Ferrantia

ISSN 1682 - 5519

Aberrant plumages in grebes Podicipedidae

An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide

André Konter

72 2015

Travaux scientifiques du Musée national d'histoire naturelle Luxembourg

Ferrantia est une revue publiée à intervalles non réguliers par le Musée national d'histoire naturelle à Luxembourg. Elle fait suite, avec la même tomaison, aux TRAVAUX SCIENTIFIQUES DU MUSÉE NATIONAL D'HISTOIRE NATURELLE DE LUXEMBOURG parus entre 1981 et 1999.

Mise en page:

Romain Bei

Design:

Thierry Helminger

Prix du volume: 15 €

Rédaction:

Musée national d'histoire naturelle
Rédaction Ferrantia
25, rue Münster
L-2160 Luxembourg

Tél +352 46 22 33 - 1
Fax +352 46 38 48

Internet: http://www.mnhn.lu/ferrantia/
email: ferrantia@mnhn.lu

Échange:

Exchange MNHN
c/o Musée national d'histoire naturelle
25, rue Münster
L-2160 Luxembourg

Tél +352 46 22 33 - 1
Fax +352 46 38 48

Internet: http://www.mnhn.lu/ferrantia/exchange
email: exchange@mnhn.lu

Page de couverture:

1. Great Crested Grebe, Lake IJssel, Netherlands, April 2002 (PCRcr200303303), photo A. Konter.
2. Red-necked Grebe, Tunkwa Lake, British Columbia, Canada, 2006 (PGRho200501022), photo K. T. Karlson.
3. Great Crested Grebe, Rotterdam-IJsselmonde, Netherlands, August 2006 (PCRcr200602012), photo C. van Rijswik.

Citation:

André Konter 2015. - Aberrant plumages in grebes Podicipedidae - An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide. Ferrantia 72, Musée national d'histoire naturelle, Luxembourg, 206 p.

Date de publication:

25 septembre 2015
(réception du manuscrit: 9.1.2014)

Impression:

Imprimerie Faber, Mersch

 ISSN 1682-5519

Ferrantia

72

Aberrant plumages in grebes Podicipedidae

An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide

André Konter

Luxembourg, 2015

Travaux scientifiques du Musée national d'histoire naturelle Luxembourg

André Konter

Aberrant plumages in grebes Podicipedidae

An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide

Contents

Aberrant plumages in grebes Podicipedidae

An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide

André Konter
45, rue des Romains
L-6478 Echternach
podiceps@pt.lu

Abstract

Records of aberrant grebes Podicipedidae of all species worldwide (i.e. mentioned in the ornithological literature; reported by museums of natural history; retrieved via the internet; stemming from own observations) were aggregated in a register. Based on the available descriptions and photos, each record was analysed individually with respect to the cause for its abnormal appearance. The study was based on the assumption that grebes' integument colouration is almost entirely based on the two melanin colour pigments, eumelanin and phaeomelanin. Its main objective was to distinguish between genetic and non-genetic causes of aberrations and to correctly classify individuals in the first category according to the genetic mutations:

- albinism (no production of melanin pigments at all, neither for feathers nor bare parts, nor eyes),
- total leucism (no delivery of melanin to feathers and skin (bare parts), but presence in the eyes),
- partial leucism (not all feathers are affected, the eyes are not affected),
- brown (qualitative reduction of eumelanin only),
- ino (qualitative reduction of both eu- and phaeomelanin),
- dilution (quantitative reduction of melanin(s))
- different forms of melanism (in most cases increased quantity of melanin, in some cases altered distribution).

Due to a lack of descriptive detail, it was not possible in all cases to re-assess the cause of an unusual appearance in a grebe. In the great majority of the cases verified, the initial assessment by the observer proved to be wrong. Regardless of whether the initial records were older or were from the 21st century, in only 18% of all aberrations were the causes correctly identified. The mutations brown and ino appeared to be unknown to field ornithologists, and dilution was familiar only to a minority. Progressive greying, an age related cause leading over time to more and more white feathers in the plumage, was often confused with leucism or dilution. The examples show that correct identification of causes in the field is often difficult, sometimes even impossible. Records from 2000 on represented 53% of all datasets. This must not be interpreted as an increase in the number of grebes with aberrant plumages. The phenomenon is rather related to the reporting facilities offered by the internet and to an increase in the number of people interested in field ornithology. In all grebe species, genetic mutations are very rare.

Not surprisingly, the Black-necked/Eared Grebe *Podiceps nigricollis* contributed most of the records to the register (44%), being by far the most numerous grebe species in the world. Great Crested *P. cristatus* (26%) and Little Grebes *Tachybaptus ruficollis* (8.5%) came next. Geographically, the records were concentrated in western and central Europe and North America. They were largely absent from eastern parts of Europe, Asia, Africa and South America.

The most frequent genetic mutation of grebes was dilution, followed by brown. Total leucism ranked third. The aggregated results for all grebe species were strongly influenced by the distribution between the mutations in *nigricollis* grebes. Also, in by no means all cases was assessment of the cause possible.

The colours displayed by affected grebes confirmed the initial assessment that the pigmentation of feathers in this family of birds is entirely melanin-based. This may be less the case for yellow bare-parts and red and yellow eyes.

Not much information was available with respect to lifetime histories, siblings and parents of aberrant grebes. The overwhelming majority of records concerned one-off observations. An assessment of the survival chances of genetically affected individuals was not possible. The available evidence confirmed, however, short survival in albinism. In the vast majority of cases, aberrant offspring hatched from normally pigmented parents.

The unusual colouration in the fore neck or/and upper breast of different grebe species needs further investigation. This relates to the chestnut red colouration in the normally black breeding plumage of Black-necked

and Eared Grebes, to the rusty to chestnut hues in normally white-breasted and -necked grebes, and to the occurrence of individuals with largely white feathered upper breasts, fore necks and/or chins in predominantly Black-necked and Eared Grebes during the breeding season. The possible implications of genetic mutations with respect to genotypic variability and speciation in grebes are discussed. Some of these mutations may have contributed in the past to the appearance of new grebe forms. A major task for the future will be to select a uniform nomenclature and ensure its use by observers. Future analytical work should investigate further the molecular genetic root causes for abnormal integument colouration in grebes and related processes.

Zusammenfassung

Ungewöhnliche Federkleider bei Lappentauchern Podicipedidae – Eine Analyse von Albinismus, Leuzismus, Braun und anderen Fehlfärbungen bei allen Lappentaucherarten weltweit

Beobachtungen von farbaberranten Lappentauchern Podicipedidae aller Arten weltweit (i. e. aus der ornithologischen Literatur, aus Sammlungen naturhistorischer Museen, aus dem Internet, eigene Beobachtungen) wurden in einem Register zusammengetragen. Basierend auf den Beschreibungen und verfügbaren Fotos wurde jeder Eintrag einzeln hinsichtlich der Ursache für die anormale Färbung analysiert. Dabei wurde von der Hypothese ausgegangen, dass die Färbung des Gefieders der einzelnen Arten ganz auf den beiden Pigmenten Eumelanin und Phaeomelanin beruht. Es galt dabei zwischen genetisch bedingten und nicht genetisch bedingten Ursachen für Fehlfärbungen zu unterscheiden, und die Lappentaucher in der ersten Gruppe korrekt auf die u.a. Mutationen zu verteilen:

- Albinismus (keine Produktion von Melanin Pigmenten, weder für Federn noch für nackte Hautstellen oder hornige Körperteile noch für die Augen),
- totaler Leuzismus (keine Melanin Pigmentierung der Federn und der nackten Haut sowie der hornigen Teile, aber normale Pigmentierung der Augen),
- partieller Leuzismus (wie totaler Leuzismus, aber nicht alle Federn weiß),
- Braun (qualitative Reduzierung des produzierten Eumelanins),
- Ino (qualitative Reduzierung des produzierten Eu- und Phaeomelanins),
- Fahlfärbung (quantitative Reduzierung der produzierten Melanine),
- Melanismus (in den meisten Fällen Überproduktion, in einigen Fällen Umverteilung der produzierten Melanine).

Da nicht in allen Fällen eine vollständige Beschreibung des farbaberranten Lappentauchers vorlag, war eine korrekte Bestimmung der Ursache nicht immer möglich. Dort wo diese aber möglich war, zeigte sich, dass bei der überwiegenden Mehrzahl der Beobachtungen die ursprünglich angegebene Ursache falsch war. Nur bei 18% der Lappentaucher erfolgte eine korrekte Bestimmung durch den Melder, unabhängig davon, ob die Beobachtungen älter waren oder ob es sich um Einträge aus dem 21. Jahrhundert handelte. Die Mutationen Braun und Ino schienen den Feldornithologen gänzlich unbekannt, und den Begriff Fahlfärbung schienen nur einige wenige zu kennen. Progressives Ergrauen, eine durch den Alterungsprozess hervorgerufene und weiter schreitende Weißfärbung des Gefieders, wurde oft mit den beiden Arten von Leuzismus, aber auch mit Fahlfärbung verwechselt. Wie einige Beispiele gezeigt haben, ist im Feld eine korrekte Bestimmung der Farbaberration sehr schwierig oder in manchen Fällen sogar unmöglich.

Der überwiegende Anteil, nämlich 53% aller Einträge im Register, stammen aus den Jahren seit 2000. Dies ist aber nicht auf einen generellen Anstieg der Anzahl farbabnormer Lappentaucher zurückzuführen. Der Grund liegt vielmehr in den verbesserten Mitteilungsmöglichkeiten über das Internet sowie in einer gestiegenen Anzahl der auf dem Feld tätigen Ornithologen. Insgesamt sind farbaberrante Individuen in der Gesamtpopulation einer Art sehr selten.

Nicht überraschend betraf die Mehrzahl der Einträge im Register den Schwarzhalstaucher *Podiceps nigricollis* (44%). Er ist die mit Abstand häufigste Lappentaucherart der Welt. Es folgten der Haubentaucher *P. cristatus* (26%) und der Zwergtaucher *Tachybaptus ruficollis* (8,5%). In diesem Zusammenhang sei darauf hingewiesen, dass die Beobachtungen sich geografisch auf West- und Mitteleuropa sowie auf Nordamerika konzentrierten. Einträge aus Osteuropa, Asien, Afrika und Südamerika waren selten.

Bei den farbaberranten Lappentauchern war die häufigste genetische Mutation die Fahlfärbung, gefolgt von Braun. Totaler Leuzismus war am dritthäufigsten. Die zusammengefassten Resultate für alle Lappentaucherarten wurden allerdings stark durch die Klassierung der aberranten Schwarzhalstaucher beeinflusst. Auch war die Feststellung der ursächlichen Mutation bei weitem nicht in allen Fällen möglich.

Die Färbung des Gefieders der durch genetische Mutationen veränderten Lappentaucher bestätigte die Anfangshypothese, dass nämlich die Pigmentierung des Gefieders in dieser Vogelfamilie ausschließlich auf Melaninen beruht. Dies muss aber nicht der Fall bei gelben Horn- oder Hautstellen sowie bei gelben und roten Augen sein.

Die zur Verfügung stehenden Informationen zu Lebenserwartung und Fitness abnormer Lappentaucher sowie zur Färbung deren Geschwister und Eltern waren in der

Regel eher dürftig, da die überwältigende Mehrheit der Einträge Einzelbeobachtungen betraf. Eine Ermittlung der Überlebenschancen farbaberranter Individuen war daher nicht möglich. Ein lediglich kurzzeitiges Überleben albinistischer Vögel konnte aber bestätigt werden. In den meisten bekannten Fällen wurden farbaberrante Küken von normal gefiederten Eltern produziert.

Die ungewöhnliche Färbung, die gelegentlich in Vorderhals- und Brustgefieder einiger Lappentaucherarten auftritt, muss weiter untersucht werden. Dies betrifft die rötliche Pigmentierung im Brutkleid der Schwarzhalstaucher, die Kastanienfärbung bei normal weißhalsigen Lappentauchern wie dem Haubentaucher sowie die Weißfärbung bei hier während der Brutzeit normal pigmentierten Arten wie dem Schwarzhalstaucher. Die möglichen Folgen genetisch bedingter Farbmutationen für die genotypische Variabilität sowie für die Artentstehung bei den Lappentauchern werden besprochen. In der Vergangenheit könnten einige der Mutationen schon zur Entstehung neuer Lappentaucherformen beigetragen haben. Eine Hauptaufgabe für die Zukunft besteht in der Festlegung einer einheitlichen Terminologie und deren Weitergabe an die Feldornithologen. Auf analytischem Gebiet gilt es, die molekulargenetischen Ursachen dieser Aberrationen weiter zu hinterfragen und die damit verbundenen Prozesse aufzuzeigen.

Résumé

Plumages aberrants chez les grèbes Podicipedidae – Une analyse de l'albinisme, du leucisme, de brun et d'autres aberrations chez toutes les espèces de grèbes du monde

Des observations de grèbes Podicipedidae aux plumages aberrants de toutes les espèces du monde telles que reflétées dans des publications ornithologiques, reportées par des musées d'histoire naturelle, retrouvées via l'internet ou observées personnellement étaient agrégées dans un registre. Sur base des descriptions et photos disponibles, l'aberration de chaque grèbe était analysée par rapport à sa cause. L'étude se basait sur l'hypothèse que la pigmentation du plumage des grèbes provient intégralement des deux mélanines, l'eumélanine et la phéomélanine. Son objectif principal était de distinguer les causes génétiques pour une coloration anormale du plumage des causes non-génétiques ainsi que de classifier les individus atteints de causes génétiques dans les catégories suivantes :

- albinisme (pas de production de mélanines, ni pour les plumes, ni pour la peau ou les parties dépourvues de plumage, ni pour les yeux),
- leucisme total (pas de livraison de mélanines pour les plumes, la peau et les parties dépourvues de plumage, mais pigmentation normale des yeux),
- leucisme partiel (semblable au leucisme total, sauf que le plumage n'est pas atteint en entier),
- brun (réduction qualitative dans la production de l'eumélanine),
- ino (réduction qualitative dans la production de l'eumélanine et de la phéomélanine),
- dilution (réduction quantitative dans la production des mélanines),
- différentes formes de mélanisme (surproduction de mélanines dans la plupart des cas, dans certain cas redistribution).

Le Grèbe à cou noir *Podiceps nigricollis* contribuait le plus d'observations au registre (44%). Ceci n'est pas surprenant comme il s'agit de l'espèce de grèbe de loin la plus nombreuse au monde. Il était suivi du Grèbe huppé *P. cristatus* (26%) et du Grèbe castagneux *Tachybaptus ruficollis* (8,5%). Géographiquement, les observations se concentraient en Europe de l'ouest et centrale ainsi qu'en Amérique du Nord. Elles étaient largement absentes de l'Europe de l'Est, de l'Asie, de l'Afrique ainsi que de l'Amérique Latine.

La mutation génétique la plus fréquemment observée chez les grèbes était dilution suivi de brun. Le leucisme totale passait au troisième rang. Le résultat global pour toutes les espèces de grèbe était cependant fortement influencé par la répartition des mutations chez les Grèbes à cou noir. En outre, rappelons qu'il n'était pas possible d'identifier ou de vérifier la cause d'une aberration dans tous les cas.

Les couleurs présentées par les grèbes affectés de mutations génétiques démontraient que l'hypothèse de départ était correcte, c'est-à-dire que la pigmentation du plumage de cette famille d'oiseaux repose entièrement sur les mélanines. Ceci n'est cependant pas nécessairement vrai pour des parties de peau ou de bec colorées en jaune ainsi que pour des yeux de couleur rouge ou jaune.

Les informations disponibles quant à la survie, la reproduction, la coloration des poussins issus d'une même couvée ou des parents étaient plutôt limitées. La grand majorité des donnés concernait des observations isolées ne permettant pas d'affirmations quant aux chances de survie de ces grèbes. Seul pour l'albinisme, une durée de vie courte était la règle. Dans la plupart des cas connus, les poussins aberrants étaient produits par des parents pigmentés normalement.

La pigmentation étrange apparaissant sur le cou et la poitrine de différentes espèces de grèbes nécessite des études supplémentaires. Il s'agit ici notamment de la coloration rougeâtre apparaissant notamment dans le plumage nuptial du Grèbe à cou noir, de la pigmentation châtaigne chez les espèces à cou blanc comme le Grèbe huppé ainsi que des plumes blanches couvrant parfois ces parties dans le plumage nuptial usuellement coloré de certains grèbes dont à nouveau le Grèbe à cou noir. Les implications des mutations génétiques analysées sur

la variabilité génotypique ainsi que sur la spéciation chez les grèbes sont discutées. Il est bien possible que dans le passé certaines de ces mutations aient contribué à l'apparition de nouvelles formes de grèbes. Une tâche primordiale pour l'avenir consistera dans la sélection d'une nomenclature uniforme et dans sa propagation chez les ornithologues. Les travaux analytiques pourront faire avancer nos connaissances en matière de causes moléculaires génétiques responsables pour ces aberrations ainsi que sur les processus impliqués.

Fautes de descriptions adéquates, il ne fut pas possible de déterminer ou de vérifier les causes des aberrations dans tous les cas. Néanmoins, pour les observations vérifiables, la cause initialement indiquée par l'observateur était seulement correcte dans 18% des cas, et ceci indépendamment si l'observation datée déjà d'un certain temps ou si elle était du 21e siècle. Les mutations brun et ino semblaient être inconnues des ornithologues et seulement une minorité était familier avec le terme dilution. Le grisonnement progressif, un phénomène lié au vieillissement, était souvent confondu avec les deux types de leucisme ainsi qu'avec des cas de dilution. Les exemples montraient qu'il était souvent difficile, voire impossible de correctement identifier sur le terrain les causes d'une aberration.

Les observations depuis l'année 2000 représentaient 53% de toutes les données. Ce chiffre ne doit pas être interprété comme représentatif d'une augmentation des cas d'aberration survenus plus récemment. Il résulte plutôt de facilités de reporting améliorées grâce à l'internet ainsi que du nombre croissant d'hommes intéressés par l'ornithologie. Peu importe l'espèce de grèbe, les individus aberrants demeuraient plutôt rares.

1. Introduction

Observers have always been intrigued by perceived abnormalities in animals, be they abnormal behaviour or appearance or any other form of abnormality. In birds, individuals with markedly different plumage to conspecifics have proved particularly interesting: both private and museum collections of skins contain many specimens with aberrant features. Most of them are not recent additions, but were collected during the 19th and the first half of the 20th century, when individuals with abnormal colouration were regularly shot and then presented to ornithological or scientific associations. In the absence of good knowledge about how colouration in birds and abnormalities arise, some "albinistic" specimens even achieved separate species rank. Coues (1868) already doubted the justification for some of these species, considering that "the study of this condition (albinism) among birds is more than a matter of simple curiosity, having important bearing upon the validity of … accredited … species".

