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Review

Color aberration by the Eurasian woodcock (*Scolopax rusticola* L.)

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Abstract
In Hungarian and international ornithology literature certain colour variations of Eurasian woodcock (*Scolopax rusticola*) and their pattern are described, but the literature on the topic is rather incomplete and often contradictory. This article deals only with colour changes caused by genetic disorders i.e., with mutations that affect pigmentation. These include melanism, i.e., brown mutation, dilution, gray discoloration, leucism and Ino mutation. The descriptions of the colour variants help to identify the mutations by briefly explaining physiological processes in the background, pointing out uncertainties and the misinterpretation of the different mutations. In addition to a literature review of the mutations we illustrate the most significant colour varieties with photos, and we present our own research results on colour aberration. The large-scale analysis of the variability of colors and patterns was supported by the Woodcock Monitoring Project managed by the Hungarian Hunters Association since 2010. Based on countrywide Woodcock wing collection, as part of the biometric module of monitoring, we examined 12 078 wing samples from 2010 to 2018. Only six specimens (0.05%) were found in the entire data set showing deficient pigmentation of some degree or pastel colour.

Keywords: *Scolopax rusticola,* Woodcock curiosities, color aberration, colour variability, pigmentation disorders

Introduction

The plumage colour variability in birds is not rare, in polymorphic species forms with deviating colours are generally regarded as varieties (van Grouw 2013). In the case of the Woodcock (*Scolopax rusticola* Linnaeus 1758 - Scolopacidae), however unique coloured specimens occur only very rarely. The aim of the study is to represent a uniform system of colour deviations occurring by Woodcock and to resolve the related contradictions in the professional literature. Representing the basic characteristics of the most common mutations promotes the use of correct terminology and makes easier to identify them. It is to be noted that there are also known colour deviations which are difficult to distinguish from one another (van Grouw 2006, 2013). Since pigmentation disorders, as well as any disorder of varying quality and quantity in melanin production, can lead to similar coloration, a visual examination is not consistently sufficient to precisely describe the lesions (van Grouw 2006, 2013). The classification of curiosities in taxidermic collections is also made more difficult by the fact that the feather loses its fine, detailed pattern over time, as pigments are also destroyed by light, however, there is often the only possibility of examining unique specimens in such collections or photos of their materials.

Pigmentation process

To correctly identify these colour mutations, is important to know which pigments define the species-specific normal colour of feathers and the physiognomy of pigmentation process disturbances. The multistage chemical process of the melanin formation as well as the pigmentation process itself became known in the second half of the 20th century (Mason 1953; Lubnow 1963). The typical colour and pattern of Woodcock are determined by two types of melanin - eumelanin and pheomelanin. Melanocytes are formed by melanoblasts that develop in the embryonic spinal cord at an early embryonic stage and then spread during transport processes to the skin and feather follicles where they may produce melanin. Both forms of colour-determining melanins are not necessarily present in the plumage of all species (Lubnow 1963). In the species of the Corvidae family only eumelanin is found in the plumage, while both melanins are present in the feathers of the Woodcock. In this case feathers can be characterized by certain patterns and/or colour differences caused by different amount, oxidation state and specific distribution of eumelanin and pheomelanin. During the development of the species-specific pattern and colouration, eumelanin is mainly concentrated in the centre while pheomelanin on the edges of the feathers. The central compound in the chemical process of melanogenesis is the amino acid tyrosine, pigment formation occurs through its oxidation and is regulated by the tyrosinase enzyme (van Grouw 2006). Melanin polymer molecules are oxidized during the process. However, the degree of oxidation can vary, and thus the intensity of the colour produced. Black is the most oxidized form, while brown indicates a weaker oxidation state. Depending on the concentration and distribution of the different melanin types in the feather, eumelanin is responsible for the black, gray and dark brown shades. Pheomelanin produces a red-brown hue at high concentrations and a yellowish-brown colour at lower concentrations. The common presence of the two melanins leads to a combination of the colours determined by them, resulting in a normal coloration and pattern typical for the species (van Grouw 2006). It should be noted hereby that any abnormality during

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the melanoblast spread, or melanin synthesis may affect the final pigmentation of the plumage. Of course, the deviations do not always have a genetic background, unusual colour changes can also develop due to external factors. In the ornithological literature, the nomenclature of lesions indicating colour varieties are mainly based on the mutations of rock doves (*Columba livia* Gmelin 1789) (van Grouw 2013).

