colour) and the eyes are coloured. Such a bird may resemble a 100% leucistic bird but the feathers of the latter are usually pure white.

Phaeo can be mistaken for the mutations 'brown' and 'dilution' in birds in old and bleached plumage. As said earlier, feathers with reduced eumelanin (both quantitatively and qualitatively) are sensitive to light and can bleach to almost white. All eumelanin seems to have disappeared, and therefore such birds look like a phaeo. However, they can be recognized by the coloration of those parts of the feathers where light could not penetrate (see also the mutation 'brown'). Again, examination of the feather parts where light could not penetrate as well as the down layer can often reveal the correct aberration.

Melanism
Melanism is defined as an increase of melanins. Two forms can be distinguished.

Eumelanism
Eumelanism is defined as an increase of eumelanin. In this mutation, the total appearance of the bird is blackish.

Phaeomelanism
Phaeomelanism is defined as an increase of phaeomelanin. In this mutation, the total appearance of the bird is reddish-brown.

Partial melanism sometimes occurs but this is not caused by a mutation but by, eg, disease, malnutrition or lack of exposure to sunlight. If these causes are removed, normal feathers will appear during the next moult. Melanism is one of the few mutations in which there is no loss of pigments but, on the contrary, an increase in pigment concentration. Birds with an increase in concentration of both melanins at the same time are not known. Also, one melanin form does not replace the other. For instance, phaeomelanin is not transformed into or replaced by eumelanin. So, in an eumelanistic bird, the amount of phaeomelanin remains normal but through the increase of eumelanin concentration, the phaeomelanin will not or hardly be visible. Eumelanism occurs more frequently than phaeomelanism.

Differently coloured

The term 'differently coloured' is used here to indicate all other inheritable colour aberrations. Two other aberrations are mentioned here because they occur quite frequently, although their appearance can be very diverse, making recognition difficult.

Grizzle

This is a leucism-like mutation. In contrast to leucistic feathers, grizzled feathers are partly pigmentless.

Acromelanism

Acromelanism is defined as the deposition of eumelanin and phaeomelanin in the feathers depending on body temperature and environmental temperature of the bird (Lubnow 1963). This mutation is allelic (involving the same gene) with albino. The coldest parts of the body, such as the top of the head, have more pigmentation than the warmer parts.

Concluding remarks

Giving a complete overview of possible inheritable colour aberrations in a limited amount of space is hardly possible. The aberrant plumages discussed above are grouped according to their appearance so that they can be identified in the field or in the hand. For instance, there are many different types of leucism, all with a different mechanism of inheritance and connected to different genes, but all resulting in more or less colourless feathers. The same holds for the mutations 'dilution' and, to some extent, 'ino'. It is, therefore, impossible to give strict and exhaustive descriptions and definitions for these groups of comparable mutations: an exception can always be found.

Only the mutations 'albino' and 'brown' are connected to the same genes in all species; and the gene for 'brown' is always located on the sex chromosome.

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Samenvatting

NIET ELKE WITTE VOGEL IS EEN ALBINO: ZIN EN ONZIN OVER KLEURAFWIJKINGEN BIJ VOGELS De belangrijkste pigmenten die kleuren van vogelveren bepalen zijn carotenoïden en melaninen. Carotenoïden zijn verantwoordelijk voor gele tot scharlakenrode kleuren; ze worden via de voeding opgenomen en met behulp van enzymen in kleurpigmenten omgezet. Afwijkingen in deze pigmentkleuren zijn meestal een voedselprobleem en slechts zelden genetisch bepaald. Melaninen zijn te verdelen in eumelanine (zwartbruin pigment) en phaeomelanine (roodbruin pigment). Melaninen ontstaan door een serie chemische reacties, te beginnen met de oxidatie van het aminozuur tyrosine, onder invloed van het enzym tyrosinase. De uiteindelijk gevormde melaninen zijn zelf ook onderhevig aan oxidatie en dit oxidatieproces kan zich in verschillende gradaties afspelen. Zwart is de sterkste oxidatievorm, bruin is een zwakkere vorm. Afwijkingen in door melaninen bepaalde kleuren zijn in belangrijke mate genetisch bepaald. Er zijn allerlei verschillende mutaties die op verschillende punten in het vormings- en distributieproces van melaninen kunnen ingrijpen. Enkele van de belangrijkste worden in dit artikel besproken: albinisme, leucisme, bruin, dilutie (pastel en izabel), ino, schizochroisme (phaeo en grijs) en melanisme. Hierbij worden ook enkele hardnekkige foutieve opvattingen over kleurafwijkingen uit de weg geruimd, zoals de per definitie onmogelijke aanduiding 'partieel albinisme' (albinisme is een mutatie waardoor het enzym tyrosinase ontbreekt, waardoor melaninen totaal ontbreken). Vaak hebben vogels met een gedeeltelijk wit verenkleed betrekking op leucisme. Afwijkingen die in literatuur als leucisme worden gemeld hebben dikwijls betrekking op de mutatie 'bruin' of dilutie ('verdunning').

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