In the course of the 20th century, most of the species based on only a single specimen in a collection and thought to be extinct were identified as aberrations of more widespread stocks. Over time, scientific progress provided ever more complete explanations for abnormally coloured individuals, and the criteria for the different categories of aberrations received a scientifically well-founded theoretical basis. This went in hand with changes in the terminology applied to abnormalities: new names were introduced, the meaning of others was altered, restricted or clarified, and it was proposed that some terms be abandoned. Unfortunately, not all scientists always adhered to a common nomenclature. This is one reason why field observers often had problems with changing terminology or were even not aware of the changes. As a consequence, they continued applying an obsolete terminology of aberrations. The situation is not much different today. Davis (2007) noted that birders, aviculturists and ornithologists alike are confused and continue to disagree about how aberrant colour terms should be used. A major reason for this is that many terms were coined before we knew much about the mechanisms behind the conditions they describe. Also, despite the comparable nature of the pigmentation process in birds and mammals, little has been done to establish some uniformity in the nomenclature of genes (loci) involved in the production of pigments between mammals and birds. Consequently, the naming of colour aberrations still causes problems in the ornithological world. Most commonly misapplied is the term "albino" or "partial albino" used for all sorts of different colour aberrations. Only in a tiny proportion of cases is the term used correctly (van Grouw 2013).

The growth in aberrant sightings and the more widespread knowledge thereof encouraged the

publication of regional, national, continent-wide and world-wide compilations (e.g. Deane 1876, 1880, Gross 1965a, 1965b, Hanebrink 1968, 1985, Harrison 1963, McGregor 1900, Sage 1963). Rather than setting geographical limits, some compilers restricted their work to specific bird families. At the latest in the second half of the 20th century, all compilations encountered increasing difficulties in correctly classifying published records of aberrations from different periods. The terminology applied to abnormal appearances was unreliable, and detailed integument descriptions was often lacking. The collection and conservation of specimens did not necessarily enable these difficulties to be overcome, as the colours of the plumage and the bare parts may change with the age of a skin. Moreover, the eyes are not conserved.

The situation is no different for grebes Podicipedidae. Changes in, and unprofessional use of the terminology of aberrations complicated the work of the compilers, and any lists established in the past have to be treated with caution. In addition, species identification was not always correct. Previous papers concerned with plumage aberrations in grebes have been by Chernel de Chernelháza (1907), Weller (1959), King (1973, 1975), Dittberner and Dittberner (1979), Jehl (1985) and Thiede (2005). In his paper, King (1973) included the data of Sage (1963), who reported six cases of "albinism" in two species of grebes (Little *Tachybaptus ruficollis* and Red-necked Grebe *Podiceps grisegena*). It appeared however that the initial classification of one Red-necked Grebe record was wrong and in fact concerned a Great Crested Grebe *Podiceps cristatus*. This rectification remained unknown to Dittberner and Dittberner (1979), who still cited Sage (1963) reporting six cases in two species from the UK.

The latest paper by Thiede (2005) bemoaned the lack of precision in naming aberrations. The author stated that any compilation of aberrant grebes encounters a practically insurmountable problem because of superficial and often even wrong original classifications: a schizochroic bird is listed as leucistic, a leucistic grebe with dark eyes as albino, and partial albinos may be about everything. This made it impossible to him to separate "whitish" grebes into leucistic and albinistic specimens, and a separation between different degrees of leucism was likewise impossible. Finally, Thiede avoided any misleading classification of the retrieved records by assembling all observations of light to whitish coloured grebes in a single category that he named "whitelings".

Melanistic individuals did not pose a similar problem, and melanism was in most cases correctly identified, although in the absence of a detailed description, the extent of darkening may remain unknown. Also, melanism is an extremely rare condition (Coues 1868), and there are far fewer cases of melanism than of albinism (Gross 1965b).

While Thiede's (2005) comments are understandable, his solution of having all whitish and pale grebes classified as whitelings is too simplistic. Such a methodology does not really help us to progress as it puts observations which have been correctly named and have a detailed description which enable an unequivocal assessment of their correctness in the same pot as those without any details and where the terminology applied might be misleading or wrong. In addition, while a lack of confidence in older data is undoubtedly justified, especially as the possibilities of verification are often limited, more recent observations are generally published via the internet and accompanied by good photos. In many cases it is thus possible to correctly identify the aberrations or to exclude possible causes, even if pictures cannot solve all problems. For instance, the pigmentation of the folded wing may remain uncertain, and distance and light conditions may hamper identification of the fine-scale colour distribution in the plumage and of the colours of eyes and bare parts.

The present study tries to correct the shortcomings of the method applied by Thiede (2005). It will therefore revisit the details of each single record. It will in addition be extended to all sightings of aberrant grebes worldwide. This requires not only a good understanding of the regular juvenile and adult plumage and of the moulting processes in the different grebe species: theoretical knowledge about how colouration in birds develops is just as important as knowledge about how abnormalities may arise, how they translate into a bird's appearance, and how they may survive from one generation to the next. A global view about how the terminology of aberrations has changed over time and how this translated into practice is necessary for the assessment of older records.

Last but not least, it is indispensable to adhere to a nomenclature of aberrations which features clear definitions and that is well-founded and ideally of universal use.

While the methodological part of the study will deal in great detail with the theoretical aspects mentioned above, the analytical part will first of all try to achieve the correct identification of all aberrant individuals. As far as possible, it will also provide data about survival, breeding and breeding success of abnormally coloured grebes and about the heritability of the observed aberrations.

To sum up: all kinds of names have been used randomly to identify colour mutations (van Grouw 2010), and there is much potential for confusion in the naming of aberrant birds. Before starting any analysis, it is therefore indispensable to clarify the concepts applied. This is best done by first explaining how natural colours are produced in birds and how abnormalities may arise and be maintained in a population. This is followed by a brief description of how aberrations were historically named, before adopting for the present study a contemporary nomenclature that is based on today's scientific knowledge and that provides clear definitions.

Besides genetic abnormalities arising from pigment production, or from failures to do so, other causes of abnormal colourations occur in nature, e.g. hybridization, sun bleaching of feathers, staining during incubation, pollution, oiling, sickness, feather abrasion, trauma, hormonal disorder, and old age. Their effects on the appearance of birds are sometimes similar to those caused by genetic mutations, and they cannot always be easily differentiated from cases of hereditary abnormal pigmentation. It seemed therefore advisable to include in this study all occurrences of aberrant grebes. Each available record of an abnormal grebe is entered into a database organized by species (Appendix 1). Every single record is assessed anew and reclassified in the light of all information collected and according to the newly adopted definitions. Finally, the identification of colour mutations, their extent and their consequences for individual birds and for a species are discussed.

2. Methodology and theoretical aspects of colouration

This chapter first defines the term "aberration". It then describes briefly how the different records were collected and assembled. It continues with a detailed explanation about how colouration in birds is normally achieved and how aberrations can occur. It then gives an overview of the terminology of abnormalities applied historically. It finishes by providing a modern identification guide for grebes affected by genetic colour mutations.

2.1. What is an aberration?

Individual birds belonging to the same species do not always look the same. Besides possible geographic variation (often expressed by subspecies status), there is phenotypic variation in every population. The question is when this variation becomes abnormal or, to put it differently, when such variation no longer falls within the regular appearance range of the species. For the purpose of this study, a grebe's appearance will be considered normal if it corresponds to the description provided in specialized publications (monographs of individual grebe species or of the family Podicipedidae, scientific articles dealing with moulting patterns) for juvenile, breeding, non-breeding and moulting plumages. All deviations from the descriptions provided in Bandorf (1970), Bauer and Glutz (1987), Cramp and Simmons (1977), Cullen et al. (1999), Fjeldså (2004), Fjeldså and Krabbe (1990), Johnsgard (1987), MacDonald (1992), Marchant and Higgins (1990), Melde (1973), Muller and Storer (1990), Palmer (1962), Prinzinger (1979), Stedman (2000), Storer (1992), Storer and Jehl (1985), Storer and Nuechterlein (1992), Stout and Nuechterlein (1999) and Wobus (1964) will be considered as aberrations, even if the reference source states that individuals displaying the character trait are not infrequent. The dividing line remains somewhat arbitrary, as a value for the degree of frequency of a particular trait has generally not been established, and there is no globally recognized percentage that would constitute a border line between frequent and infrequent. For hereditary differences that have in some species led to fairly large proportions

of aberrant individuals in the population, the term "polymorphism" is often used instead of aberration (van Grouw 2013). No grebe species seems to be in such a situation. We can therefore be fairly confident that "not infrequent", if used for a grebe species, targets quite a low percentage value, generally below 2%. Although hybrid grebes are a priori a different subject and are not directly targeted here, in some cases confusion with aberrant purebred individuals is possible. For this reason, a short chapter will summarize our knowledge about interbreeding in grebes.

2.2. Compilation of the register

Ornithological publications and national and regional avifauna works published over the last 150 years were searched for records of aberrant grebes. Literature databases such as SORA (Searchable Ornithological Research Archive) or OWL (Ornithological Worldwide Literature) accessible via the internet were all investigated. A circular letter was sent by e-mail to many museums of natural history all over Europe and to some museums in North America with a request for information about aberrant grebes in their collections. More recent observations were mostly available via the internet and were retrieved using search engines. They were in most cases either accompanied by photos, or the e-mail address of the observer was indicated. This offered the possibility to contact the observer for additional details. For records published in an avifauna or an ornithological journal and referring to an earlier publication elsewhere, the original references and all later publications mentioning the record were likewise investigated. Again, wherever necessary and possible, the authors were contacted for additional details. In addition, I investigated my own photo database containing over 10,000 pictures of grebes of all species. All individuals with aberrations, even if a priori minor, were copied into the register.

Every single record of an aberrant grebe was registered in a table including (as far as possible) the following details: date(s)/period(s) of sighting and re-sighting(s); place of observation; assessment of aberration/cause of aberration by original observer/assessor; indications about the appearance of parents and siblings, raising, mating, breeding, breeding success, other behaviours, and other remarks of relevance; publication details in literature and internet, including indications about photographs. The table itself was subdivided according to species. Within a species, subspecies followed consecutively. Once the compilation was complete, every single dataset was assessed anew in the light of the theoretical aspects as outlined in 2.3 below. In an additional sub-table, details about hybridization in grebes were summarized.

2.3. Theoretical aspects of plumage colouration and terminology of aberrations

Natural colours in feathers arise from the deposit of pigments, the development of keratin microstructures – or both – during feather production (Davis 2007). Pigmentation is essential for the appearance of individual birds. This chapter will therefore first present the theory of pigment production. It will then explain how aberrations may arise, before defining the terminology applied to them in general and in this study. The genetics of abnormalities are the subject of an additional section.

2.3.1. Pigmentation and colouration of plumage and bare parts

Colouration is largely based on pigmentation. Apart from in feathers, pigment colours are also present in the skin, in horny skin parts (for instance in the beak, legs and feet), and in the eyes of birds. The patterns created by variation in pigmentation, especially melanin distribution in feathers and bare parts, are distinctive characters of many species; within populations, marked variation in visible patterns is unusual (Campbell & Lack 1985). Plumage colouration is typically obtained during moult, when pigment deposit in growing feathers occurs. According to their production and composition, pigments may be classified as (a) those built by the body of the bird itself and (b) others ingested with the food (Busching 1997). Görnitz (1923 in Busching 1997) subdivided pigment colours into melanins and lipochromes. In addition to colour pigments, structural colours contribute to the phenotype of birds. Structural colours of avian barbules are

produced by coherent scattering of melanosomes (synthesized melanins) that are distributed in the keratin of the barbules (Prum 2006).

In bird colouration, melanins play a major role and have been present since ancient times. The two types of melanin – the one creating dark shades (eumelanin) and the second associated with reddish hues (phaeomelanin) – have been recorded in fossil feather samples in *Sinosauropteryx* (Early Cretaceous, about 130 million year ago) and in *Anchiornis* (Late Jurassic, about 155 million years ago) (Switek 2010). They remain today the most prevalent pigments in birds.

Melanins are colour pigments produced by the body itself. Melanin production is dependent on colour cells that start their development in the early stages of the bird embryo in the neural crest. The first basic colour cells, called melanoblasts, are still unpigmented. They appear in the connective tissue of the occipital and sacral regions, where the two pigmentation centres are located. Depending on the genetic constitution of the bird, a more or less substantial number of the melanoblasts move into the epidermis, from where they also invade the feather follicles. The melanoblasts are precursor cells to the melanocytes. The latter are able to produce colour pigments via melanogenesis, which starts once the cells have reached their final destination (Lubnow 1963). The cells contain the amino acid tyrosine, which can be released from nutrients in the food or synthesized from available phenylalanine, an essential amino acid, by a single hydroxylation step. The sulphur-containing amino-acid cysteine is only used in the formation of phaeomelanin (McGraw 2006b). A series of chemical reactions is started with the oxidation of tyrosine catalysed by tyrosinase, a controlling enzyme present in the melanocytes (van Grouw 2006). The melanin pigment granules that are synthesized inside the melanocytes are called melanosomes. The role of tyrosinase is central to the initial oxidation step that forms dopaquinone, an intermediary that can generate either phaeomelanin or eumelanin. The presence of sufficient cysteine in melanosomes drives the reaction to produce cysteinyldopa and other benzothiazine precursors of phaeomelanin. Phaeomelanin production is also thought to predominate when tyrosinase concentration or activity rate is low (McGraw 2006b). The melanin itself is a polymeric molecule. Depending on the degree of oxidation, the resulting colours differ: black is the strongest oxidation form, brown is a weaker form (van Grouw 2006). Melanins are subdivided into eumelanin (producing black to dark brown colours) and phaeomelanin (responsible for red brown to dirty yellow colours). In its lightest phases, phaeomelanin appears colourless (van Grouw 2013). In high concentrations, it produces reddish brown feathers (van Grouw 2006). According to Frieling (1936 in Busching 1997), both types of melanin may be distinguished according to their chemical and physical properties, but the precise structures and characteristics of the melanins remain incompletely described so far (McGraw 2006b). Frank (1939) was of the opinion that the form of the pigment corns was independent of their colouration. He thought that in Podicipedidae, the darker melanin mostly takes the form of sticks. More recent publications adhere to Frieling's earlier statement that eumelanins have the form of sticks in most cases. They are derivatives of the amino-acid tyrosine (Frieling 1936 in Busching 1997), and the molecules are thought to be the larger of the two forms of melanin (McGraw 2006b). Phaeomelanins consist of round corns or granules and are derivatives of the amino-acid cysteine. Occasionally, the latter may cause very bright colours. Both melanins occur regularly in one and the same feather. Then, the phaeomelanin is often located more centrally in the feather, in the knots of the radiae; the eumelanin is stored more towards the edges (Frieling 1936 in Busching 1997). Phaeomelanin in the feather centre is however often less visible, partly because it is often mixed with eumelanin. Phaeomelanin on the edges is mainly without eumelanin and forms a clearly visible reddish brown lace that can be found in many Passerine species (van Grouw, pers. comm.).

Harrison (1965) introduced a third type: a melanin that, in the absence of a name, he proposed to refer to as erythromelanin. It was thought to be responsible for chestnut and erythristic red plumages and, if present in small quantities, to give a pinkish tint. Harrison saw a close link between eumelanin and erythromelanin. In a previous paper (1963) he had noted that where the chestnut-red melanin appeared, it seemed to replace the other melanin pigments. Also, where erythromelanin occurred, it tended to be most intense in those portions of the feather where the greatest amount of the other melanin pigments should have been present. In

addition, the chestnut-red pigment seemed to show a tendency to spread into normally unpigmented portions of the feather. According to Campbell and Lack (1985), pigment replacement rarely happens. These authors considered the abnormal change to chestnut-red occurring in individuals of some species rather as a mutation consisting in a qualitative reduction of eumelanin. A qualitative reduction occurs if the number of eumelanin pigment granules remains unchanged, but the eumelanin synthesis is incomplete and the eumelanin is not fully oxidised. As a consequence, the appearance of the pigment is altered. The partial oxidation of eumelanin would change its colour for example from normally black to brown (van Grouw 2013), but not necessarily to chestnut. It is therefore plausible that a switch from black to red brown colouration is triggered by a change in the type of melanin that is produced. Today, we know that pigment cells can produce both melanins, depending on what they 'are told to do'.

Once the melanoblasts have produced pigments and contain melanin granules, they change their name to melanocytes. Inside the feather follicles, such melanocytes are located close to the centres of feather production; more precisely they can be found in the epidermal, and not in the connective tissue. The melanocytes are cells consisting of one or more granules. They have branching extensions (dendrites) into the developing feather containing varying amounts of pigment corns, with which they intrude into the inter-cellular spaces and also the feather follicles. In this way, they kind of graft the future feather cells with pigments (Lubnow 1963), and the dendrites deposit the pigments in the growing feather (van Grouw 2006, 2013): they bring the melanins to their final destinations. In a similar way, colour pigments are deposited in the connective tissue and the epidermis of birds (Lubnow 1963). The addition of melanin to the dendrites is not necessarily at a constant rate. The pigment-producing cells have localized control in turning melanin synthesis on and off during feather growth (McGraw 2006b). So feather patterns may differ not only due to the type of melanin they receive, but also according to the amounts received and the distribution. During feather growth, sudden changes from the production of eumelanin to phaeomelanin may occur, giving rise to differences in feather patterns (van Grouw 2013).

In Aves, eumelanin is more common than phaeomelanins, and the relative importance of these two pigment types determines most colours (Davis 2007). In most birds, both types of melanin are present (van Grouw 2013), and there are no species in which only phaeomelanin occurs. All melanin-containing feathers analysed so far have contained both eumelanin and phaeomelanin granules, although one of them may have represented only a very small fraction of the total melanin contents. Total melanin concentration is less meaningful in shaping colour variability than is the relative proportion of the two pigment types (McGraw 2006b).

In summary, the properties of the pigment corns produced by the melanocytes, for example their colour and their distribution, depend on the genetic constitution of the melanocytes. Whether a typical breast or mantle feather results is decided solely by the epidermis. Hormones and their relative levels may, however, play a role as modifiers (Campbell & Lack 1985, Lubnow 1963). While eumelanin is responsible for the colours black, grey and brown, depending on the amount of oxidation, phaeomelanin is responsible for red-brown to dirty yellow colours. Phaeomelanin is probably also an oxidation product of eumelanin. The different shades of this pigment, from deep red-brown to yellowish cream, depend on its concentration (van Grouw 2006). Both melanins together can give a wide range of greyish-brown colours (van Grouw 2013).

In birds, carotenoids are the next most common pigments. They are a group of lipochromes – lipid soluble hydrocarbons or diffuse colour pigments that cannot be synthesized by the animal body directly, due to a lack of the enzyme necessary to manufacture it (Busching 1997, McGraw 2006a). Carotenoid pigments must be obtained from food as intact pigment molecules. Consequently, the expression of carotenoid-based pigmentation can be affected directly by the availability of dietary pigments (Hill 2006). Carotenoids occur either as carotenes containing only carbon and hydrogen or as xanthophylls containing oxygen (Busching 1997, McGraw 2006a). Carotenoids are easily taken up with plant diets, as they are present in modest to high concentrations in nearly all plant parts, although very few are used by birds (Goodwin 1980 in McGraw 2006a). Carotenoid accumulation, and thus colour intensity, is influenced by their

absorption in the gut, their transport bound to lipoproteins through the bloodstream, the uptake of circulating carotenoids by maturing feathers, and their metabolism at feather follicles. Birds use almost exclusively xanthophylls rather than carotenes for colouration. Some species do not metabolize carotenoids acquired from food, but deposit them directly into feathers and bare parts. This corresponds to the ancestral use of dietary carotenoids for colouration. Many species have evolved the capacity of modifying ingested carotenoids, specifically within the follicles, into oxidized or hydrogenated forms that are then used as colorants. Birds have the ability to limit carotenoid colouration to well-defined local areas of feathers and bare parts. Generally, only a small portion of individual feathers, typically the distal ends, contain carotenoids. Sex differences in carotenoid circulation are common in birds, and lipoproteins and sex-steroid hormones, like testosterone, are likely to contribute to their physiological control (McGraw 2006a). The carotenoids are able to build red (the carotenes astaxanthin and canthaxanthin, the xanthophyll rhodoxanthin), orange (resulting from a lower concentration of red carotenoids or from a blend of red and yellow carotenoids), yellow to yellow-brownish (the xanthophylls like lutein and zeaxanthin) and more seldom green pigments (Busching 1997, McGraw 2006a). Changes in carotenoid-based pigments caused by mutation are rare (van Grouw 2013).