Mutations leading to colour varieties

Woodcock's most extensive knowledge of colour varieties was published in the journal of the Club National des Bécassiers, La Mordorée, in France (see e.g., Boidot 2002a–2015; Chantron 2019; Jarry 2018 etc.). Although the uniquely coloured Woodcocks are presented, they are not comprehensively systematized and the genetic and physiological reasons for the lesions are not presented. In our study we performed the systematization of colour deviations due to genetic mutations in this species. According to the literature, the following colour deviations occur in Woodcock: melanism, melanin thinning (pastel, Isabella), brown mutation Ino and leucism. In addition, some special colours (agate, opal) have also been described.

Melanism

Melanism is the most common polymorphism in birds (Mundy 2006), but in Woodcock, the lesions associated with an increase in the amount of melanin are rather infrequent pigment disorders. No birds are known in which the concentrations of both melanins were increased at the same time (van Grouw 2013). If the amount of pheomelanin remains at a normal level with increased eumelanin concentrations, the colour induced by pheomelanin is hardly or even not recognisable, which means that the bird will turn completely black as the brown / gray patterns are barely noticeable. This mutation appears in two forms:

(1) Eumelanism – a lesion associated with an increase in the amount of eumelanin that results in a black-tinted appearance of the bird's plumage. Eumelanism is the most common melanistic lesion (Van Grouw 2006).

(2) Pheomelanism – an increase in the amount of pheomelanin, which shifts the colour of the bird's plumage more towards red-brown than the normal wild-dominant colour.

In French literature, Boidot (2009a) distinguishes the following two main categories in case of Woodcock melanism:

(1) Jet-black mutation – affects the entire plumage, the legs are dark, steel gray, the nails black. In this case, the brown colour is completely absent, so the wild dominant pattern does not appear due to the lack of transverse markings on the feathers. Jet-black plumage has not been observed in the Woodcock until now (Boidot 2009b, 2012).

Figure 1. A pheomelanic Woodcock described as a transitional form of the gray colour variety. (Boidot 2009a) (Photo: J-P. Boidot).

(2) Transient black mutation – the black mutation is to a greater or lesser extent present in the plumage, the brown colour is still visible in some places, so that the classic wild-dominant pattern is locally recognizable (especially on the lower body and on the wings with the exception of the primaries and secondaries). But these transitive forms appear also very rarely in Woodcock (Boidot 2012). According to Boidot's (2009b) hypothesis, the melanistic mutation can occur in two ways, depending on the initial melanisation sequence in the feather: type I: brown/black and type II. black/brown.

In the first type the brown markings in the patterning are replaced by black melanin during the development of the feather. Oxidized black eumelanin is the only pigment synthesized in the early stages of feather growth. Later, however, some brown, red pigments are occasionally incorporated, resulting in a light brown or very fine beige pattern on the tip or the edge of the feathers. *In the second type*, the process begins with a brown/black sequence. The patterns of the feathers are getting blacker as the oxidation process continues, and the markings in the patterning are thickening during the melanisation. Even the lightest areas will be filled with dark pigment and the feather will be deeply black tinted as it grows. The brown patterns change to gray while the gray patterns turn to black. In the first type, it is remarkable that the melanisation affects feathers from the upper body, with very few feathers from the lower body. In the second case Boidot (2009b), believes that the entire plumage

is concerned by the melanisation. During the first type the melanisation process is slowed down, disrupted, or blocked by genes responsible for pigment polarity. In connection with the phenomenon declares Boidot (2012), that Woodcock specimens even with a patterned melanistic character are extremely rare.

Boidot (2009b) suggests the following classification based on the low number of known melanistic birds:

Black / melanistic plumages
Brown / black pattern-dependent melanisation
Black plumage pattern
Black / brown melanisation independent of the pattern
1. Transient black, upper body intensely, lower body not significantly melanized
2. Limited / partial black, intensive melanisation in the upper or lower body

Figure 2. Special black coloured Woodcock from France. (Boidot 2009b) (Photo: M. Baril).