More than a single carotenoid may play a role in the colouration of a species, and the colours displayed may result from their combination, from their co-occurrence with other types of pigments, for instance the melanins, from structural mechanisms and from the qualities of the tissue on which they are displayed (McGraw 2006a).

Besides carotenoids, at least six other groups of pigments can generate red, orange or yellow colours in birds. They include haemoglobin in the blood-filled tissues of avian skin and eyes. Apart from melanins and carotenoids, however, other pigment types are rather occasional and may be more species specific, such as the psittacofulvins, which contribute to the red, orange and yellow in parrots, or the pterins, which are responsible for red, orange and yellow irises in different species (Davis 2007). At least five other classes of endogenously synthesized colorants have been identified in bird feathers, bare parts and other colourful structures. To those mentioned by Davis, we may add the porphyrin pigments, the flavin pigments and as yet undescribed pigments such as the biochromes in the yellow plumage of penguins or in the downy plumage of many species (McGraw 2006c). The keratin microstructure of feathers, together with pigments, may then produce blue, green and iridescent colours (Davis 2007).

The embryonic origin of eye pigments is different from that of the rest of the body. Eye pigments originate mainly from the cells in the outer layer of the optic cup, not from the neural crest (van Grouw 2013). Generally, research into the nature of avian iris colours has so far been limited. Dark eyes often result from melanin, more precisely from eumelanin, as phaeomelanin is absent from the eyes (van Grouw 2012). Oehme (1969 in Prum 2006) identified carotenoid, pterin and purine pigments in the iris of many species. Guanine is often a major component of colourful red and yellow eyes (McGraw 2006c). A sex and age specific variability in pterin-based eye colouration has been noted in a number of species (McGraw 2006c). Oehme (1969 in McGraw 2006) noted the presence of colourful pterins in 150 bird species from 18 different families with red, orange and yellow eyes. Far fewer birds use carotenoids as eye colorants (Oliphant 1987 in McGraw 2006a), and in rare cases haemoglobin may contribute to red eye colouration. Many grebe species have a glowing red and some a bright yellow iris. In red-eyed species, the colouration is often age specific. It may therefore well be that their eye colours are largely pterin-based. The origins of these colours in Podicipedidae have so far not been studied. In the case of black or brown irises, that also occur in different grebe species, the pigmentation of the iris is plausibly due to melanins (Oliphant 1988 in McGraw 2006).

2.3.2. Possible causes of aberrations

Aberrant plumage and bare part colouration may have genetic, hereditary or other causes. The first may be subdivided into those originating within species and those produced by mixed-species pairing. While hybrids are not at the focus of this study, for completeness, their occurrence in grebes are summarized in a separate chapter. In their majority, within-species genetic causes impact melanin-based colouration. In carotenoids, mutations seem rather to be the exception.

As melanins play a major role in feather and bare parts colouration in birds, they are also at the root of many abnormalities. Limited intake of the amino acids needed for melanin synthesis might limit the expression of melanin colouration (Jawor & Breitwisch 2003 in Hill 2006) but, except perhaps for certain critical amino acids or minerals, melanin pigmentation is not very sensitive to food deprivation during moult (Hill 2006), and aberrations in melanin deposit are mostly of hereditary and other origins. Aberrations can be caused by improper incorporation of melanins into the integument of birds, which can be due to changes in melanin production or distribution (Lubnow 1963). The melanin formation process is determined genetically. Any aberration in the process, any disturbance in the melanoblasts' migration or in the melanin synthesis has a potential influence on the colour of a bird. We may distinguish between cases with

- complete or partial absence of both melanins,
- changes in the combination of melanins,
- decreased deposit of one or both melanins,
- partial loss of pigment deposit affecting more or less important parts of a birds plumage,
- excessive deposit of one or both melanins,
- invasion by melanins of parts normally not coloured,
- pigment replacement.

Overall in birds, many different colour mutations are known and, in the field, they can lead to partially distinguishable and partially indistinguishable colour aberrations (van Grouw 2006, 2013). Abnormalities are in many cases extremes of tendencies apparent in the individual variation of a species (Campbell & Lack 1985).

A complete absence of melanin results from the genetically controlled absence of the enzyme tyrosinase in the pigment cells, making melanin synthesis impossible. A completely colourless bird results, unless carotenoid or other pigments that are not influenced by the synthesis are present (Lubnow 1963, van Grouw 2013). The red or pinkish colour of bare parts is caused by the haemoglobin of the blood that can be seen through the colourless tissue of eyes and skin (Yeatman 1959). The loss of pigmentation in the retina of the eye will lead to impaired eyesight, especially in bright light (Campbell & Lack 1985). Apart from a genetic defect leading to the absence of melanin, a second phenomenon, at least theoretically, may cause melanin synthesis to fail: the insufficient extraction of tyrosine from food. However, in this case, the pigmentation will return to normal as soon as the external cause is removed (van Grouw 2006, 2013).

If the pigment-producing melanoblasts fail to migrate from the neural crest to some or all areas of the skin, melanin will be absent from these areas: an inherited disturbance of the pigment cell transfer mechanism prevents melanin being deposited in the feather cells. The production of abnormally white feathers (in the absence of other colour pigments) may be limited to just one or a few feathers, or it may be total, or their distribution may be patchy, depending on melanoblast migration. Commonly, the body parts farthest from the neural crest, the head, the wing-tips, the feet and the belly, are the most affected. Depending on where the colourless patches occur, bare parts may or may not retain their normal colour, but eye colour will not be affected. This is because the embryonic origin of eye pigmentation is different from that in the rest of the body. Eye pigments originating from the outer layer of the optic cup are independent of the migration of melanoblasts from the neural crest. Melanin pigments may nevertheless be missing in the iris (van Grouw 2006, 2013).

A qualitative reduction of eumelanin occurs if the number of eumelanin pigment granules remains unchanged, but their appearance is altered. This is a consequence of incomplete eumelanin synthesis: the pigment is not fully oxidised. The resulting normally black pigment remains dark brown. The colour of the eyes is not visibly affected by the mutation, but the feet and bill are slightly paler than those of normally coloured birds. A qualitative reduction may concern both eumelanin and phaeomelanin. If both pigments are insufficiently oxidised, eumelanin will turn brown and phaeomelanin pale. The degrees of oxidation may differ. Due to the qualitative reduction of eumelanin, the eyes become reddish, but the eyesight is much better than without any melanin (van Grouw 2013).

The reduction of melanins may also be quantitative. The number of pigment granules is reduced without the pigments themselves changing: their chemical composition remains unaltered. The

lower concentration of granules results in a weaker or paler colour than usual. The degree of pigment reduction is variable, not only between different individuals, but also between different parts of the body of the same individual. Quantities produced – of only eumelanin or phaeomelanin or of both pigments – may be lower. Most commonly, a reduction of both eumelanin and phaeomelanin occurs. Then, black feathers will turn grey, and reddish or yellow-brown feathers will turn buff or cream-brown to whitish. Most mutations cause a roughly 50% reduction of both melanins, making individuals look like a pale or bleached version of their normal conspecifics. If only eumelanin is reduced and phaeomelanin remains unaffected, black feathers will turn grey, but reddish or yellow-brown feathers keep their ordinary colours. Cases where only phaeomelanin is reduced and eumelanin remains unaffected are extremely rare (van Grouw 2013).

Abnormally high quantitative deposits or an altered distribution of melanins in skin and/or feathers may also occur. In contrast to the aberrations mentioned so far, no loss of pigment or change in the shape or size of the melanin granules occurs in these mutations: there is either overproduction of colour pigments or the granule arrangement is altered. For example, granules normally arranged in a clumped fashion may produce a grey colour, whereas the same amounts evenly spread make the colour appear black. In general, birds affected by these mutations appear dark, mostly, but not always blackish. The effects can be visible in different ways:

- normally dark markings may become bolder and noticeably overrun their typical boundaries, often somewhat darkening the rest of the plumage as well;
- the entire plumage may be darkened and appears dark brown or black, including in those parts that normally exhibit white feathers;
- the normal pattern and/or pigment distribution is changed, but the plumage is not darker overall.

In most occurrences, only eumelanin is affected, and the birds concerned look blackish. Abnormal deposit of phaeomelanin only is rare and will result in an entirely red-brown bird (van Grouw 2013). As melanins may spread to parts of the plumage which are normally devoid of it, they may mask other colours, where these are present (Campbell & Lack 1985). According to Koop (2003), the partial or complete lack of black melanin in the usually shining black neck feathers of Black-necked Grebes *Podiceps nigricollis* during the breeding season leads to chestnut-red-necked individuals. How this change in colouration occurs is still unclear.

Multiple types of plumage aberrations in the same individual may indicate a genetic defect influencing several pigmentation systems (Buckley 1982 in Hosner & Lebbin 2006). The distinctive patterns which are characteristic of the display plumage of males of many species appear to be to some extent under independent genetic control, and they are not necessarily responsive to changes in the pigmentation in the remainder of the plumage. This is particularly true of the patterns on head and breast (Campbell & Lack 1985).

In the absence of genetic mutations, aberrations may be caused by more temporary external factors. Seasonal appearances of birds may be controlled by the relative levels of hormones. Any imbalance in the endocrine system is likely to have a noticeable effect on plumage (Campbell & Lack 1985). Disturbed physiological processes that determine moult may lead to unexpected plumages for the season, for instance when hormones, which can vary seasonally, sexually and ontogenetically, affect colouration. They may do so by affecting pigment synthesis, pigment use or the formation of specific microstructures (Kimball 2006). Luteinizing hormones and oestrogens may adjust upward tyrosinase, which is critical in melanin synthesis (Okazaki & Hall 1965 in Kimball 2006). Supplementation of thyroid has led to melanism in some studies and to albinism in others (Miller 1935 in Kimball 2006).

Deviations from normal colouration may be related to age. Often a progressive loss of pigment cells occurs with increasing age, when progressive greying arises. The bird will display an increasing amount of white feathers after every moult. A similar effect may also be due to disorders, causing melanocytes, the cells responsible for skin pigmentation, to die or to be unable to function; depigmentation of the skin occurs by sections (van Grouw 2013).

Environmental conditions can have large disruptive effects on colour displays in birds.

Pollutants and toxins in the environment can stress birds and lead to reduced expression of ornamental colouration (Hill 2006). Carotenoid based colours may suffer from changes in diet; however, the effects are reversible. Food deficiencies may lead to a fading of colours or even their complete disappearance, while excesses may generate intensifications (Campbell & Lack 1985) or even unusual hues in otherwise light or white plumages (McGraw 2006a). Even if present in sufficient quantities in the food, other problems related to the circulation of carotenoids inside the body or in their metabolism may occur. Thus, the action of endoparasites, such as coccidian, can lead to a disruption of carotenoid transport (Allen 1987 in McGraw 2006a). Problems related to the gut, an important site for the production of the high-density lipoproteins that transport carotenoids through the circulatory system (Hill 2006), can cause transmission irregularities. Also, poisonous and other chemical substances present in the environment may enter the body with food intake, by respiration or by simple contact, and may be at the origin of abnormal appearances. Feathers coming into contact with natural or chemical dyes or soot are likely to take on at least some faint tinges that are visible especially on white or light plumages. Injury to individual feather follicles or to areas of skin can result in follicles continuing to produce feathers, but unable to deliver melanin, resulting in the production of abnormally white feathers (Campbell & Lack 1985). Finally, parasitic invasion, disease, exposure to iron oxides in soil or water (leading to a rusty appearance of particularly white plumage), normal wear and tear, soiling, staining, exposure to sun, rain, wind, dirt, abrasion and the action of microorganisms can alter the appearance of the plumage (Montgomerie 2006).

In the field, especially at a distance, the causes of aberrant plumages are often not easily identified. Plumage abnormalities, sometimes very similar to those of genetic origin, may occasionally be the result of quite different causes. It is probable that over time, the appearance patterns of birds apparent today have undergone progressive changes to evolve into what is now present. Earlier patterns on areas of plumage may have been lost, but the genetic potential for their re-appearance may remain (Campbell & Lack 1985).

2.3.3. Terminology of aberrations

So far, aberrations in plumage and bare parts of birds, especially those caused genetically and provoking changes in melanin production or distribution, have not been linked here to specific terms. The reason is that over time either the words used for naming specific aberrations have changed or their meaning has changed. With scientific progress, a better understanding of the root causes of abnormalities was acquired, and consequently more differentiation and fine tuning in terminology was introduced. New terms appeared or the meaning of those applied until then was altered, often becoming more restrictive. Modified terminologies, however, did not necessarily oust existing ones. Field ornithologists often continued to apply the traditional categories and naming. To properly assess older records of aberrations, awareness of possible misinterpretations of sightings and a good knowledge of the terminology as historically applied are of advantage.

An exhaustive historical review of all possible usages and definitions of terms related to aberrations in the appearance of birds is not intended here. The examples given should rather aid the general understanding of changes in terminology over time, starting with the second half of the 19th century, when people like Coues (1868) and Deane (1876, 1879, 1880) presented compiled lists of aberrant birds. However, neither Coues nor Deane gave clear definitions of partial or complete albinism. While Coues spoke about instances of albinism, he included in his list of albinos specimens with light or faded tints. Deane stated that pure albinism was of rare occurrence (1876) and that most aberrant specimens retained more or less of their normal plumage (1880). He recognized that there were a great many instances of albinism. Similarly, McGregor (1900) avoided definitions and simply explained that his list contained "birds, either albino or with some white feathers in areas where they normally do not occur".

When assembling records of colour aberrations in the Zoological Museum of Berlin, Rensch (1925) noted chaos in the terminology thus far applied and proposed a subdivision of abnormalities into two main classes, with several levels of sub-classes. At the highest level, he distinguished phenotypic, non-hereditary aberrations, caused for example

by accident, disease or dietary deficiencies, from genotypic, hereditary abnormalities. Genotypic aberrations were subdivided into three categories:

- Hypochromatism, covering different aberrations caused by an abnormal lack of colour pigments,
- Hyperchromatism, aggregating cases of abnormal pigment invasion,
- mutative changes of a complex nature.

Hypochromatism was further subdivided into:

- albinism (lack of pigmentation),
- schizochroism (lack of only one pigment),
- chlorochroism (partial and balanced fading of pigments).

One level down, three types of albinism were described:

- total albinism (total lack of pigments in feathers and bare parts),
- partial albinism (partial absence of pigments),
- leucism (total lack of pigments in feathers).

Cases of pigment invasion (hyperchromatism) were subdivided into:

- melanism (invasion by melanins),
- lipochromatism (invasion by lipochromes).

Melanism could then occur in two forms:

- eumelanism (invasion by only eumelanin),
- phaeomelanism (invasion by only phaeomelanin).

Two types of lipochromatism were mentioned:

- zoonerythrism (abnormal spreading of zoonerythrin),
- zoofulvinism (abnormal spreading of zoofulvin).

Complex mutations were finally subdivided into:

- atavism (appearance of a phylogenetically earlier colouration),
- defect mutation (complete colour change provoked by a defect of colour or pattern characteristics),
- gain mutation (change in colouration by acquisition of new colours or colour patterns).

While Rensch's (1925) paper attracted much attention and proposed a clearly structured categorization of abnormalities, it was unable to eliminate terminological confusion. About 25 years later, Hanson (1949) acknowledged that "albino" was often misused and that "partial albino", from a strictly genetic standpoint, was entirely incorrect, while "white spotting" would be the correct term to designate partially unpigmented individuals. He also proposed grouping individuals with a piebald pattern of white spotting according to the distribution of white on the body. Lee and Keeler (1951) confirmed that there was much confusion in the ornithological literature between piebald (or white spotting) and albinism, and they proposed a classification of mutant birds into six categories: (i) pink-eyed albinism, (ii) pure albinism, (iii) pale, (iv) white spotted, (v) mottled in several shades, and (vi) miscellaneous. However, complete and partial albinos continued to be recorded from the field. Yeatman (1959) stated that true albinism was the complete lack of pigment in feathers, hair, skin, bill, claws, iris or eyes and that technically there was no such thing as partial albinism. He referred to large irregular blotches of white in plumage as piebald. Yet, in 1962 Sage still differentiated between partial and complete albinism, and individuals with a very pale or washed out appearance were said to be leucistic or diluted.

In 1963 Harrison, referring to Haecker (1908), stated that schizochroism initially described the loss of any one pigment but that, according to Rensch (1925), only the loss of any one of the melanins was meant. Harrison (1963) then subdivided schizochroism into two types: (i) a non-phaeomelanistic form with loss of the red brown pigment, and (ii) a non-eumelanistic or fawn form with loss of eumelanin. He also accepted "dilution", a term used by Frank (1939), as a synonym for Rensch's chlorochroism. It described a quantitative reduction in melanin presence. Harrison acknowledged that dilution may occur to differing degrees. He introduced erythrism as the replacement of black or dark brown melanin by a chestnut red colour that could be an oxidation product of eumelanin (Fox & Vevers 1960 in Harrison 1963), and he noted a tendency in this pigment to spread into unpigmented portions of feathers.

With Gross (1965a) we return to a classification of albinos into four groups which correspond to

those applied by Hanebrink (1968 referring to Pettingill 1956): (i) total or pure (complete absence of pigments or melanin in all parts of the body), (ii) incomplete (absence of pigments from plumage, eyes or naked parts, but not from all three), (iii) imperfect (reduction or dilution of pigments in any or all three areas, but never complete absence) and (iv) partial (localized absence of pigments). Like Rensch (1925), Gross (1965b) accepted two different types of melanism, though they did not correspond to the forms suggested by Rensch. Instead, Gross designated one as normal and the other as abnormal. In the normal, the melanistic plumage was of regular occurrence: the plumage had two phases, known as dichromatism. In the abnormal, the species did not normally produce a melanistic phase. The same applied to erythrism, where Gross also recognized a normal and an abnormal form. Finally, Gross defined xanthochroism as an abnormal colouring of the plumage, perhaps related to food or some pathological condition, in which yellow replaced the normal colouring.

Buckley (1982 in Hailman 1984) proposed abandoning many of the traditional terms because of their ambiguity. Hailman agreed, adding that terms that connoted an unwarranted interpretation of the observed colouration should be avoided. Hailman (1984) found for example xanthochroism to have no stable meaning and to be used to name at least five different things, from originally simply yellow colouration, via abnormal yellow colouration, to yellow colouration appearing through the loss of melanin. In contrast to the biologist, the aviculturist would use the term "lutino" for abnormally yellow birds, but in most cases, the phenomenon under observation was schizochroism (Buckley 1982 in Hailman 1984). Buckley (1982 in Hosner & Lebbin 2006) defined albinism, leucism, melanism, schizochroism, carotenism and dilution as the major aberrant plumage conditions in birds. But Hanebrink (1985) supported anew the classification of albinos as proposed by Gross (1965a) into total albinism, incomplete albinism, imperfect albinism and partial albinism. In the last class, Hanebrink assembled not only cases of localized pigmentation absence, but also cases with pigment reduction or with the absence of one or more pigments.

The terminological mess continued into the 21st century. Bensch et al. (2000), in a study of Great Reed Warblers *Acrocephalus arundinaceus*, and Møller and Mousseau (2001), in a study of Barn Swallows *Hirundo rustica*, defined partial albinism as the abnormal presence of one or more white feathers. In 2001, Ogilvie stated that all white birds were called albinos and that they suffered a complete loss of pigments in the feathers. For him, the most extreme form was a pure albino with a complete lack of melanin, even in soft parts, including the eyes. Partial albinos suffered from a partial absence of melanin in the plumage. Ogilvie believed that it was quite usual for the amount of white in partial albinos to increase as the bird got older. With respect to birds displaying an overall paleness in the plumage, Ogilvie agreed nevertheless that there was some disagreement in the literature in how to name this phenomenon. His opinion was that "leucistic" was most commonly used, the two alternatives being "chlorochroistic" and "schizochroistic". Nevertheless, he admitted that the latter term was all-embracing and was used for a variety of plumage aberrations.

From this historical review, it is evident that we are still today struggling with misunderstandings in the terminology of aberrations and that we badly need to find agreement on the nomenclature and, possibly even more importantly, spread fundamental knowledge about abnormalities and their underlying causes. Although meanwhile there seems to be agreement that something like partial or incomplete albinism does not exist (a bird is either an albino or it is not), the term "partial albino" continues to be applied. Scientifically, albinism is today associated with a complete lack of melanin in both feathers and bare parts, including the eyes, and the term "leucism" has replaced former instances of partial albinism. Originally, leucism was first applied by Rensch (1925) exclusively to the particular condition that resulted in an all-white plumage or pelage and normally pigmented eyes and skin (Davis 2007). More recently, it has been applied to everything from an entirely white plumage to a single white feather (Buckley 1982).

In recent years, two different approaches to the definition and future naming of aberrations have been propagated. The first (van Grouw 2006, 2013) basically stuck to the terminology used so far, clarified the meanings and presented an overview of the most common types of genetic abnormalities. The second (Davis 2007), in order

to avoid future confusion with historical practices, proposed a completely new nomenclature and definitions which differed in part from those of van Grouw. What follows is van Grouw's proposal, supplemented by comments and terms by Davis.

Van Grouw (2013) first stressed that aberrant white feathers are hardly ever caused by albinism. They are usually due either to a form of leucism or to a non-heritable cause such as disease, food deficiency or trauma – Rensch's (1925) class of phenotypic aberrations. The six most common genotypic colour aberrations defined by van Grouw (2006, 2013) were (i) albinism (absence of both melanins in feathers, eyes and skin), (ii) leucism (partial or total lack of both melanins in feathers, possible lack in the skin, but not in the eyes), (iii) brown (qualitative reduction of eumelanin), (iv) dilution (quantitative reduction of both melanins), (v) ino (strong qualitative reduction of both melanins) and (vi) melanism (abnormal deposit of melanin in skin and/or feathers).

Albinism: While van Grouw (2013) stuck to the traditional term of albinism and restricted its meaning to the complete absence of both melanins from all parts of the integument, including the eyes, Davis (2007) proposed adopting a new name: total amelanism.

Leucism: In leucism, the extent of white feathering can vary from just a few white feathers (partially leucistic) to the plumage being completely white (totally or entirely leucistic). The skin is colourless for individuals in the latter category (van Grouw 2014): in entirely leucistic birds, the bill, feet and other bare parts lack melanin pigmentation. Depending on where the absence of melanin occurs, partially leucistic birds may have normally coloured bill and feet, but all leucistic birds have normally coloured eyes (van Grouw 2013). Davis (2007), referring to Rensch's (1925) original definition (all-white plumage with normally pigmented eyes and skin), concluded that leucism falls short of its usefulness for classifying colour abnormalities in birds, because it did not account for a loss of pigment in unfeathered areas. In contrast to van Grouw (2013), Davis (2007) defined his leucism, that he named partial amelanism, as an abnormal absence of all melanin from parts of the bird's integument, including the eyes.

(A rare mutation related to albinism that was not mentioned by van Grouw in 2013, but was in his 2012 publication, is acromelanism. It is reasonable to assume that this mutation is an allele (a variant form of a gene) of albino. In acromelanism, melanin deposit occurs mainly in the body extremities. Due to the mutation, the tyrosinase in the pigment cells is temperature dependent and, at normal body temperature, no melanin synthesis occurs. Melanin is only formed in parts of the body that have a lower temperature than the normal body temperature. As the extremities (the beak, the face and the feet) are colder, they are pigmented. In acromelanism however, melanin production also depends on the temperature of the environment; therefore, during moult in colder periods, melanin will be produced sporadically in other parts of the plumage.)

Brown: In brown, the quantity of eumelanin pigment granules produced remains unchanged. However, the appearance of the pigment is altered due to incomplete eumelanin synthesis. Normally black pigments remain brown, and feathers bleach quickly due to the exposure to sunlight. Bare parts are affected, too. In many species, eumelanin that is not fully oxidized also contributes to the normal plumage colouration (van Grouw 2013).

Dilution: In dilution, the quantity of pigment granules is reduced, but the nature of the pigment itself is not changed. This leads to a lower concentration of granules and consequently to weaker or diluted colours (van Grouw 2013). Davis (2007) applied the term hypomelanism to this condition. He acknowledged that the extent of pigment dilution is variable, but did not go into more detail. According to van Grouw (2013), dilution may take three main forms:

The most common form is a quantitative reduction of both eumelanin and phaeomelanin. Black feathers will turn grey and reddish or yellow-brown feathers will turn buff or cream-brown/white. The degree of dilution may vary both between individuals and within a single mutation. Most commonly, a melanin reduction of about 50% occurs in both types of melanin. Affected individuals look like a pale version of their normal counterparts. This form

is termed "pastel" from the Latin "pastellus", meaning pale or delicate colour (van Grouw 2013).

If a quantitative reduction of only eumelanin occurs, with phaeomelanin remaining unaffected, black feathers will turn grey, but reddish or yellow-brown feathers keep their ordinary colour. This form of dilution is called "isabel" from the Latin "isabellinus" meaning greyish yellow. In species with only eumelanin, it is impossible to distinguish a dilution mutation as either isabel or pastel. According to van Grouw (2006), the absence of one melanin pigment, while the other is still present, is often identified as schizochroism, meaning colour dividing. But, because schizochroistic mutations often do not reduce eumelanin completely in the plumage, van Grouw (2013) recognized schizochroism (termed phaeo or non-eumelanin schizochroism in 2006) as a form of isabel. Davis (2007) defined aeumelanism as the abnormal absence of eumelanin from the integument without explicitly specifying if a reduction could be incomplete.

An extremely rare form of dilution is the reduction of phaeomelanin only, while eumelanin is unaffected (van Grouw 2013). This condition could be seen as corresponding to Davis's (2007) aphaeomelanism, though Davis referred to the absence of phaeomelanin. Among bird breeders, the terms "silver" and "grey" have been used for this mutation. The almost complete disappearance of phaeomelanin was termed grey or non-phaeomelanin schizochroism by van Grouw (2006).

Ino: In ino mutations, both melanins are produced in normal quantities, but both are incompletely oxidized: eumelanin turns brown and phaeomelanin gets very pale. The degree of pigment synthesis may differ, making the black eumelanin vary from dark to very pale brown. The reddish-brown phaeomelanin always becomes very pale and may remain barely visible (van Grouw 2013). The dark form of ino is comparable to brown, but can be distinguished from brown by the parallel reduction of phaeomelanin. A light bird may resemble an albino. In ino, the eyes become reddish due to the reduction of eumelanin (van Grouw 2012).

Melanism: While melanism was generally associated with a quantitative increase in pigments, van Grouw insisted that it may also express by an altered distribution or "abnormal deposit" of the usually produced amount of melanin. For example, granules usually arranged in a clumped fashion may become evenly spread. In most cases, the appearance of a melanistic bird is dark or blackish, as mostly only the eumelanin is affected. Abnormal deposit of phaeomelanin only is rare, and a phaeomelanistic bird will appear entirely reddish-brown. Melanism is the only mutation in which there is no loss of pigment or change in the shape or size of the melanin granules (van Grouw 2013). Melanism broadly corresponds to hypermelanism (Davis 2007), qualified by an abnormally high concentration of melanin in the bird's integument. According to van Grouw (2013), melanism can affect the plumage in three ways:

- Normally dark markings are bolder and noticeably overrun their typical boundaries, the rest of the plumage often appearing somewhat darker as well.
- The entire plumage is affected and appears dark brown or black.
- The normal pattern and/or pigment distribution is changed, but the plumage as a whole is not darker.

Brown, ino and albino are all mutations that cause a defect in melanin synthesis, while other mutations affect melanin transfer: from the pigment cells into the feathers cells (dilution), the distribution between eu- and phaeomelanin in the plumage (melanism), or the absence of melanin cells (leucism) (van Grouw 2012).

A priori, there is no third type of melanin as suggested by Harrison (1965). Instead, what we may have is a switch in melanin production or incomplete eumelanin oxidation: a change from black or grey to more reddish tones occurs. In these cases, in cases where the mutation is the other way around and replaces phaeomelanin by eumelanin, and if melanin deposit occurs at places where it is normally absent, a form of melanism may be present. Any form of abnormal melanin deposit, without any change to the pigment granules themselves (even if one melanin replaces the other), falls under van Grouw's definition of

melanism. To differentiate a change in plumage colouration for chestnut or red from other forms of melanism, this form should perhaps be called erythromelanism. To what extent this is caused by melanin replacement or by incomplete eumelanin oxidation remains open. In some bird families, ordinarily uncoloured parts of the plumage are occasionally partially or entirely chestnut or rusty brown. In these cases, and provided external factors such as pollutants are not involved, again a form of melanism may be involved. The resulting colours in the affected plumage parts do not differ much from erythromelanism. Nevertheless, the causal mutations may be different, and this second case should perhaps be referred to as chestnut melanism.

In addition to the genotypic aberrations, van Grouw (2013) introduced progressive greying. This arises as a consequence of old age accompanied by a progressive loss of pigment cells. In this case, there is a change in the appearance of the bird over time, the number of white feathers increasing with every moult. The entire plumage may eventually become white. Leucism and progressive greying are hard to distinguish in the field (van Grouw 2012). Progressive greying may or may not be heritable (van Grouw 2013). A progressive loss of pigment cells may also be due to disorders such as vitiligo, a disease causing depigmentation of certain areas and occurring when melanocytes die or cease to function. The causes of vitiligo are still unknown. Possible external, non-heritable factors include illness and food deficiency. As a consequence, the bird is unable to extract sufficient quantities of tyrosine from its food and this leads to disturbed melanin synthesis (van Grouw 2012).

In his publications, Van Grouw (2006, 2010, 2013) concentrated on genotypic aberrations impacting melanin. He listed conditions such as progressive greying and vitiligo because the resulting aberrations could be confused with hereditary mutations. In contrast, Davis (2007) included in his list other colour abnormalities. He gave a very wide definition of carotenism that he qualified as an abnormality of carotenoid pigmentation. Davis distinguished four types: i) change in the normal distribution or extent of carotenoid pigments, ii) increase or decrease in carotenoid concentration resulting in a change in colour or colour intensity, iii) change in carotenoid pigment type provoking a change in colour, iv) total absence of carotenoids from all or part of the plumage or skin. This was in line with Buckley (1982 in Hosner & Lebbin 2006), who used carotenism to describe any abnormality in the degree or distribution of carotenoid pigments, including the replacement of melanins by carotenoids. Davis (2007) admitted that carotenism often results from dietary factors during or just prior to moult, although it can be caused by a genetic mutation disrupting carotenoid metabolism. In the latter case and based on Buckley (1982 in Hosner & Lebbin 2006), the replacement of carotenoid pigmented feathers with white feathers should be termed non-carotenoid leucism.

Additional colour abnormalities may result from changes in other less common pigment types, and Davis (2007) suggested applying the appropriate modifiers where possible, using "a" as a preposition for decreases in pigment concentration and "hyper" for increases.

The proposal by Davis (2007) had the merit of breaking with the traditional terminology. It thereby potentially avoided confusion between historical and current meanings. A priori, Davis proposed a fairly straightforward system for naming genetic aberrations. He failed however to apply unequivocally a system that respected the genetic root causes of the aberrations. This becomes obvious when we consider the differences in the definitions with van Grouw. In Davis's system, a qualitative change in pigmentation remained unnamed, and different levels of quantitative pigment reduction were not sufficiently differentiated. Van Grouw, on the other hand (2006, 2013), used different terms if the genetic causes differed, and he distinguished between degrees in mutations, like dilution or ino. Van Grouw's proposal appeared to be the most complete and balanced. I shall therefore apply his terminology. In a wider sense, intraspecific aberrations could be organized according to Rensch's (1925) system: a subdivision as displayed in Table 1 would result.

In agreement with van Grouw (2013), I have deleted from this table the two forms of schizochroism with close to a 100% reduction of the respective melanin. Both are considered as extreme forms of either isabel or silver dilution: the almost complete disappearance of eumelanin, initially termed non-eumelanin or phaeo-schiz-

Table 1: Terminology of intra-specific aberrations (largely based on van Grouw 2006, 2012, 2013).

Genotypic aberrations			
Category	**Sub-category**	**Gene action**	**Consequences on colours in the absence of other pigments/ remarks**
Albinism		Absence of both melanins in feathers, eyes, bare parts and skin stemming from an inherited absence of tyrosinase	All-white plumage, red eyes, pink to flesh-coloured feet and bill
Acromelanism		Allele of albino; melanin deposit in the colder extremities of the body only	Body plumage white, pigments present mainly in the face, the bill and the feet
Leucism		Partial or total lack of both melanins in feathers, bare parts and/or skin, but not in the eyes, resulting from an inherited disorder of deposit	Affected feathers all-white, skin, bill and feet affected or not, always normally-coloured eyes
	Total leucism	Total lack of both melanins in all feathers; bill and feet are affected	All-white plumage, yellowish bill and feet, normal eyes
	Partial leucism	Total lack of both melanins in some, but not all, feathers (variable degree); bill and feet often normally coloured, but may be affected	Partially white plumage, from just one white feather to almost completely white; white pattern often patchy and bilaterally symmetrical; most commonly, head, wing tips, feet and belly affected; unaffected parts normally coloured
Non-carotenoid leucism		Genetic mutation inhibiting the deposit of carotenoids in all or part of the plumage and in bare parts where they normally occur	(Partial) replacement of carotenoid pigmented feathers with white feathers (unless other pigments are present)
Brown		Qualitative reduction of eumelanin only; changed appearance due to inherited incomplete oxidation, no effect on quantity	Originally black or grey becomes brown and bleaches further; originally reddish-/yellow-brown unaffected; mutation hard to detect if naturally both melanins are combined; eye colour mostly not visibly affected, but bare parts slightly paler
Dilution		Quantitative reduction of one or both melanins	Affected individuals look like a pale version of their normal counterparts; affected feathers subject to bleaching; bare parts may or may not be affected
	Pastel (dilution)	Quantitative reduction of both melanins (degree variable, mostly about 50%)	Originally black is silvery grey, originally reddish-/yellow-brown is buff/cream; generally bleached appearance, especially in feathers exposed to the sun
	Isabel (dilution)	Quantitative reduction of eumelanin only	Originally black is silvery grey; originally reddish-/yellow-brown unaffected or may occasionally appear brighter due to a reduction of overlying eumelanin; if naturally only eumelanin occurs, distinction between isabel and pastel impossible; eumelanin dominated plumage may appear white, if reduction almost complete or after sun bleaching

Category	Sub-category	Gene action	Consequences on colours in the absence of other pigments/ remarks
	Silver or grey (dilution)	Quantitative reduction of phaeomelanin only (rare)	Depends on regular composition of both melanins in the feather; in eumelanin-dominated feathers hardly any effect; phaeomelanin-dominated feathers appear buff to cream white
Ino		Qualitative reduction of both melanins that are produced in normal quantities (incomplete or poor synthesis, degree variable)	Eumelanin turns pale brown and phaeomelanin very pale to barely visible, plumage subject to bleaching; eyes reddish or pink, bare parts visibly affected and more yellowish to flesh-pink
	Light ino	Strong qualitative reduction of both melanins due to incomplete oxidation of both melanins	Originally black is very pale brown/ cream, originally reddish-/yellow-brown remains hardly visible; eyes pinkish, pinkish feet and bill due to strong reduction of melanin
	Dark ino	Qualitative reduction of both melanins due to incomplete oxidation of both melanins	Originally black is light brown, originally reddish-/yellow-brown is buff/ cream; eyes, feet and bill less visibly affected
Melanism		Abnormal deposit (altered distribution or higher quantity) of melanins in skin and/or feathers; change generally limited to one melanin type	Not necessarily entire plumage affected, invasion of normally unpigmented areas occurs not necessarily; therefore, may manifest in three ways: normally dark markings are bolder and overrun typical boundaries/ entire plumage affected, appears dark brown or black/ normal pattern and/ or pigment distribution changed, plumage as a whole not darker; darkening of bare parts depends on form
	Eumelanism	Abnormal deposit of only eumelanin (most common case)	Dark or blackish appearance
	Phaeomelanism	Abnormal deposit of phaeomelanin only (rare)	Appearance entirely reddish-brown
	Erythromelanism	Mutation possibly leading to the production of phaeomelanin instead of eumelanin (partial replacement)	Red-brown to chestnut appearance of plumage that is normally blackish
	Chestnut melanism	Deposit of phaeomelanin in feathers normally not pigmented	Chestnut tinges in feathers that are usually white
Atavism		Re-appearance of a phylogenetically earlier appearance	Species dependent

Phenotypic aberrations

Category	Sub-category	Cause/effect	Action on colour/remarks
Diet		Limited or no effect on melanin, other pigments may be affected	
	Nutritive scarcity	Irregular feather growth/deposit of pigments; absence of pigments relying on food	Unusual feather bars, absence of carotenoid-based colours
	Unusual intake of pigments	Increased deposit of pigments usually present or deposit of an unusual pigment	Altered intake of pigments with food is pre-condition, but does not necessarily lead to altered appearance

Category	Sub-category	Cause/effect	Action on colour/remarks
Weather			
	Bleaching	Effect of sunlight causing increased paleness	Feathers subject to a genetically caused reduction of melanin deposit or weakened by disease or parasites are easily affected by sun bleaching
Abrasion		Abrasive wear	Often paler appearance
Soiling		Absorption of colorants contained in the soil through contact	Presence of unusual colours, predominantly visible in white or light coloured parts of the plumage
Staining		Similar to soiling, often resulting from contact with moist substrates	Presence of unusual colours visible in white or mostly light coloured parts of the plumage
Pollution			
	Contact pollution	Similar to soiling or staining, except that the colorant is not of natural occurrence	Examples include chemical colorants, excessive dust, rust, petro-chemicals
	Intake pollution	Poisoning via food or breathing affecting pigmentation	Cause dependent
Shock, injury		Local effect	Isolated unpigmented feather tracts that are usually pigmented
Parasites			
	Endoparasites	Parasites present in the inner bird affecting pigmentation	Cause specific
	Ectoparasites	Parasites present on the integument leading to abrasive appearances	Possibly slightly bleached appearance or irregular distribution of colours
Disturbed moult		Multiple reasons are possible, including disease, diet, hormonal disorder, trauma	Plumage not aberrant generally, but unusual for the season as the moulting stage is not expected at that time of the year
Disease		Multiple effects depending on disease	
		Genotypic or phenotypic aberrations	
Carotenism		Abnormal carotenoid pigmentation, mostly caused by diet, rarely by mutation	Wide array of possibilities; effects mainly visibly in white or light coloured feathers
	Distributional change	Change in the normal distribution or extent of carotenoid pigments	Depending on distribution
	Quantitative increase	Increase in carotenoid concentration	Intensification or change in colour
	Quantitative decrease	Decrease in carotenoid concentration	Paler colour, occasionally associated with a change in extent
	Pigment change	Change in carotenoid pigment type	Change in colour
	Pigment replacement	Change from melanistic to carotenoid pigmentation	Disappearance of melanistic colours that are replaced by carotenoids
	Total absence	Total absence of carotenoids from all plumage or skin	In the absence of other pigments, white feathers/ colourless bare parts
Progressive greying		Partial or total lack of both melanins in feathers (and skin) with age due to progressive loss of pigment cells in some parts or all of the skin	Amount of white feathers increases after every moult, normal-coloured eyes (may or may not be heritable)
	Vitiligo	Age related disease causing depigmentation of some areas	Occurrence of white patches (causes unknown)
Hormonal imbalance/ disorder		Variable effect depending on disorder	Often unusual moulting stage

ochroism, will be included in isabel dilution, and the virtually entire reduction of phaeomelanin will be part of silver or grey dilution.