Brown mutation
The brown colour change is caused by a qualitative decrease in eumelanin. In case of this mutation the amount of eumelanin remains unchanged by decreasing oxidation degree. The hereditary, incomplete oxidation of eumelanin causes black feathers to turn dark brown, while the colour induced by unchanged quality and quantity of the pheomelanin dominates (Kopf 1986). In the Woodcock, caused by the presence of both melanins, this mutation is less pronounced than in species whose feathers only contain eumelanin. This phenomenon gives the birds different colour intensity in patches, caused by melanin amounts present in various oxidation states. Overijssel (1996) refers to this change as *„biscuitcoloured"* which deviation also occurs in Woodcock (Url. 1; Url. 2; Url. 3; Url. 4; Boidot 2012; Vorontsov 2014). There is a mentionable important fact that eumelanin in different oxidation degrees is responsible for the different shades of brown, so eumelanin is not only by deviations present in feathers in different qualities and concentrations. The decrease in quality of eumelanin in feathers causes sensitivity to sunlight, which effects the pigments a rapid and strong fading. In case of such a very pale, almost white "brown mutant" bird, it is worth looking at the lower layer under the contour feathers as well as the plumage on the inner, covered parts. The brown mutation is widespread among bird species and is also one of the most common lesions in the Woodcock, but extremely light, almost white "brown mutants" are very rare. Inheritance of brown mutation is linked to sex chromosomes. In birds, males have homogametic (ZZ) females heterogametic (WZ) sex chromosomes, which explains why most brown mutant birds female are, since in their case the brown mutation appears even by one altered gene sequence (Van Grouw 2006, 2013).

Changes associated with melanin dilution
The melanin dilution is defined by Kopf (1986) as a quantitative decrease, which means, that the quality, i.e. the oxidation state of the pigment does not change during the mutation, but the concentration can decrease significantly. As a result, a "thinned", lighter shade can be observed compared to the original colour. Two types of this lesion can be distinguished:

(1) Isabella plumage – defined by French experts as a separate colour category, but aware of the biological causes that lead to the development of the lesion, Van Grouw (2006) classifies it among melanin dilution mutations. In contrast to pastel mutations, the Isabella mutation results in a quantitative decrease of eumelanin, only one of the two melanins, the black/dark brown feathers turn gray, while the concentration of pheomelanin causing the red/brown colour does not change. According to Boidot (2012), two mutations occur in this case, the number of brown pigments decreases, but the black colour is missing because of the incomplete oxidation of eumelanin, which results in a lighter so-called Isabella plumage.

(2) Pastel mutation – caused by a quantitative decrease in both eumelanin and pheomelanin. Black feathers turn gray, while red-brown feathers yellowish-brown. The extent of pigment concentration decrease in Woodcock is varying widely, which affects plumages faded to different degrees. According to Boidot (2008a, b, c), the changing melanin concentration is also responsible for pattern formation in different shades. The pastel mutation actually leads to a normally patterned, but to different degrees faded bird. The plumage of birds with heavy melanin dilution are often almost white as the low pigment concentration in the feathers fades further by sunlight.

Figure 3. Woodcock with Isabella plumage from Italy. (Url.5). (Photo: P. Pennacchini).

According to the French literature, melanin dilution occurs simultaneously with further mutations causing colour lesions and induce together a colour change. An example of this is the *black pastel* (Boidot 2013a; Pennacchini 2013; Maltot 2017) colour variety. In these birds, a significant part of the body plumage is white due to a strong melanin dilution. Patterns of normal coloured plumage are often completely absent, but melanin responsible for the black colour is present in high concentrations, in a highly oxidized state in some regions of the plumage. The peculiarity of this colour variety is confirmed by the low number of known black pastel birds in the Palearctic (Bende & László 2019a, 2020a,b, 2022).

Figure 4. Black pastel Woodcock from Hungary. (Photo: Zs. Marton).

The first known mutated brown pastel Woodcock was exhibited in the collection of the Rothschild Zoological Museum accompanied by a pure white specimen (Anonym 2018). In these birds, due to the very low oxidation level of eumelanin the black colour does not appear at all, stronger or weaker brown shades dominate depending on the concentration. The pattern of these birds corresponds to that of classic wild-dominant birds but is paler due to the lower pigment concentration.