In ornithology and beyond, we need a common terminology for aberrations in order to avoid misunderstandings. Apart from the difficulties in achieving agreement among scientists, a major problem resides in disseminating a common terminology and the associated knowledge needed to apply it correctly. Field ornithologists are accustomed to applying a simplified set of terms which do not necessarily reflect the root causes of what they perceive. It is often difficult to identify these root causes unambiguously.

2.3.4. Genetics of aberrations and heredity

Studies of genetic transmission can detect the specific mode of inheritance of character traits, such as the number of loci involved, whether the loci are autosomal or sex-linked (allosomal), and the dominance relationship among alleles. Many colour traits show inheritance patterns that follow simple Mendelian rules (Mundy 2006). This is also the case for genetically controlled aberrations, the great majority of which concern the formation and distribution of melanin (see text box 1). Abnormalities tend to be remarkably consistent, genetically controlled and usually recessive. They can be produced predictably by subsequent controlled breeding. In the wild, their survival or spread is more problematic as the individuals concerned are generally at a disadvantage (Campbell & Lack 1985). Another important element is whether the control of the plumage variation/aberration is oligogenic (involving one or very few genes) or polygenic. Different colour traits, or a colour trait and another trait, may be genetically correlated. Different pigment systems and structural colouration are, however, to a large extent under independent genetic control (Mundy 2006).

Complete albinism is linked with a single autosomal gene (Sage 1962). It was the first pigmentation gene to be isolated in birds (Ochii et al. 1992 in Mundy 2006). Loss-of-function mutations in tyrosinase cause albinism with complete loss of melanin in skin, feathers, iris and retina (Mundy 2006). Due to a mutation of the gene responsible, symbolized by *c*, and which is the same in every species, an albino completely lacks the enzyme tyrosinase in the pigment cells. Because of this, an albino cannot produce melanin at all. Inheritance of the mutation is recessive, and an albino can be either male or female (van Grouw 2006, 2010). The effect of the gene is expressed in the homozygous state (presence of two alleles for albinism), but is masked in the presence of the dominant allele (i.e. when the organism is heterozygous for the gene). Albinism will therefore only express in the complete absence of the dominant allele (Allaby 1999), i.e. if a bird inherits the mutated gene from both parents (Davis 2007). The normal pigmentation gene is dominant to albinism. According to the rules of Mendelian inheritance, a pure albino mating with a homozygous, but pigmented, bird results in offspring which is normally pigmented, but will carry a suppressed gene for albinism in each body cell. It is therefore called heterozygous. If two individuals that are heterozygous for albinism mate, statistically one fourth of the offspring will be homozygous and pigmented, two fourths will be heterozygous and pigmented, and one fourth will be homozygous and albino. The albino gene, being suppressed by the pigmentation gene, may remain hidden for several generations in the heterozygous offspring. Two normally pigmented, but heterozygous, parents may therefore have some albino offspring (Yeatman 1959).

Sage (1962) thought that leucism might be caused by a dominant genetic trait, usually affecting one or more distinct parts of a bird's plumage. The mutation can be defined as the heritable failure of the pigment-producing cells, the melanoblasts, to migrate to the skin during embryonic development (van Grouw 2012), leading to a pied appearance in birds affected. This can be caused by a delay in the migration of the melanoblasts from the neural tube to the skin (Wagener 1959, Wendt-Wagener 1961, both in van Grouw 2014). Because of the delay, some melanoblasts reach certain parts of the body when the skin is too far developed to incorporate them: as a consequence, these parts lack colours. Another possibility is that, from the outset, insufficient melanoblasts develop in the neural crest and therefore not all parts of the body are provided with pigment cells (van Grouw 2014).

There are many different mutations or forms of leucism, recessive or dominant, sex-linked or autosomal (Davis 2007), all connected to different

Box 1: Mendelian inheritance of colour abnormalities (based on Campbell & Lack 1985)

Simple Mendelian inheritance patterns are based upon the principle that every individual possesses two factors or genes relating to a character trait, one inherited from the father and one from the mother. If they are the same, the individual is said to be homozygous (BB) for the factor; if different, it is heterozygous (Bb). Heterozygous (Bb) individuals resemble one of the parents and are not intermediate. If one and the same character regularly results (B), it is said to be dominant; the other (b) is said to be recessive to it.

If heterozygous offspring (Bb) mate together, three possible genotypes may result: BB, Bb and bb. However, only two phenotypes will appear, viz. B and b (BB and Bb will look similar as B is dominant):

- A recessive colour aberration b will disappear visually in Bb, but its allele, masked by the dominance in the heterozygotes, continues to be passed on to offspring and may reappear whenever two such heterozygotes mate.
- Any colour aberration b disappears completely in BB and can no longer be passed on from BB to its offspring.
- The recessive colour aberration b will express in bb (unless the expression of the character trait is polygenetic) and continues to be passed on to offspring. It may reappear in matings with heterozygote and homozygote partners.
- A dominant colour aberration B will express in BB and Bb. It continues to be passed on to offspring and reappears in all matings with heterozygote and homozygote partners.
- A dominant colour aberration B is only lost in bb offspring and can no longer be passed on from bb to its offspring.

If the heterozygote Bb mates with the homozygote BB, the phenotypes Bb and BB will result in approximately equal numbers:

- A recessive colour aberration b will not express at all visually (neither in Bb nor in BB offspring).
- A recessive colour aberration b disappears completely from half of the offspring (in BB) and can no longer be passed on from BB to its offspring.
- A recessive colour aberration b will continue to be passed on from the other half of the offspring (in Bb).
- A dominant colour aberration B will express in all cases and will continue to be passed on to offspring.

If the heterozygote Bb mates with the homozygote bb, the two parental phenotypes will also result in approximately equal numbers:

- A recessive colour aberration b will express visually in half of the offspring (in bb) and continues to be passed on in all cases, including in Bb.
- A recessive colour aberration b will not express in the other half of the offspring (in Bb).
- A dominant colour aberration will express in half of the cases (Bb) and continues to be passed on to offspring only in these.

A special colour trait or aberration may be controlled by more than one gene. Such a situation will complicate the inheritance patterns as outlined above.

genes, but all resulting in more or less colourless feathers. The origin of the mutation causing leucism is unknown in most cases (van Grouw 2006). In the case of recessive inheritance, the genes can be inherited invisibly through many generations before two birds, both carrying the recessive gene, mate, making the white speckling visible in their offspring. Depending on the type of leucism, the amount of white can vary (van Grouw 2014), but its location in the plumage is roughly the same per mutation (van

Grouw, pers. comm.). Within any group of related species, partial whiteness is however likely to occur more consistently on some areas of plumage than on others (Campbell & Lack 1985). According to van Grouw (2014), the distribution of white feathers in partially leucistic birds is often patchy and bilaterally symmetrical. This is due to the way melanoblasts migrate to the rest of the body. The commonest form of leucism affects body parts furthest from the neural crest: the face, the "hand" of the wings, the feet and the belly. Depending on where in the face pigment is lacking, the melanin in the eyes may be absent too, resulting in only those pigments that formed in the optic cup being visible.

The white pattern caused by leucism is already present in juvenile plumage (van Grouw 2014) and remains consistent from one moult to the next (Davis 2007), i.e. it does not change with age (van Grouw 2014). Van Grouw (2014) states that leucism in general is uncommon: a far more widespread cause of the lack of pigment in feathers – and often confused with leucism – is progressive greying.

Brown results from an inherited, incomplete oxidation of eumelanin which, like albinism, is caused by a single and same mutation in every species. The inheritance of the mutation is recessively sex-linked. Van Grouw (2013) has comprehensively explained the transmission mechanisms of brown. Being sex-linked, the gene is always located at the X-chromosome. The gene for brown is symbolized by *b* and the unchanged form of this gene leading to normal colours is therefore B. Given that male birds have two X-chromosomes, they can have three different genotypes for brown: BB (normal pigmentation), Bb (normal pigmentation, but heterozygous for brown) or bb (brown). Females are either normal (B-) or brown (b-). They cannot be heterozygous for brown. If an ordinarily coloured male which is heterozygous for brown mates with a normal female, half of its daughters (or 25% of its total offspring) will be brown, the other half will be normally coloured. Half of the male offspring will be heterozygous for brown and the other half will have a normal pigmentation, not having inherited any means of transmitting the mutation. By comparison, for recessive mutations which are not sex-linked, both parents need to be heterozygous to get 25% aberrant offspring. Females need only one gene for brown to express the mutation. A brown male needs a heterozygous or brown father and a brown mother. This explains why generally only brown females are seen in the wild. As a consequence, a brown specimen with ordinarily coloured parents is always female (van Grouw 2006, 2010).

There are strong indications that ino too is based on a same single gene in all species. The same gene is involved in dark and light ino. The inheritance is recessive and sex-linked. As is the case for brown, only females will be found in the wild (van Grouw 2010, 2012).

Like in leucism, several mutations (genes) can be responsible for dilution and melanism (van Grouw 2010). The non-phaeomelanistic form of schizochroistic plumage (now included in isabel dilution) is subject to different genetic control to the non-eumelanistic form (now included in isabel dilution), being apparently autosomal and recessive. Birds showing it are as likely to be males as females (Campbell & Lack 1985, Davis 2007).

The melanocortin-1 receptor (MC1R) has been shown to be a key regulator of melanin synthesis in the feather melanocytes. It is associated with melanism in Anseriformes, Charadriiformes and Passeriformes (Mundy et al. 2003, Theron et al. 2001). MC1R plays a critical role in determining what type of melanin is synthesized during feather development. MC1R is a seven transmembrane, G protein-coupled receptor that is activated by melanocyte stimulating hormones, leading to an increase in black/brown eumelanin production in melanosomes that are then transferred to the surrounding feathers. In many domesticated species, gain-of-function MC1R variants are associated with an increase in the production of eumelanin, while loss-of-function mutations are associated with an increase in red/yellow phaeomelanin production (Theron et al. 2001). MC1R alleles causing increased eumelanin synthesis are inherited in a dominant or partially dominant fashion. The alleles causing increased phaeomelanin synthesis exhibit recessive inheritance. The patterning mechanisms are lineage-specific. Results from one species may not be directly applicable to an unrelated species (Mundy 2006).

2.3.5. Usual pigmentation and possible effects of mutations in grebes

The colours that we perceive in any species are generally the result of a combination of different pigments. Once the general pigment distribution

in the plumage of a particular species is known, it is usually possible to predict what potential plumage abnormalities there might be (Campbell & Lack 1985). In the family of the grebes, precise knowledge about the composition of the pigmentation in different body and feather parts is generally lacking. Apart from Niethammer (1964), nobody seems to have worked on this subject. He analysed the development of pigments in embryos and young of the Great Crested Grebe. In the typical striping of pulli, the feathers of dark stripes are eumelanin-based, whereas the white feathers do not possess unpigmented melanocytes, but undifferentiated melanoblasts. The feathers of the initially white stripes on the back later become yellowish when receiving yellow phaeomelanin. Frank (1939), in a more general study about the colouration of bird feathers and the nature of melanins, stated that in Podicipedidae, rusty red and brown red colours are achieved by a regular distribution of melanin pigments and that the golden ear tufts of *Podiceps nigricollis* result from the presence of rusty coloured melanins too. No species-specific studies of the complete pigmentation in adult grebes or with respect to breeding ornaments have been found. In an investigation about the underlying pigment producing red hues in birds' plumages, Toral et al. (2008) found phaeomelanin to produce the chestnut colour in the fore neck of Great Crested Grebes. Based on these few indications about the origins of colours in grebes and in the absence of more complete and species-specific biochemical analyses, we may speculate that the regular appearance of the different grebe species is largely, if not entirely, melanin-based.

In grebes, the under parts of the plumage are generally composed of white or at least light coloured feathers, whereas in the upper parts grey to black and darker brownish to bright chestnut colours dominate. This corresponds to the general pattern in waterbirds, that show counter shaded colours, developing dark, melanistic upper parts, but light under parts in their plumages (McGraw 2006b). Excluding elongate ornamental feathers present in the breeding season, the overall picture is no different whether we consider individuals in winter or summer or immature plumage. Darker and lighter grey and grey-brown to brown feathers dominate in the non-breeding plumage of grebe species, while black and chestnut tones mostly appear with the pre-breeding moult.

In wild birds, black and grey are caused by the same eumelanin granules. The differences in colouration stem from distribution differences in the feathers. If the granules are equally spread, we perceive the feathers as black. If the granules occur in little clumps and are unequally spread, we perceive a grey colour (van Grouw, pers. comm.). So far, the only pigment encountered and capable of producing a black colouration is eumelanin. We may therefore assume that eumelanin causes black and dark grey feathers in grebes. However, we cannot rule out the simultaneous presence of low concentrations of phaeomelanin. Davis (2007) and van Grouw (2012) considered that eumelanin dominates in black, grey and dark brown feathers, phaeomelanin in chestnut or reddish brown to pale buff feathers. This will also be the working hypothesis for this study.

Allowing for all due caution before classifying colours as either phaeomelanin- or eumelanin-dominated, blackish and greyish plumages in grebes should have rather high proportions of eumelanin. How a particular mutation will affect such plumages then becomes predictable. Dark brown plumage may rely on high percentages of eumelanin too. Phaeomelanin may play a leading role in chestnut or rusty brown plumages: in high concentrations, it produces reddish brown feathers (van Grouw 2006). In some species or some plumage parts, both forms of melanins may be present in relatively high proportions. It might then be more difficult to predict the effects of a genetic mutation on the plumage. With these limitations in mind, Table 2 provides an overview of how the different genetically conditioned aberrations may affect the plumages of grebes. After analysing the different cases of aberrations, we can check in the 'discussion' section how far the results support the initial assumptions.

Where this table falls short is that so far we have no verified knowledge about the regular pigmentation in grebe plumages. In particular, we do not know how far both melanin pigments could be combined to achieve the colourations of grebes. If the assumptions are correct, the table confirms that different mutations can achieve similar appearances. As a consequence, identifying colour mutations in the field remains difficult (van Grouw 2013). For instance, in species with only eumelanin, it is impossible to distinguish a dilution mutation as either isabel or pastel (van

Table 2: Possible effects of genetic mutations on melanin-based plumage colouration of grebes.

		Original plumage colour categories			
Aberration	**Genetic effect**	**Blackish**	**Grey**	**Grey brown**	**Chestnut**
Albinism	Total absence of melanins from feathers, bare parts, skin and eyes	Totally white, colour of eyes and bare parts affected	Totally white, colour of eyes and bare parts affected	Totally white, colour of eyes and bare parts affected	Totally white, colour of eyes and bare parts affected
Total leucism	Total absence of melanin from all feathers and from skin and bare parts, but not from eyes	Totally white, bare parts affected, but eye colour **not** affected	Totally white, bare parts affected, but eye colour **not** affected	Totally white, bare parts affected, but eye colour **not** affected	Totally white, bare parts affected, but eye colour **not** affected
Partial leucism	Lack of melanin in parts of the plumage, perhaps from skin and bare parts, but not from eyes	Partially white, eye colour **not** affected, bare parts may or may not be affected	Partially white, eye colour **not** affected, bare parts may or may not be affected	Partially white, eye colour **not** affected, bare parts may or may not be affected	Partially white, eye colour **not** affected, bare parts may or may not be affected
Brown	Incomplete oxidation of eumelanin	Pale brown, subject to bleaching; eye colour not visibly affected, bare parts slightly paler	Pale brown to more beige, subject to bleaching, eye colour not visibly affected, bare parts slightly paler	Possibly pale brown, bare parts paler, eye colour not visibly affected	No effect at all or hardly visible effect if low presence of eumelanin in ordinary plumage
Pastel dilution	Quantitative reduction of both melanins (~50%), bare parts may or may not be affected	Medium grey, if higher-percentage reduction, light grey to whitish; subject to bleaching	Light grey; if high-percentage reduction, whitish with grey hue; virtually white after bleaching	Light brown; subject to bleaching; may then turn white	Buff to reddish tan or cream; subject to bleaching; may then turn white
Isabel dilution	Quantitative reduction of eumelanin only, bare parts may or may not be affected	Medium to light grey, with almost complete reduction virtually white; subject to bleaching	Light grey, with almost complete reduction virtually white; subject to bleaching	Pale greyish brown subject to bleaching	Unaffected or, if normally low eumelanin presence, possibly brighter
Silver or grey dilution	Quantitative reduction of phaeomelanin only, bare parts may or may not be affected	Unaffected	Unaffected	Unaffected, or effect hardly noticeable if usually low presence of phaeomelanin	Fading chestnut to buff, with almost complete reduction very pale, cream or virtually white; subject to bleaching
Light ino	Very strong qualitative reduction of both melanins	Pale brown to pale tan, turning white with bleaching, eyes and bare parts visibly affected	Pale brown to cream, turning white with bleaching, eyes and bare parts visibly affected	Pale brown or tan to cream, turning white with bleaching, eyes and bare parts visibly affected	Very pale with just a hue of rusty colour, turning white with bleaching, eyes and bare parts visibly affected

		Original plumage colour categories			
Aberration	**Genetic effect**	**Blackish**	**Grey**	**Grey brown**	**Chestnut**
Dark ino	Strong qualitative reduction of both melanins	Brown, subject to bleaching, eyes and bare parts less visibly affected	Pale brown, eyes and bare parts less visibly affected	Pale brown, eyes and bare parts less visibly affected	Pale, with stronger hue of chestnut, eyes and bare parts less visibly affected
Eumelanism	Increase of eumelanin	Dark blackish, regularly unpigmented parts may be invaded; darkening of bare parts possible	Dark blackish, regularly unpigmented parts may be invaded; darkening of bare parts possible	Blackish brown, regularly unpigmented parts may be invaded; darkening of bare parts possible	Black pigmentation darkening chestnut parts; darkening of bare parts possible
Phaeomelanism	Increase of phaeomelanin	May look more dark brown, often hardly visibly affected, normally unpigmented parts may be invaded; darkening of bare parts possible	Dark brown with chestnut hue, normally unpigmented parts may be invaded; darkening of bare parts possible	Reddish brown, normally unpigmented parts may be invaded; darkening of bare parts possible	Dark chestnut or cinnamon, normally unpigmented parts may be invaded; darkening of bare parts possible
Erythromelanism	Red to chestnut tones replace eumelanin-based colours	Chestnut or rufous in parts affected	Chestnut or rufous in parts affected	Chestnut or rufous hues in parts affected	No visible effect
Chestnut melanism	Appearance of chestnut hues in normally white plumage	No effect, only visible in usually unpigmented feathers	No effect, only visible in usually unpigmented feathers	No effect, only visible in usually unpigmented feathers	No effect, only visible in usually unpigmented feathers

Grouw 2006, 2013). Dark ino and brown may lead to similar plumages, but ino can be distinguished from brown by the bill and feet: they are always pinkish in ino because of the absence of eumelanin (van Grouw 2013). In addition, plumage parts relying entirely on phaeomelanin would not be affected by brown, but would be by ino. The lightest forms of ino resemble albino and may only be distinguishable in fresh plumage, in which colour patterns remain just visible (van Grouw 2013). Given that this mutation is recessive and sex-linked, ino individuals are always females. In ino, the pigment concentration differs in different parts of the plumage. Like in brown, the pigment granules themselves are changed, and different parts of the plumage show different pigment concentrations. In dilution, plumage parts with a naturally very high concentration of pigments may appear unaffected, whereas in areas with the naturally lowest concentration, the dilution effect will be clearly visible (van Grouw, pers. comm.). None of the mutations brown, ino and dilution produce uniform colouration of the plumage.