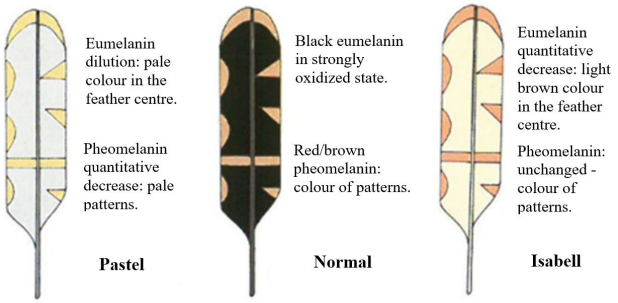

Figure 5. Classic wild-dominant, pastel and Isabella mutation of Woodcock. (after Boidot 2008c).

Gray mutation

The gray colour variety results from the strong pheomelanin decrease, leading to a suppression of brown and red shades and the more intense appearance of gray and black tones (van Grouw 2006). Among the special pastel birds, the French experts also described the medium gray and gray pastel types (Boidot 2012). According to Boidot's (2012) assumption and to Grow's (2006) assertions, there is a connection between the origin of the black and gray colour varieties, because both lesions are caused by the inhibition of phaeomelanin, whereby gray shades are emphasized. Only two such specimens are known from the literature (Chantron 2019; Url. 5.). It is important to point up that schizochromism in which one of the melanins is completely missing is not identical to gray mutation.

Figure 6. Gray Woodcock. (Chantron 2019) (Photo: P. Chantron).

Albinism and leucism

Some information about the colour and pattern variability of the Woodcock is known from the second half of the 1800s. These usually report on birds with a lack of pigmentation with very pale patterns on the feathers. Other specimens are known with basic white plumage with very few dark patterns or patchy unpigmented, so-called "varicoloured" Woodcocks. However, these designations are ambiguous in many cases contradictory.

According to the definition of Fox & Vevers (1960) albinism means the deficiency of both pigments in plumage, skin and in the iris caused by the inherited lack of the enzyme tyrosinase. In this case, the pigments are not only missing in the plumage (white colour), but also in legs, claws and eyes. Real albino specimens are very rare among wild birds because they have no depth perception with eyes without pigments. There are not any known reports of true albino Woodcock. In the published, white-feathered specimens, the eyes, the skin and the naked horny structures have always been pigmented. Accordingly, with the correct terminology, these partially unpigmented specimens are not albinos, but leucistic mutants which means white specimens with some pigmentation.

In the case of leucism, the enzyme tyrosinase is present so that melanin is produced in the body of these birds. The pigment deficiency occurs in the feathers because the pigment-producing melanoblasts cannot reach certain parts of the body (in extreme cases the entire surface of the skin) due to a congenital and hereditary defect. Pigment cells are therefore absent from the skin or part of it, where they would normally supply pigment material to the growing feather. The size of the body surface covered with white feathers shows a varied picture, from a few white feathers (partly leucistic) to full plumage; in the latter the skin appendages are also colourless. Leucistic birds always have dark eyes and pigmented bills, legs and claws (van Grouw 2006). White groups of feathers caused by leucism usually have bilateral symmetry, so some white primaries appear on either side (van Grouw 2013). At first, describing leucism, it was assumed to be caused by malnutrition (Rollin 1964), but later it came to prove of a mutation of genetic origin behind the phenomenon.

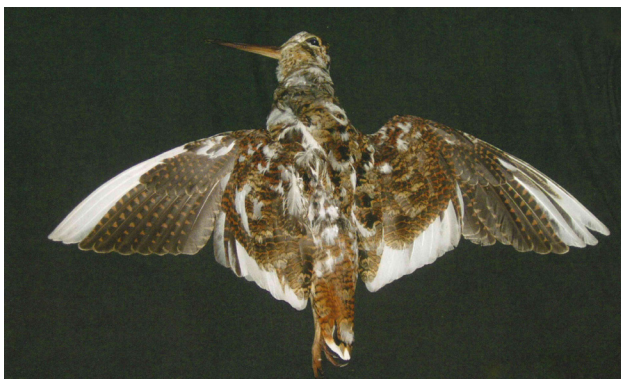

Figure 7. Rare leucistic Woodcock from France. (Boidot 2008a) (Photo: M. Tauxe).