As most colour mutations create colours more sensitive to light, the plumage may bleach in the course of a season. Just prior to moulting, individuals affected look much paler than immediately afterwards. While moulting, a mix of fresh and bleached feathers may be present. Similarly, museum specimens may be subject to bleaching or may look melanistic, but in fact be just very dirty or dusty (van Grouw 2010). Without knowledge about the eye colour of a really white plumaged individual, it is impossible to distinguish albinism from total leucism. We also have to bear in mind that the eye colour is only affected in as far as it is eumelanin based. In grebe species with glowing

red eyes, the pigmentation of the iris may not be that much dependent on melanins, but perhaps more on pterins or other colorants. As a consequence, neither albinism nor ino would change much in the colouration of the iris. However, any totally white fully grown and independent grebe can be assigned to leucism as albinos would not survive for long after fledging (van Grouw 2012). Finally, we may observe appearances resulting from two or more non-mutually exclusive aberrations: this will often further complicate the correct identification of the underlying mutations.

With respect to previous work, leucism could a priori be the only mutation that has been analysed to a certain degree of detail in one grebe subspecies, namely the Eared Grebe *P. nigricollis californicus*. In the plumage, leucism starts with one white feather that is ordinarily pigmented and ends with an entirely white plumage. The latter condition is qualified as total or pure leucism. All other degrees, irrespective of the amount of white feathers present and to the extent really caused by the mutation, represent cases of partial leucism. In his analysis of aberrant Eared Grebes, Jehl (1985) proposed six common patterns of leucism, consisting of various combinations of white with black or grey feathers. This study will not in the main rely on Jehl's subdivision, as will become obvious later when analysing Jehl's records and his methodology, because he did not differentiate between leucism and progressive greying. He simply ignored progressive greying, and we cannot rely on a common fine-scale subdivision of partial leucism that mixes up the mutation effect with the age effect. Therefore, this study will stick to a simple differentiation between total and partial leucism.

Before now embarking on the analysis proper, it is worth reiterating that not all aberrations necessarily result from genetic mutations affecting melanin pigmentation. Other causes, such as hormonal disorder, disease or simply age, may lead to unusual plumages. Also, natural and chemical colorants occurring in the environment may give strange tinges to plumages, visible especially on white or light feathers. In grebes, this may happen for instance during incubation on wet plant substrate and as a result of exposure to iron oxides or other chemical substances in the water.

Fig. 1: Two White-tufted Grebes at Parque 3 de Febrero, Buenos Aires, Argentina, in January 2006 (photo A. Konter).

3. Records of grebes with aberrant plumages per species

A complete list with detailed information of all records analysed during this study is given in appendix 1. An aberrant grebe contained therein is a grebe that showed colour variations in plumage, bare parts and/or eyes that did not fall within the normal range of phenotypic variation for the species concerned. Possible hybrids are the subject of a separate subdivision of this list. In the text, all intermediates are treated together in a separate section at the end of this chapter.

3.1. White-tufted *Rollandia rolland* and Titicaca Flightless Grebe *R. microptera*

For both *Rollandia* species, not a single record of an aberrant individual has been published. For the Titicaca Flightless Grebe, this may be a consequence of the small population size and the remote geographic area to which it is restricted. The White-tufted Grebe is widespread in southern South America, and its population is far more substantial. The absence of abnormal specimens may therefore be more surprising. My own observations during several visits to Bolivia, Argentina and the Falkland Islands included no aberrant White-tufted Grebes either. As for minor deviations from regular plumage patterns, I have occasionally encountered adult birds in breeding plumage with a black neck but a mostly rufous chestnut upper breast. Examples include an individual of the nominate subspecies displaying with a normally plumaged partner on Big Pond, Pebble Island, Falkland Islands, in November 2010. It was the only grebe displaying the condition out of 91 birds observed all over the islands in that period (Konter 2011). A similar pair of the mainland form *chilensis* was seen in Buenos Aires on 5 January 2007: one grebe had a more chestnut, its mate a largely black upper breast (Fig. 1). According to Fjeldså (2004), White-tufted Grebes have black necks and upper breasts with a bottle green gloss. Their bellies are deep coppery rufous. In the non-breeding season, black feathers in the neck change to dull rufous-brown. The *chilensis* individual described here was observed rather late in the breeding season. It could already have been moulting into the non-breeding plumage. The rufous colouration could equally stem from feather abrasion. However, both explanations are not very likely for the individual from the Falkland Islands observed early in the season. The phenomenon might correspond to a form of erythromelanism, as is occasionally observed in *Podiceps nigricollis*. It could perhaps simply fall within the limits of regular phenotypic variation in the species. For these reasons, the two records were not included in the register. They are mentioned here because they present similarities with phenomena observed in other black-necked grebe species.

3.2. Eurasian or Common Little Grebe *Tachybaptus ruficollis*

The register contains 32 records of aberrant Little Grebes belonging to the nominate form *ruficollis* and an additional eight records from four different subspecies.

Seven records of the nominate form date from the 19th century or earlier. At least two melanistic individuals first mentioned by Salvadori (1865) were in the collection of the Cagliari museum, Sardinia, Italy. Places and dates of collection are not known. A skin in breeding plumage had a completely dark black neck with no chestnut red feathers. The underparts were almost completely black too (Bandorf 1970, Witherby 1958; TRUru18xx01100). The conditions perfectly correspond to eumelanism. A skin in winter plumage was blackish brown at the throat. The underparts were heavily mottled in black and brown (TRUru18xx02100). Eumelanism was again a plausible explanation for this appearance. Whereas most authors, including Salvadori (1865), who visited the museum, referred to several skins at the museum, according to Hennicke (1903) there were only two. In any case, Salvadori (1865) only described two specimens, so only two records can be included here. Von Tschusi (1867) reported two abnormal Little Grebes from Austria. Except for 'south Austria', the exact place and date of collection of the first bird were not mentioned (TRUru18xx03100). The individual was part of the collection of the Zoological and Botanical Society.

It had a dark red-brown back with a reddish hue. Its throat and breast were pale rose-red with a silky sheen. It was not mentioned whether the grebe was in breeding or non-breeding plumage. The colour of its belly was not reported. Phaeomelanism would best explain the strange colouration. The second individual was shot by R. von Khevenhüller-Metsch at one of his domains in Lower Austria in 1842 (TRUru184201200). The grebe was not described at all. It was simply stated that it presented a highly interesting colour abnormality. Von Tschusi (1867) listed it as an example of abnormal plumage in a paragraph dealing with albinism and white feathers. The poor description makes almost any mutation (excluding perhaps forms of melanism) conceivable, and non-genetic causes are also possible. The solution "whiteling", introduced by Thiede in 2005, may best apply in this situation. A Little Grebe collected near Freiburg im Breisgau, Germany, in December 1887 (TRUru188701200) and at that time in the collection of the local Zoological Institute, was said by Schelcher (1914) and Bandorf (1970)to be a complete albino. The classification cannot be verified as none of the authors provided a description. The collection itself was destroyed in a bombing raid in 1944 (S. Heyl, pers. comm.). As the grebe was collected in December, it is unlikely to have been an albino. Knopfli (1956) mentioned two albino Little Grebes from St. Galle, Switzerland, observed by E. Zollikofer (TRUru189401200, TRUru189402200). The fact that they were described as almost completely white individuals implied that they were perhaps either partially leucistic or subject to progressive greying. However, "almost completely white" could also be interpreted in a different way, namely as slightly greyish or cream white. In conclusion, the only mutations that can be excluded as a cause are albinism and melanism. Here, classification as whitelings would seem appropriate.

The next seven records of the subspecies *ruficollis* date from the first half of the 20th century. Von Besserer (1905) reported a case of rufinism from Bavaria in November 1904 (TRUru190401100). The adult male was entirely chestnut or cinnamon red. Its upper head, nape, hind neck and back were of a darker rusty brown or chestnut red and displayed a silky sheen. The cheeks, the chin, the front neck and the underparts of the body were rusty yellow. The lobed feet differed greatly from the normal condition and were light olive green. The lobes and the beak were very pale. The flight feathers and those covering the upper legs were of a darker rusty red, the wing coverts rusty brown. Whereas the conditions of the plumage correspond to phaeomelanism, the legs and feet may have been affected by a different mutation. Bandorf (1970), referring to this record, said that his own observations confirmed that the conditions described by von Besserer were not uncommon during winter. By contrast, von Besserer (1905), referring to Naumann, said rufinism (here termed phaeomelanism) was rare in Little Grebes. The skin was deposited with the "Naturwissenschaftlicher Verein – Kreis Schwaben und Neuburg". Gurney (1908) described an albino from Norfolk, UK, shot in October 1907 (TRUru190701100). It was "a pure white bird with bright lemon legs and pale brown irides". This specimen is unlikely to have been an albino: if it were, it could not have survived into October, unless it hatched very late in the breeding season of 1907. In addition, the pale brown (not red) eyes make total leucim a more plausible explanation. If brown was the cause, the legs should have been less visibly affected. The Museum König in Bonn holds a skin of a Little Grebe collected at Pachutken, Riesenkirch, West Prussia, on 22 August 1918 (TRUru191801032). At first glance, the bird looks rather white. The photos of the skin received from Dr. Töpfer, Museum König, showed that the apparently white plumage of the back had retained a suspicion of a fawn rusty hue. It was strongest on the head and the less exposed feathers of the chin, upper breast and lower flanks. The feet and the beak were yellowish, which speaks for a strong reduction of melanin in these parts. The eye colour was not recorded. The description suggests a qualitative reduction of both melanins. This perfectly matches the conditions for light ino. Knopfli (1956) reported an albino individual from Lake Constance, Germany, seen by H. Noll in February 1928 (TRUru192801200). Its appearance was not described. Bandorf (1970) later included this grebe in his list of complete albinos. The well-founding of this decision is challengeable. Poncy (1953) mentioned a partial albino juvenile that was in the company of three additional immature grebes. It was seen near Geneva, Switzerland, in March 1943 (TRUru194301100). The grebe had an overall light brown plumage with the nape, the hind- and fore neck and the flanks bright white. The grebe's appearance may plausibly have been caused by brown. An albino (TRUru194801200)

reported by Knopfli (1956) from Lake Constance, Germany, seen by Effertz in October 1948, was not described and cannot be assessed. Hertenstein (1952) recorded an albino on the lower Rhine near Constance, Germany, observed during the winter of 1948/49 (TRUru194802200). During his winter counts, he had regularly seen an albino over three successive winters. It is unclear whether he thought he had seen the same bird or different individuals in each year. As no description followed, the record could not be assessed. It is however highly unlikely that an albino with poor eyesight survived until its first winter, and we can exclude the possibility that it survived for that many years. Therefore, total leucism or other mutations that, under the effects of bleaching, lead to virtually white feathers, are more plausible than albinism.

In the second half of the 20th century 16 observations of abnormal European Little Grebes followed. King (1973) reported an albino with a bright orange bill and legs from Northampton (TRUru195201100). The individual discovered by B. R. Spence in September 1952 was possibly not a true albino: there is no mention that the grebe was not fully grown or still dependent. In addition, the late date of the observation makes total leucism more plausible. A young Little Grebe observed by A. & N. Gonzalez at Woodall Park, Hertfordshire, UK, had hatched there in spring 1956 and was present until the winter (TRUru195601200). According to King (1973), it was an albino. The individual was probably already all white at hatching. Its survival over several months at least indicates that it was plausibly totally leucistic. The Ribi collection in Ermatingen, Switzerland, owned a pale, slightly yellowish Little Grebe with dark wings (TRUru195x01030). Its back was slightly lined. The place and date of collection are unknown, but most specimens in the Ribi collection stem from the period 1958-1963, and this individual is likely to have been collected inside the Basin of Ermatingen on Lake Constance (H. Jacoby, pers. comm.). The qualification 'pale' suggests that there was no change in colour pattern. Therefore, the causal mutation may have been dilution. Brown and ino cannot be entirely excluded as these mutations also lead to a light plumage, albeit with a change in the colour itself. In addition, dilution would not normally lead to a kind of linear striping on the back. Ultimately, the details available do not allow a sound assessment. Jacoby (1964) reported an entirely white individual with a yellowish beak, probably in its first calendar year, from the Basin of Ermatingen on Lake Constance, Switzerland (TRUru195801130). The grebe was seen on 19 October and 1 November 1958. Its eye colour was not recorded. The late date of the record tends to exclude albinism as causal mutation. We cannot be sure whether this was a completely leucistic bird. The yellowish beak could argue in favour of this mutation, but it would also display this condition in a sun-bleached light ino individual. Bandorf (1970) mentioned a complete albino observed on Lake Constance prior to 1964 by J. Szijj (TRUru196x01200). Without description, the sighting cannot be assessed. In a manuscript prepared in 1968, but apparently never published, Sudhaus included a report of a complete albino from Lake Warder, Germany (TRUru196x04200). The exact date of the observation by F. Dau is not known and no description of the grebe was given by Bandorf (1970). Foschi (1986 in Brichetti et al. 1992) reported a totally albinistic Little Grebe seen in Emilia Romagna, Italy, in 1960 without giving a description (TRUru196001200). In the same year, Jacoby (1964) saw an albino at the Basin of Ermatingen on Lake Constance, Switzerland. He also failed to describe the individual (TRUru196002230). All four sightings cannot be assessed. King (1975) described an albino seen by R. A. Frost in Derbyshire, UK, in 1962, as all white with reddish legs and orange red bill (TRUru196201100). The colour of the eyes was not mentioned. The individual was only observed in September and may have been fully grown. Therefore, it is likely that it was not albinistic, but rather totally leucistic. Bandorf himself (1970) observed two abnormal individuals. He first saw an aberrant Little Grebe at the Frankfurt Zoo, Germany (TRUru196202200). It was completely in non-breeding plumage, but had a broad eye stripe. Its colour was not indicated. The description is too imprecise to assess the underlying cause of the aberration. It could be of non-genetic origin and was perhaps related to a collision with an obstacle. At Stein on the Rhine, Switzerland, Bandorf noticed a partial albino in November 1965 (TRUru196501100). It was presumably in winter plumage and had a white upper breast and lower front neck. The description is too vague for a sound assessment. Based on the details available, the grebe was possibly either subject to progressive greying or partially leucistic. In December 1975, Bernecker

(1976), H. Hörl and H. Schmid observed an albinistic Little Grebe on Lake Ammer, Germany (TRUru197501100). Its plumage was overall light beige to cream coloured, except for the upper head and an area between both ends of the closed wing, that were middle to dark brown. The mutation responsible was neither albinism nor leucism. It was probably brown. Paolillo (1988) reported a perfect albino from Lake Angitola, Italy, seen there on 24 and 25 September 1983 (TRUru198301200). Without description, the record cannot be verified. Leuzinger (1996) recorded a leucistic grebe near Stein on the Rhine, Switzerland, in 1987 (TRUru198701100). It was observed at roughly the same place over eight successive winters, for the last time in December 1994. It had then reached an age of at least seven years. Each winter, the grebe stayed for 76 to 183 days. It could always be found in a section of the river about 1 km long. The grebe was light coloured all over, especially on its head. Its upper back was only slightly brownish. During autumn moult, in September, red-brown dotting appeared on its head. Its nape and hind-neck became rusty chestnut. By mid-March, the head and back turned brown with fine white lines. The individual may have been affected by the mutation brown. Brichetti et al. (1992) reported leucism from Veneto, Italy, in 1989 (TRUru198901200). No description of the grebe was given, and no assessment of the underlying mutation was possible. The individual was included in the register as a whiteling. Paillisson (1999) described a complete albino from the Loire-Atlantic region in France seen in July 1998 (TRUru199801100). The young grebe was unpigmented and had a whitish or cream white plumage on its head, breast, flanks and back. A light beige tinge was visible on the scapulars and wing coverts; its beak was pink. The beige tinge and the pinkish beak suggested that light ino rather than albinism was responsible for the grebe's paleness.

Only two aberrant Little Grebes of the nominate form have so far been reported in the 21st century. The Schorndorfer Nachrichten (NABU Schorndorf 2008) reported a complete albino from Plüdershausen, Germany, first seen by D. Schnabel in March 2008 (TRUru200801100). One chick out of a brood of five was correctly qualified as albino. It was completely white and had red eyes. It may have survived for only 19 weeks, when it probably either starved or was predated. Even fully grown, it remained apparently unable to fly. It reacted more sensitively to warning calls and then remained hidden much longer than other birds. A second brood in the same year by the same pair produced three normally coloured chicks. An albino Little Grebe was observed by V. Cavaliere in Persano, Italy, from July to September 2011 (TRUru201101222). Belfiori et al. (2011) gave no description of the individual. The accompanying photo showed an entirely white bird with a pink or pale flesh-coloured beak. The eye colour, although more difficult to define, seemed unaffected, so that total leucism is very plausible.