Ino mutation

The Ino mutation arises from a strong qualitative reduction in eumelanin and pheomelanin. In contrast to melanin dilution, in this case both melanins are present in normal amounts, but in an incompletely oxidized state, so that brown eumelanin and pale pheomelanin lead to this colour. The Ino mutation is based on a single gene linked to the sex chromosome in each species (Van Grouw 2013). The mutation can lead to a variety of phenotypes depending on melanin oxidation grade. The oxidation degree of melanin varies, so that black eumelanin can be dark to very light brown, whereas reddish-brown pheomelanin is always very pale or even barely visible. The plumage has a faint pattern, particularly at higher levels of eumelanin, which is typically noticeable in species where the feathers usually contain white parts, like the feathers of Woodcock. According to Boidot (2014), Ino is characterized by a special melanisation in which eumelanin, often in a strongly oxidized state, accumulates in the plumage of certain body regions, especially in the wings, at the tip of the feathers. The mutant Ino bird has reddish eyes, although the iris pigments are not absent, but melanin is in a slightly oxidized state. Due to the available pigment materials, these birds have much better sight than an Ino. It is to claim that the red-eyed white birds registered under natural conditions are certainly INOs and not albinos. This recessively inherited mutation occurs only in females (Van Grouw 2013).

English specialist literature (Van Grouw 2013) distinguishes between two categories:

(1) Ino-Light – significant quality decrease in of both melanins due to insufficient oxidation grade. The original black colour turns very light brownish cream, while the original red yellowish-brown colour is barely visible. The eyes, beak, and legs are pink.

(2) Ino-Dark – strong quality reduction of both melanins due to insufficient oxidation state. The original black colour becomes light brown while the red yellowish-brown colour changes to brown cream. The beak and legs are also creamy brown coloured (Van Grouw 2013).

French literature (Boidot 2014) also distinguishes two main categories:

(1) Standard Ino plumage – the pattern of the upper parts of the body is characterized by a complete lack of brown colour. The concentration of pigment granules occurs in more distant parts of the body. The body is typically white with a fuzzy pattern. The beak and legs are yellow, the tips of the wing feathers show a disproportionate colour change without wild dominant patterns.

(2) Transitional Ino plumage

Type 1 – blurred pigmentation is characteristic in the upper body. The wings are evenly dark gray coloured due

to a pigment lack. The legs and beak are yellow.
Type 2 – only in the upper part of the bird's body and only to a negligible extent, but the discoloration with a blurred contour in the white colour is present. Discoloration is mainly seen on the end or side of the wings, leg, and beak of the bird.

Further mutations in the Plumage of Woodcock
Opal
The opal mutation prohibits the appearance of the brown colour, since it is coupled with the inconsistently positioned quantitative decrease in eumelanin. It differs from pastel in that the pigment concentration in the centre decreases more intensely than at the edges of the feather (Boidot 2008c). Boidot considers the simultaneous appearance of the opal and pastel mutations is possible, which leads to an even more intense decrease in the pigment concentration. As a result of the opal mutation, the melanins responsible for the brown colour decrease quantitatively, which leads to a bluish effect. The pattern usually appears in light brown and with a blurred contour, which is most noticeable on the wing plumage. This recessive mutation is described by Boidot (2006) for Woodcock using unusual wing patterns from two different countries (Russia, France).

Agate plumage
The mutation, which leads to a quantitative reduction in melanin giving the brown colour, does not change the quality of the melanin. A characteristic of the agate mutation is the simultaneous presence of eumelanin and pheomelanin, like black and "diluted" brown pigments (Boidot 2002a, 2008a). Boidot (2003) reported that the agate and opal mutations can even occur simultaneously.