Eight additional aberrant Little Grebes from different subspecies are known. They include an individual of the yellow-eyed subspecies *japonicus*. S. Tracy, observer of the first reported sighting at Inogashira, Tokyo, Japan, qualified the bird as an albino (TRUja200901022). The internet photo from August 2009 indeed showed a mostly white adult grebe, except for the upper head and nape that were very light grey with a pale beaver hue. The greyish tint appeared to run down on the hind neck that was hidden on the photo. A clear cut division separated the upper head from the white lower face at the height of the eye. The beak was dark and had a light tip. The bare skin at the gape was very pale yellow, nearly white. The iris was more greenish or olive yellow. This could have been attributable to young age. The overall appearance indicated that the pale colouration resulted mainly from bleaching. A similar looking individual, most probably the same, was photographed by J. Sargatal at Inogashira Park Zoo, Tokyo, Japan, on 12 February 2010. It was accompanied by a conspecific in normal breeding plumage to which it may have been paired. This time the female grebe displayed a slightly more intense pigmentation on its upper head, the chin region, the hind neck and the back. These parts were more brownish grey whereas the flanks, the fore neck and the upper breast were roughly white. The bare parts of the gape were yellow, as was the iris. The intensity of the yellow gape colouration corresponded to that of the partner. As the parts of the plumage in the cheeks and in the neck that have a mostly phaeomelanin-based pigmentation were almost completely white, it was obvious that phaeomelanin production had failed. This excluded brown as causal mutation. The regular pigmentation of the bare parts disqualified ino too. The only remaining and plausible mutation was a form of pastel dilution with perhaps a stronger effect on phaeomelanin than on eumelanin.

Fig. 2: Ino Little Grebe at Armash fish ponds, Armenia, 28 July 2006 (TRUir200601022) (photo V. Anadian).

Three observations of abnormal Little Grebes were of the subspecies *poggei* from China. Zhao et al. (2010) provided their report of an albinistic individual (TRUpo200801101) only in Chinese. According to Li et al. (2012), the individual observed in Jinan in 2008 was almost entirely white. It had a yellow iris, and its upper mandible was black with a white tip. These conditions are normal for this subspecies. The photo in Zhao et al. (2010) showed an almost completely white plumaged individual with some remains of light red brown in the front neck and a hue of the same colour in the lower face. The forehead was brownish grey above the bill. A few feathers in the lifted wing were dark. The bare parts – as far as was visible – and the eyes were not affected. This excluded ino as causal mutation. The completely white upper plumage may have resulted from bleaching. Pastel dilution appeared to be a probable cause for the aberration as both eumelanin and phaeomelanin were affected. Li et al. (2012) gave a complete description of a leucistic Little Grebe observed in Hebei Province on 17 December 2010 (TRUpo201001101). The publication contained two photos. With the exception of the dark grey primaries, most of the individual's plumage was greyish white. Some grey stripes resembling the patterns observed in chicks subsisted in the upper head and face. The bill was orange yellow with a paler tip. It was heavily affected. The iris was slightly pale greenish yellow. It appeared rather unaffected, and the colour could be typical for juveniles. Tarsi and feet were yellow rather than grey. The immature female was unable to fly and was captured by hand. Overall the plumage was not really white, but displayed a greyish hue. Therefore, albinism and leucism could be excluded. The degree to which the mutation had affected bare parts suggested ino as a plausible cause, even though the condition of the eyes was really no different from what one would expect. Possibly in this subspecies the pigmentation of the eyes relies not on melanins, but on pterins. This could explain why the eyes were not affected. However, for ino (or brown) the hues in the plumage should have been more pale brown or tan. As they were clearly grey, with the edges of the wing even of a darker grey, a form of dilution strongly affecting bare parts must have caused the grebe's appearance. The skin is now deposited in

the museum of the Hebei Normal University. For the last record (TRUpo201101022), the observer (Aberlin?) indicated no place and it is thought that the albino grebe was seen somewhere in China in July 2011. The picture showed a mostly white grebe with a few remains of pale rufous chestnut tinges in the upper head and neck. While the beak colour was light orange, the bare skin at the gape was bright yellow. The pale green yellow eye colour suggested that it was a juvenile or subadult grebe that was more or less normally pigmented there. This excluded light ino as a plausible mutation cause. As both melanins were affected, a form of dilution may have been the root cause. The observer wrote that he had again found an albino Little Grebe. This suggests that a fourth record of an aberrant *poggei* exists.

Another three aberrations dealt with the subspecies *capensis* in India. Mlíkovský (2010) reported the whitish individual already collected in the 19th century in Native Sikkim and obtained by Mr. Mandelli (TRUca187x01100). The forehead and the anterior sides of the grebe's head, including the orbits and chin, were blackish. The nape and the upper neck were entirely chestnut and unlike any pattern known from any other species. The lower hind neck was more brownish, the remainder of the plumage white, except for the wings. The primaries were brown, while the secondaries displayed dark brown shaft-stripes. The bill and the feet were regularly coloured. The mutation underlying this appearance may have been dilution. The second record from Bilaspur District of Madhya Pradesh (TRUca199401200) was more recent. Bharos (1996) gave no description of his albino seen in November 1994. He simply stated that the individual could be distinguished from two conspecifics in its company by its unusual colour. He continued that albinism had not previously been reported in the species. During the Asian Waterfowl Census of 15 January 2004, a white Little Grebe was recorded at Muval Village, Gujarat, India (TRUca200401200). It was present there at least until 26 January 2004. Patankar (2004) gave no other details about the grebe's appearance. The timing of the observation suggests that the grebe was not albinistic: an albino would probably not have survived for that long into winter. It may have been totally leucistic, but other mutations cannot be excluded.

A last observation of an albino Little Grebe concerned the subspecies *iraquensis* (TRUir200601022). J. Aalto discovered the individual at Armash fish ponds, Armenia, in summer 2006 (Fig. 2). The grebe had an entirely white plumage, a pale pinkish bill and pale yellowish legs. Unfortunately, the picture provided was not good enough to allow the eyes to be assessed. They were affected, but their colour could have been either pink or red. Pinkish eyes would tend to indicate ino as causal mutation (van Grouw, pers. comm.).

There is no way of assessing whether all of the 12 whitish Little Grebes of Thiede (2005), reported in addition to those of King (1973), are included in the register of this study. It could be that, for instance, Thiede's own record of a schizochroic individual was missed.

3.3. Australasian Little Grebe *Tachybaptus novaehollandiae*

Only two records of perhaps related individuals have been published. Both individuals were observed in South Morang, Victoria, Australia, and were mentioned in the same article (McKenzie & Ford 2011). The grebe observed in 2010 (TNOno201001101) was believed to be the parent of a much lighter bird recorded in 2011 (TNOno201101101). The possible parent seen in 2010 was in the company of a regularly coloured chick (Fig. 3) and must therefore have been paired. It displayed normal breeding colours in its head and upper neck. The blackish and chestnut feathering ended rather abruptly a bit below the chin, at the level where normally the chestnut red area ends. The ordinarily blackish feathers below were replaced by a mix of whitish and pale grey feathers that covered the neck and the mantle. The flanks were entirely whitish. Eyes and bare parts at the gape of the beak displayed the colours expected for the species, although they appeared paler than normal. The bill was perhaps a bit greyish and not quite as dark as usual. Van Grouw (pers. comm.) suggested that this grebe was affected by a form of dilution. The effects of dilution will be clearly visible in the parts of the plumage with naturally the lowest concentration of melanins, while parts with naturally a very high concentration appear

Fig. 3: Diluted Australasian Little Grebe with chick, Morang Wetlands, Victoria, Australia, in 2010 (TNOno201001101) (photo D. Ford).

Fig. 4: Diluted and sun bleached Australasian Little Grebe (TNOno201101101, in the back) and individual possibly subject to progressive greying (TNOno201102001), Morang Wetlands, Victoria, Australia, in 2011 (photo D. Ford).

less or even unaffected. Isabel dilution would perfectly explain the appearance of the grebe. Bare and plumage parts receiving phaeomelanin were not visibly affected. In the Australasian Little Grebe, the highest eumelanin concentration is found in the plumage of the brow and chin region. So these parts still looked very dark whereas the effects of the dilution were clearly visible in other parts that regularly receive less eumelanin.

TNOno201101101 (Fig. 4) was almost completely whitish or cream coloured. It had a pale fleshy beak with very light yellow bare parts at its onset. The iris was of a less bright yellow than usual. In the upper head, from the eye upward, a pale chestnut colouration subsisted in an area where normally eumelanin spreads. Comparison to the accompanying bird in breeding plumage suggested that the whitish dabchick was a female. With both melanins concerned and bare parts visibly different from regular conditions, ino was a possible causal mutation. However, sun bleaching should have had the greatest effect on those parts of the plumage that were most exposed. This was not the case, and the upper head still displayed pigmentation. H. van Grouw (pers. comm.) suggested dilution as a cause. A similar looking grebe was detected by D. Ford at about the same place in December 2011 (TNOno201103032). On the photo received by courtesy of the observer, the mostly white individual had few pale rusty remains of pigmentation in its upper head. Its eyes were yellow, the beak was mostly pale flesh coloured. On the sides of the neck, on the back and on the wings, some very pale greyish shadows remained just visible. Otherwise, the plumage was quite white. The individual was believed to have been a chick of TNOno201101101 from the preceding season. It was most probably affected by the same mutation. It cannot be entirely excluded that the two diluted birds were one and the same, as sun bleaching would change an individual's appearance in the course of the season.

Another Australasian Little Grebe (TNOno201102001, Fig. 4) was not specifically mentioned in McKenzie and Ford's (2011) article. It was present on the photo published with the article and was the partner of TNOno201101101. Its overall appearance did not differ from the

Fig. 5: Under parts of a melanistic Least Grebe from Panama (TDObr196401202, in the front) and of a regularly plumaged individual from the collection of the US National Museum (photo J. R. Saucier).

ordinary breeding plumage. The coloured bare parts and the eyes appeared normal. However, its upper breast and lower fore neck showed intense mottling with white feathers. Progressive greying may have affected this individual.

3.4. Least Grebe *Tachybaptus dominicus*

A melanistic female Least Grebe (TDObr196401202, Fig. 5) from La Laguna, Panama, collected in 1964, was reported by King (1975). It had very dark underparts. No other details were mentioned. Photos of the skin received from J. R. Saucier from the US National Museum, where the skin is preserved, showed that the individual had an absolutely normal pigmentation in its upper plumage (head, neck and back). Its belly was overall much darker than in other conspecifics, but neither blackish nor dark cinnamon. It simply had much less white than is normal for the species. The belly was mostly rather greyish brown and mottled with fewer white feathers. The lower mandible looked darker than in other individuals. Since this record, no additional aberrant individual of the species has been added.

3.5. Madagascar *Tachybaptus pelzelnii* and Rusty Grebe *T. rufolavatus*

If we exclude probable hybrids, no records of abnormally plumaged individuals exist for both species endemic to Madagascar. The Madagascar Grebe and the now extinct Rusty Grebe are both known to hybridize or to have hybridized with the African subform of the Common Little Grebe *T. ruficollis capensis*. Even in this context, descriptions of aberrations are rare (see chapter 3.23).

3.6. Pied-billed Grebe *Podilymbus podiceps*

The register contains eight records of aberrant Pied-billed Grebes. The oldest observation is from 1907. Rockwell (1910) reported an albino individual (PPDpo190701200) from the Barr Lakes, Colorado. The grebe had an entirely snow white plumage. Although the observers tried to shoot the bird, it succeeded in keeping out of gun range. The successful escapes suggest that this individual's eyesight was most probably better than that of a pure albino. If we assume that the feathers were not white as a consequence of bleaching, the causal mutation may have been leucism. A male Pied-billed Grebe (PPDpo193601100) collected by L. Lehr on Lake Keesus, Wisconsin, (Dettmann 1937) was qualified as a pure albino. Its entire plumage was pure white with no dark markings. The feet were apricot yellow. The iris was neutral grey and the bill greyish lavender. The latter two conditions triggered doubts about the correctness of the initial identification of the mutation. Even total leucism appeared unlikely as the grey lavender pigmentation of the bill could correspond more or less to the ordinary condition. To what extent the eyes were affected is difficult to say, as "neutral grey" could again be interpreted as normally pigmented. Possibly a form of dilution caused the grebe's appearance. The specimen was deposited with the Milwaukee Public Museum.

C. Titus informed me of her sighting of an aberrant individual at Floyd Lamb Park, Las Vegas, Nevada, USA, on 19 November 1988 (PPDpo198801032). Her photo showed a grebe in winter plumage with a rather light brownish orange to rusty buff upper plumage. It was overall much paler than conspecifics around. Face, front neck, upper breast and flanks were very light, mostly cream coloured with few hues of buff. Its bill was ivory to pale flesh coloured and had no dark central band or culmen. Its eyes appeared pale, but not pinkish. The causal mutation may have been brown. A chick (PPDpo199601202) collected at Brooklyn, Washington, on 8 August 1996 was said to be an albino (Muller & Storer 1999). Its skin is now at the Slater Museum of the University of Puget Sound, Olympia. G. Shugart, collection manager, was kind enough to send me a few pictures of the skin. They proved that the young grebe was not an albino. The regular juvenile pattern of the plumage remained well visible in the head. However, the normally dark striping was of reddish buff to beige colour with some light grey feathers in the upper head. The mantle feathers and wing coverts displayed different shades of orange beige to buff. Chin and throat were white, the flanks light. The feet and the bill were heavily affected by the mutation and

Fig. 6: Dark ino juvenile Pied-billed Grebe (above head pattern; below upper plumage) collected at Brooklyn, Washington, on 8 August 1996 and now at Slater Museum, Olympia (PPDpo199601202) (photo G. Shugart).

displayed different tones of orange yellow. The eye colour was reported as pinkish. With the iris and the bare parts affected, the individual is best classified as dark ino. A regular winter resident (PPDpo199801010) at Terra Verde Ponds, Florida, from 1998 to 2001 was identified as partially leucistic by B. Ahern. It had white feathers scattered on the upper head, the cheek area, the neck, and in parts of the back. According to the observer, the grebe may not have changed its appearance over the years. The presence of white feathers in all plumage parts suggests that progressive greying was the cause. In 2005, Martes reported a white Pied-billed Grebe (PPDpo200501010) from

Sepulveda Basin, California. It was a totally white bird with a pink bill, but with dark eyes and, apparently, normally coloured legs. If we assume that the observer was unable to get a good look at the colour of the legs, total leucism seems quite plausible. On 16 September 2013, an individual resembling a juvenile Red-necked Grebe was reported from an unknown place in North America (PPDpo201301020). It had entirely white, not beige, cheeks and was not further described. The resemblance to a juvenile Red-necked Grebe may have been limited to a rusty chestnut hue in the fore neck, which is not unusual for Pied-billed Grebes in winter plumage. It was said to have been partially leucistic. On the basis of the description, this could not be verified. However, the white feathers in the cheeks could simply be related to young age.

The eighth record mentioned by Ross lacked all details. Besides the observation of Rockwell (1910) discussed above, Ross's (1963) paper included a sight record of a pure white individual qualified as totally leucistic (PPdpo19xx01200). Neither place nor date of observation were given, and a more detailed description was also lacking. Therefore, it is not possible to indicate the causal mutation with certainty.

3.7. Hoary-headed Grebe *Poliocephalus poliocephalus*

An older record concerned a skin at the Victoria Museum, Melbourne, Australia (PPLpo19xx01303). The grebe was collected between 1897 and 1987, probably in Victoria, as two thirds of the skins in the museum's collection stem from there. The individual in breeding plumage displayed a mix of silvery white and rusty chestnut hair-like feathers on the sides of the head and in the crest. The presence of the rusty colour is unusual. According to Fjeldså (2004), this species exhibits during the breeding season a variable intensity of cinnamon-buff hues on its lower neck and breast. It seems that in the museum specimen, the same colour was present in about half of the elongate ornamental feathers in the head. The causal mutation may have been chestnut melanism.

Fig. 7: Aggregation of Hoary-headed Grebes at West Gate Ponds, Melbourne, Australia, in 2003, all individuals displaying rusty orange feathers in their upper breasts and fore necks (photo A. Konter).

Two additional observations of aberrant Hoary-headed Grebes were retrieved via the internet. The first bird was present at the coastal ponds of the Western Treatment Plant of Werribee, Victoria, Australia, on 30 December 2011 (PPLpo201101020). No photo was provided and the text simply stated: Albino grebe (probably Hoary-headed). It is unknown what prevented final species identification, possibly the distance to the bird. The record could not be verified further. The place of observation is however well known for Hoary-headed Grebes: the species is likely to be correct.

A recent example of a grebe in breeding plumage with a heavily pigmented upper breast and lower neck was provided on the internet by R. and M. Alcorn (PPLpo201301012). Their photo from River Gum Creek Reserve, Hampton Park, Melbourne, Victoria, taken on 18 July 2013, showed an individual in breeding plumage with bright chestnut upper breast and lower fore neck. The colour faded quickly in the upper fore neck and towards the flanks. The appearance confirmed Fjeldså's (2004) statement about the occurrence of rusty colouration on breast and lower neck during the breeding season. Own observations at Lake Wendouree, Ballarat, at Werribee and around Melbourne, especially at the Westgate Ponds, in 2003, confirmed the statement: while in some of the Hoary-headed Grebes present there, no cinnamon-buff shadow at all was detectable in the field and their front necks and upper breasts appeared white, in others tinges of rusty cinnamon spread to varying degrees. At Ballarat, in one Hoary-headed Grebe the lower front neck and the upper breast were entirely of an intense rusty orange colour. In most others no such hues were visible in the field. In contrast, at the Westgate Ponds most individuals present had rusty orange tinges on their upper breast and neck (Fig. 7). Whereas Fjeldså (2004) had nothing to say about the origin of the colour, Marchant and Higgins (1990) attributed it to ferrous oxide staining and staining from vegetation. However, there has so far been no verification of this assertion. For PPLpo201301012, a form of chestnut melanism appeared more plausible.

Fig. 8: New Zealand Grebe in regular plumage, Lake Rotoiti, New Zealand, 2005 (photo A. Konter).

3.8. New Zealand Grebe *Poliocephalus rufopectus*

There is no recent record of an abnormal New Zealand Grebe. Two of the three records in the database concern specimens at the Canterbury Museum, Christchurch, New Zealand, that were described by Buller (1875, 1888). The first grebe (PRUru18xx01100) may have been present for some time in the museum's collection. Its aberration was not further qualified. The abnormally coloured specimen had the whole of the underparts dark buff (instead of silky white), deepening into dull chestnut-brown on the breast and fore neck. The term "buff" may have indicated a more yellowish red pigmentation. The qualification "dark" suggested a more red brown hue, in which case the grebe may have been phaeomelanistic.