Some literature discrepancies regarding colour variations
Melanism
Finding that the markings are reduced through progressive melanisation or during pattern independent incorporation of dyes is fraught with uncertainty if it is relied only on phenotypic traits. In this way, the system of melanistic categories (partially black, transient black, limited black, black in pattern) constructed by Boidot (2009b) is also uncertain.
With regard to the hypotheses on the melanisation process described by Boidot (2009b), it should be pointed out that in type I it is not known whether the colour modification is caused by a change in the oxidation state and / or an increase of melanin concentration. According to Van Grouw (2006), the two melanins (eumelanin and pheomelanin) cannot be substituted, so that the appearance of the colour determined by them is ruled by their oxidation level and relative concentration. In type II. the exact genetic background of the concentration and/or oxidation state of the weakly oxidized eumelanin and pheomelanin resulting the brown colour is not known, which means that the reduction processes behind the species-specific wild-dominant patterns are also not clear identified. It can even be difficult to determine, especially in specimens with partially pattern-deficient melanistic plumage, whether the lesion is indeed caused by a mutation. In case of many bird species, it has been proven that non-mutational lesions may also underlie this phenomenon e.g.: illness, malnutrition. Unfortunately, the problem of partial melanism in Woodcock is still unclear, although Boidot (2009b, 2011) considers this as a common phenomenon especially in the coverts of flight feathers. Between 450 and 500 samples of this wing type have already been collected by French experts. However, there are only a few literature references to larger lesions affecting other areas of the body's plumage.

Lesions caused by melanin dilution
French ornithologists investigating colour variations of Woodcock use pastel shades to differentiate further each of the classic colour categories such as black, agate, brown (classic brown and reddish brown) and Isabella pastel (Boidot 2008a). In French literature, Isabella-lesion is classified as one of the main categories (Boidot 2003b, 2007; Jarry 2018) and Isabella pastel often described as its colour variant based on French and Italian Woodcock specimens (Boidot 2008e, 2009a). In the case of Isabella, this description of the colour variant is questionable, as Isabella is formed by quantitative eumelanin reduction, while pastel by the combined quantitative reduction of eumelanin and pheomelanin, therefore, the amount of either or both melanins varies, so the mutation can be either Isabella or pastel.

Figure 8. Woodcock specimen described as Isabella pastel. (Boidot 2009a) (Photo: M. J. Bernard).

Boidot (2008b) points out the uncertainty of the distinction between Isabella and pastel colour variants when publishing a photo by Fernan Blandin (England) and one by Alain Chalopin (France) of pastel Woodcock specimens. While describing the birds, Boidot (2008c) reports that the categories Isabella and pastel are often confused. In our opinion, the combined interpretation of these two phenomena is by definition contradicting, and the phenotypic features seen in photographs of preparations of these birds are not sufficient to clarify this problem.

French experts describe the so-called 'agate' mutation as a separate colour category. In this case, the mutation reduces the concentration of brown melanins, resulting in a lighter plumage. In our opinion, the agate lesion cannot be distinguished from the range of melanin dilution lesions based only on phenotypic appearances. It is also questionable whether this mutation can appear in a pastel version, however, in the case of a Woodcock shot in Ireland, Boidot (2008a) assumes a double melanin dilution and reports it as agate pastel. The agate-opal lesion was described by Boidot (2006) based on a single special sample of Woodcock.

Figure 9. Agate-opal coloured Woodcock with light gray, bluish plumage. (Boidot 2002a) (Photo: M. M. Boulanger).

Quantitative as well as qualitative disorders in melanin production often result in very similar pale colour changes, so the visual description of these mutations is rather uncertain, which Boidot (2002a) also draws attention to.

The assessment of this complex mutation is made even more difficult by the fact that it is the only known specimen in which the simultaneous occurrence of "partial agate plumage" and "opal mutation" has been described.

The literature is also often contradictory in the description of the black-pastel colour variant, since several specimens discussed among Ino mutants are clearly corresponding to the black-pastel category due to their appearance (Boidot 2003a, 2014). The classification of the unusually coloured Woodcock, recommended by Alain Le Coniac to Boidot, shot in the hunting season 2003/04 in Russia is also ambiguous, as Guy Hellequin describes the plumage as pastel mutation, while Boidot considers the opal mutation to be likely. Therefore, the opinion of the experts on the classification of individual specimens is also not clear even for these two lesions.

Leucism

Woodcock with deficiency of colour of different degrees are so-called leucistic birds (Anonym 2018), but the lack of pigment in the feather can be caused not only by mutation, but also by other factors. Worthy of mentioning is the phenomenon of gradual graying, in which as a bird ages, the amount of pigment cells gradually decreases, finally the entire plumage becomes whitish. In the case of Woodcock, this phenomenon has not yet been described, but its possibility cannot be ruled out. In the case of leucism, or in extreme cases of gradual graying, the abnormal feathers are completely white because of melanin deficiency. This issue is further complicated by the fact that external, non-hereditary factors such as disease or malnutrition can also cause discoloration because of disturbed melanin synthesis, in which case pigmentation normalizes as soon as external causes disappear.

Another difficulty with describing leucism is that the extremely pale, almost white plumage may be the result of other mutations, of which the brown mutation is the most frequent (Buckley 1982; Van Grouw 2013). It is important to note that leucistic feathers are completely pigmentless, as there are also specimens whose feathers are almost completely white, but on closer inspection the normal wild-dominant pattern in light brown or silver colour is partially or fully visible.

Ino mutation

Regarding the Ino mutation two publications with contradictory findings are known from France (Boidot 2003a, 2014). Boidot (2003a) refers to a strongly white Woodcock described as a pastel, however, he states that this specimen can be classified as Ino because of its plumage. Boidot (2014) also points to a specimen previously described as Isabella mutant, whereby Ino mutation would be the correct classification according to current knowledge. In the case of the Woodcock, we do not yet have any authentic literature on the Ino phenomenon, so we consider the French classification problematic in this regard. In published descriptions, the authors usually rely on photographs of preparations, which further impedes the

description of the lesion, since its defining characteristics cannot be objectively assessed using collection materials. Lesions examined only visually often cannot be determined with absolute certainty, not even in case of a living bird or of a fresh cadaver.

Depending on the mutation scale the degree of melanin oxidation can vary significantly, so a variety of colour changes can result in a range of theoretical phenotypes, leading to a range of specimens that can be confused with many other modifications genetic origin as well (e. g. melanin dilutions, brown mutation).

In species without phaeomelanin, Ino can be distinguished from the brown mutation by foot and beak, as they are always pink due to the lack of melanins (Van Grouw 2013), however, in the case of Woodcock, both melanins are found. The correct description of this mutation is further complicated by the fact that the plumage continues to fade over time after moulting. According to Van Grouw (2013) the mutation is recessive, its inheritance is linked to the sex chromosome, so that the change occurs phenotypically only in females, i.e., without sex dimorphism in the case of living birds and without knowledge of the sex in case of preparations, the claim about the mutation cannot be trustworthy.

Summary

Using literature data on curiosities and the results of the Hungarian Woodcock Bag Monitoring we tried to give a comprehensive picture of the colour variability in the case of Woodcock, referring to the possible reasons for the rare occurrence, as well as to the possibilities and difficulties of classification. To arrange uniquely coloured specimens in a system, described color variant categories were collected as classification options based on the nomenclature of the mutations in the English and French specialist literature.

In addition, for each category, we referred to possible inconsistencies in the literature on the coloration of Woodcock.

Four categories of colour changes caused by confirmed mutations occur in Woodcock, such as melanism, brown mutation, melanin dilution (Pastel and Isabella) and leucism. The phenomenon of Ino and albinism has not been confirmed yet in this species, but their occurrence cannot be excluded. In connection to the classification, it can be stated that the correct naming and description of the colour variants occurring in Woodcock is burdened with considerable uncertainty based only on visual inspection. This is especially true for the distinguishability of melanin dilution mutations (pastel and Isabella) as well as for the distinctness of colour variants resulting from multiple mutations.

The establishment of certain categories or the description of groups within larger categories – e.g. groups of melanism described by Boidot (2009b) or the Ino categorization also reported by Boidot (2014) – is considered justified only if the given mutation has been credibly described for the species or the abnormal feathered specimen required for exact categorization is known. It would be also important to clarify which mutations may appear together, and how they modify the colour of the specimen. It should also be elucidated which relationship exists between the individual categories (e.g., a leucistic specimen being black-pastel at the same time) since the possibility of belonging to more than one category cannot necessarily be ruled out, especially if several mutations act simultaneously. It is important to emphasize that only laboratory tests of genetic background can give credible results if accurate description of a colour variant is required.

During the investigation term 2010–2018, we observed mutations resulting in a rare colour variation (leucism and melanin dilution) in only 0.05% of the Woodcock wing samples of the 12 078 specimens examined (Bende & László 2019a, b).

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