As Buller (1875) reported the presentation by T. Waters of the second specimen (PRUru187x01100) to the museum, it was most probably collected in the 1870s. The original qualification as an albino is certainly wrong. Although the general appearance of the skin was "pure white", the further description confirmed that this was not a pure albino. The sides of the head and the throat of the individual were shaded with brown. Its crown, nape and hind neck were streaked and spotted with black, the fore neck and breast varied with pale rufous. The upper surface had a pied appearance. The wings were dusky black, more or less intermixed with white. The bill and the feet had a normal colouration. These indications can be interpreted as a very faded presence of the regular colouration in the plumage. Sun bleaching would then have caused a somewhat white overall appearance. As bare parts were not affected, ino and brown could be excluded as causal mutation. The individual not being really white, albinism and leucism were impossible too. With eu- and phaeomelanin likewise affected, pastel dilution seemed most plausible.

An additional aberrant individual was recorded by King (1975). This New Zealand Grebe (PRUru19xx01200) was reported to him in a letter by Falla, who wrote that the albino grebe had been seen at Canterbury many years ago, but that all details were mislaid. No assessment of the record was possible.

3.9. Great Grebe *Podicephorus major*

A partial albino (PMAma200701101) was reported from Laguna Napique, Sechura province, northern coastal Peru, by Torres and Franke (2008) in February 2007. This Great Grebe had dark eyes, the bill was pale and the feet were flesh coloured. The plumage was mostly white with some blackish dots in the tips of the wings and in the lower mantle. The photo provided showed scattered dark spotting in the head and the neck. The darker colour markings in the wings and the back appeared rather brownish, partially even yellow brown, and not blackish. This suggests that the mutations brown or ino were responsible. The pigmentation of the eyes was difficult to see on the picture, but appeared rather pale and not dark. The iris is generally described as deep red-brown, but according to Fjeldså (2004) may show some variation. The grebe may have been ino rather than brown. Its bare parts were much affected, its eyes probably too. No tinges of chestnut were visible, suggesting that both eu- and phaeomelanin were of inferior quality.

A priori this Great Grebe belonged to the nominate form. However, Fjeldså (2004) suggested that isolated populations in coastal Peru may differ and could be part of a third subspecies, subject to further research.

3.10. Great Crested Grebe *Podiceps cristatus*

Excluding individuals with minor deviations from regular integument patterns, a total of 123 aberrant Great Crested Grebes have been recorded, all but one of the nominate form.

No less than nine individuals of the species were reported during the 19th century. For a sandy coloured individual obtained in Leaden Hall Market, London, UK (PCRcr18xx01200), neither place nor date of collection were known. Gurney's (1887) report suggested that the grebe may have been shot only shortly prior to its sale in the market, so that it could stem from the 1880s and thus would not be the oldest specimen in the register for this species. The indication "sandy coloured" points to brown or light ino as the probable

Fig. 9: Mounted head of a brown Great Crested Grebe from Ukraine, 1914 (PCRcr191401032) (Photo H. van Grouw, copyright NHM, Tring).

mutation. As no bare parts were described, a differentiation between the two mutations was not possible. Brown is generally the more common genetic cause of both. Leverkühn (1887) published a record of a skin that he saw at a Hamburg museum in 1866 (PCRcr18xx03100). The grebe was collected at Lake Ratzeburg on an unknown date. It was white, except for isolated patches on head and back, where the normal colour was shining through. H van Grouw (pers. comm.) suggested sun bleached brown as a cause. Von Pelzeln (1865) discovered two aberrant Great Crested Grebes in the collection of the Natural History Museum of Vienna, Austria. The first was a juvenile collected in Syria on an unknown date (PCRcr18xx02102). Its crest and hind neck line were brownish, and a light brownish chestnut patch existed in the region of the ruff. The nape was whitish, as were the face and the fore neck. Its back was described as piebald, an effect produced by white edges and bases to feathers. The wing coverts were white. The legs and even more so the bill were quite pale. On the photo received by courtesy of Mr. Berg, collection manager at the Vienna museum, the back appeared pale brownish overall. A perhaps piebald pattern was produced by mottling with paler feathers, probably provoked by sun bleaching. The legs were pale yellowish with brown, the bill was yellowish. The eye colour was not reported. The conditions suggested brown as causal mutation. The second individual was a female shot in summer 1823 in Banat, a historical region today subdivided between Romania, Serbia and Hungary (PCRcr182301100). Its throat, lower neck, breast and the centre of its belly were lined in rusty yellow. This effect was apparently produced by rusty yellow ends to the feathers. Perhaps a light form of chestnut melanism was responsible for this result. Other possibilities include forms of staining. Gloger (1866) described an almost complete albino collected at Potsdam, Germany, on 6 November 1853 (PCRcr185301100). The plumage of this Great Crested Grebe was almost entirely white, except for the tips of its crest and a pale dot on both sides of the upper neck behind the ruff: these parts all showed a light yellow-brown tinge. In addition, remains of the normal greyish brown colour were detectable in the wing. The feet, including the lobes, were much paler than usual. The bill was pale yellowish red. The

iris was of about normal colour. The description strongly suggested that the whiteness of the bird materialised only after sun bleaching. Brown was quite plausible as causal mutation. It affects the eyes less than ino and could explain the abnormal pigmentation of bare parts. Altum (1867) described a pale aberration of a Great Crested Grebe from Munsterland, Germany, collected prior to 1867 (PCRcr186x02100). Despite its whitish appearance, the normal colours remained detectable overall (Hennicke 1903), and Altum qualified this grebe as a pale coloured aberration. Brown may have caused the lack of plumage colouration. A grebe reported by Leverkühn (1890) and seen in North Holland, Netherlands, at a collector's house as a mounted specimen in 1864 (PCRcr186401100) was quite similar in appearance to the preceding individual from Munsterland. Its paleness may however have been less obvious. Its feet and bill were of normal pigmentation. Van Grouw analysed the skin and found grizzled feathers all over its wings and the mantle. He concluded that probably a form of progressive greying was the cause (pers. comm.). The same grebe was included in van Oort (1908/1909), who in addition reported an albino from North Holland, Netherlands, purchased by the Leiden Museum in 1866 (PCRcr186601200). 1866 could have been the year of collection too. The bird was not described, except for having a light brown tinge in its upper parts. Therefore, it was certainly not an albino, but it may have been affected by either ino or brown. Van Grouw, after inspection of the skin, confirmed that it was a brown individual (pers. comm.). At Lake Velencze, Hungary, a partially albinistic and erythristic Great Crested Grebe was shot on 29 March 1892 (PCRcr189201100). Chernel de Chernelháza (1907) described the bird as follows: wings generally white, innermost secondaries partially brownish-grey, some of the middle wing coverts light rusty and brownish grey towards the end; crown, forehead, crest and tufts chestnut with the tips somewhat brownish-grey; back-feathers lighter than usual, especially towards the flanks; the lower neck similarly displayed more rusty and white colours. Apparently, the individual had no white feathers in abnormal places. As a consequence, it may have been brown, rather than albinistic or leucistic. Incomplete eumelanin oxidation would explain the presence of brownish and rusty brown colours in parts that are normally darker.

In the first quarter of the 20th century, eight abnormal Great Crested Grebes were added. The first record may even have been from the 19th century, as all that was known was that the individual was collected prior to 1928. PCRcr19xx01200 was exhibited at a museum at Lake Ratzeburg, Germany. Dietrich (1928) classified it as a partial albino, a partially leucistic individual in today's terms. This assessment cannot be verified. Chernel de Chernelháza (1907) described a melanistic grebe (PCRcr190501100) with an albinistic crest or albinistic tufts on each side. It was shot by himself at Lake Velencze, Hungary, on 14 April 1905. Overall it was quite black and partially brownish black, with its head and back darkest. Even the underparts were dark, although they had a silvery sheen. The ruff was slightly metallic green. Curiously, almost all feathers of the crest or in the region of the ear on each side of the nape were white. The bill, legs and feet were horn-black, the iris dark brown. The grebe was clearly melanistic and possibly partially leucistic. At Lake Kinkheim, Poland, Tischler (1941) observed a whitish coloured individual with a dark ruff that was present there during the entire breeding season of 1909 (PCRcr190901200). The qualification "whitish" suggests that this colouration may have resulted partially from bleaching. A form of dilution, brown or ino may have caused the bird's appearance. The Zoologisches Forschungsmuseum Alexander König, Bonn, Germany, holds a skin of an individual collected at Bergsee, Mecklenburg, Germany, in June 1911 (PCRcr191101032). The mounted grebe is not really white. Its plumage is more cream coloured with a light tan hue. The elongated and entirely cream white ruff proved that the grebe was in breeding plumage. The beak was light pink. After analysis, H. van Grouw identified the mutation as ino (pers. comm.). Count A. Bobrinskoy donated a skin collected near Kiev, Ukraine, probably in 1914 (PCRcr191401032), to the British Museum, at that time still based in London (Fig. 9). The short crest and ruff of the individual indicated that it was in winter plumage. The upper parts of its plumage were overall pale beige tan to cream with a few pale rusty orange tinges in the region of the ear tufts and in the upper flanks. The conserved bill today looks pale pink, but has a darker culmen (Fig. 9). It was a brown specimen (van Grouw, pers. comm.). Grochmalicki (1925) recorded a young albino, fully grown, at Lake Bytýn, Poland,

in August 1915 (PCRcr191501101). It displayed an entirely snow white plumage, a whitish yellow beak and yellowish feet with locally a brownish tint. The details available make albinism plausible, although the eye colour was not mentioned. In the same year, Hess (1915) reported an albino Great Crested Grebe that was shot on Lake Constance (PCRcr191502100). Besides being completely white, it had pale reddish eyes and pale flesh-coloured feet. This supported the correct interpretation of the mutation by A. Wimmer, who prepared the skin for preservation. At Rohrsee near Wolfegg, Germany, an albino was shot in May 1920 (PCRcr192001200). Zwiesels (1920/21) gave no other details of the grebe's integument, and the record could not be assessed. Since the grebe had survived at least one winter, it was not an albino.

Nine aberrant Great Crested Grebes were seen in the next quarter of the century. Witherby (1928) identified an albino shot at Cleethorpes, UK, in December 1927 as a Great Crested Grebe (PCRcr192701100), but Lord Rothschild and Dr. Hartert, used measurements and comparison to skins of both Great Crested and Red-necked Grebes to convince him that it was a *grisegena*. The bird was later labelled *cristatus* by the British Museum. Simmons (1974) and King (1975) agreed to the corrected species identification although they did no thorough analysis. Upon request, H. van Grouw made up for this in 2013. He concluded that the skin was of a female Great Crested Grebe. The bird was described as pure white with the exception of a creamy, slightly yellowish wash at the base of the neck. Its iris was pale rose-coloured, the feet orange yellow. The base of the bill was bright yellow, the tip yellowish-horn. Dusky splashes existed on the basal half. Van Grouw (pers. comm.) identified the aberration as ino: the down layer was still slightly coloured and ino birds indeed have pinkish eyes. Given that ino is recessive and sex-linked, the sex of the specimen fitted too. The measurements of the specimen (bill 65 mm and wing 172 mm) were commensurate with a female Great Crested Grebe, but were too large for a female Red-necked Grebe.

On 29 September 1930, a completely white individual (PCRcr193001200) was reported by Schüz (1931a) from the Baltic Sea near Ulmenhorst, today Russia. In the same paper, Schüz mentioned an observation by Gransow at Lake Ucker, Germany, of a similar looking grebe just about two weeks later, present there from 15 October to 4 November (PCRcr193003200). Schüz (1931b) believed that two different birds were present at Ulmenhorst and at Lake Ucker. Later authors questioned this, based on the short distance of only 490 km between the two places. Earlier in the same year and only some 30 km from Lake Ucker, on Lake Templin, Germany, Finkbein (1931) saw a snow-white juvenile albino present there from early August to late in September (PCRcr193004101). He considered that this was the same albino discovered later on neighbouring Fährsee and present there from 20 October 1930 to January 1931. Theoretically, all four sightings could have concerned the same individual. Based on the timelines of the observations, this grebe would have stayed as a juvenile near Prenzlau until the end of September, when it migrated over 500 km to reach the Baltic Sea on 29 September. It then returned to the region of Prenzlau about two weeks later. Although this migration pattern cannot be entirely excluded, it does seem unlikely. Therefore, we can be fairly confident that the observations at Ulmenhorst and near Prenzlau concerned two different grebes. For the observations in the Uckermark, we note a partially overlapping presence on Lake Ucker (15 October to 4 November) and on Fährsee (20 October 1930 to January 1931). Unless the grebe was constantly commuting between the two lakes, two different grebes must have been involved in the sightings. It seems appropriate to settle on three separate records and to acknowledge a slight theoretical chance that PCRcr193001100 may have been identical to PCRcr193003100.

All that we learn about PCRcr19300120 is that it was a completely white individual, and that this was confirmed by Dr. O. Heinroth, also present when the observation was made. Dittberner (1996) included this sighting with his albinos. The few indications available do not allow an assessment of the cause for the grebe's whiteness. Albinism, however, can be excluded, as the grebe was only observed in late September. PCRcr193003100 on Lake Ucker looked similar to the preceding individual. In the absence of details, the record cannot be verified, but again albinism was not plausible. PCRcr193004101 was described by Finkbein (1931) as a snow-white juvenile albino. Its plumage was entirely white. Its beak was dark and the legs were flesh-coloured yellow. The grebe

behaved very cautiously and was very shy. The dark bill excludes albinism, total leucism and ino as causes. Also, the survival period, as outlined above, does not support albinism. Brown might best explain the grebe's appearance as the bill may be less visibly affected in this mutation.

Another snow-white juvenile was registered at Lake Templin, Germany, in 1932 (PCRcr193201100). It was detected at exactly the same place where in 1930 an all-white juvenile had already been seen. Finkbein (1932) wrote that the grebe was in the company of a normally coloured adult and a regular sibling, but he failed to describe the abnormal pullus. It is likely that this descendant was a younger sibling of PCRcr193004100 and may thus have suffered from the same mutation. Since September 1932, a partial albino was present at Greater Lake Segeberg, Germany (PCRcr193202100). Sager (1933) described the grebe as entirely white seen from some distance, but at closer range with head and neck approaching the normal pattern, the back remaining bright white. The relative paleness of head and neck argue in favour of dilution as a cause for the grebe's appearance. Brown or ino would have been other possibilities, but neither brown hues nor aberrations of bare parts or eyes were mentioned. This grebe seemed to shun its numerous conspecifics present simultaneously. In contrast, it was less shy of people at the shore of the lake. At Lake Karrasch, Poland, a pure white individual (PCRcr193301100) resided in summer 1933 (Hoffmann 1934). The presence over the summer without any mention that this was a juvenile implies that the bird had survived at least one winter, which is unlikely for a true albino. Therefore, this sighting was reclassified tentatively to totally leucistic, although the lack of precise description did not definitively rule out other mutations. At Fleet Pond, Hampshire, UK, Nichols observed a pure white Great Crested Grebe displaying the faintest tinge of blue-grey along the back in October 1938 (Simmons 1974; PCRcr193801100). Judging from the size of the crest, it was still in breeding plumage. Its appearance may have been caused by dilution. In February 1944, an albino (PCRcr194401100), not further described and therefore impossible to assess, was present at Klingnau Barrage, Switzerland (Knopfli 1956).

12 observations were from the third quarter of the 20th century. Knopfli (1956) reported two partial albinos in the collection of the Vogelwarte Sempach, Switzerland (PCRcr195x01200, PCRcr195x02200). He neither mentioned whether these were recent additions, nor did he provide descriptions. The collection of the Vogelwarte was transferred to the museum in Basel in 1947. In the meantime, both partial albinos listed by Knopfli have disappeared. In the appendix, both individuals are listed as partially leucistic and as unverifiable records. Nevertheless, the young age of both would support partial leucism rather than progressive greying as cause. An albinistic Great Crested Grebe shot at Lake Constance in July 1950 (PCRcr195001100) was described as having a pure white plumage with a silvery sheen, a pale red eye and flesh-coloured feet (Knopfli 1956), and was thus most probably a true albino. Géroudet (Knopfli 1956) reported a partial albino from Lake Geneva, Switzerland, present there in November 1950 (PCRcr195002100). He said that its plumage was light instead of dark grey. Dilution was the likely cause in this case. A skin at the National Museum of Moravia and collected near Lednice, Czech Republic, in 1953, was qualified as albinistic (PCRcr195301020). No description could be obtained from the museum. The Great Crested Grebe observed by Orbahn (Berndt & Drenckhahn 1974) at Lake Warder, Germany, in April 1960 was speckled dirty white and a bit light brown (PCRcr196001100). Brown was a plausible explanation for this colouration. However, the description was superficial and did not allow final assessment excluding ino. Hofer (1962) reported an albino pullus raised by normally pigmented parents at Lake Sempach, Switzerland, in August 1960. It was completely white, but had a dark beak and dark legs (PCRcr196002100). Neither albinism nor complete leucism are likely to have been involved, as bare parts had apparently received normal amounts of melanin. Based on the description, brown and ino did not seem plausible. This left only dilution as possible causal mutation. The pullus may not have survived for long, as despite the regular presence of the observer in the same area of Lake Sempach, the chick was only observed for four successive days. We might therefore question whether the bare part colours were correctly reported and whether the grebe might have been albino after all. However, a sighting of a white

grebe by an angler on 20 September might have concerned the same individual. Bonfio (1963) reported a cream coloured or isabelline individual caught at Mille Campi Valley, Italy, in December 1961 (PCRcr196101101). The bird had the upper head, the neck and the back of a uniform dark cream to tan colour. Its legs were partially pale brown. The black and white photo showed that the individual was still quite strongly pigmented, although it was paler than the normally coloured Great Crested Grebe in the same picture. In addition, it had pale spotting on its back, perhaps as a result of sun bleaching and an ongoing moult that replaced bleached feathers. As there was no mention of greyish tones, the grebe may have been brown. Dittberner and Dittberner (1979) recorded an albino at Lake Selchow, Germany, seen in August 1962 (PCRcr196201100). It was one of two chicks accompanied by regularly coloured parents that cared for both descendants with the same attention. Although its eyes were not described, its overall snowy white plumage, its pale yellow beak and its pale legs suggested that it may have been either a true albino or a totally leucistic bird. In January 1971, King (1973) observed a grebe with truly albinistic features at Durleigh Reservoir, UK (PCRcr197101100). His very superficial description only dealt with the head, that was completely white except for a small dark mark behind the eye. The indications did not address to what extent the plumage of the back and the flanks were normally pigmented. There is nothing about the colour of bare parts or of the eyes. So no mutation, except albinism, could be ruled out. Schipke (1980) observed an albino grebe at different ponds of Koblenz/Wartha, Germany (PCRcr197301100). The same bird may have been present there in three different years. It was first seen as a white pullus on the back of a normally coloured adult in July 1973. It may have returned to the region in two successive years for the periods 27 April to 13 July 1974 and 20 April to 28 September1975. In its second year, it was considered to be a female with a completely white plumage, a dark red iris and yellowish-grey feet and beak. Schipke (1980) left it open as to whether he had seen different birds, but Melde (1986) considered that it was always the same individual. Here, the adult was registered as a second individual (PCRcr197401101). In two years, it displayed with a regular partner, and in one year it may have bred in a colony, possibly without success. A black and white photo by E. Baltzer from mid-May 1975 showed an entirely white individual with fully developed crest and ruff. The grebe was classified as completely leucistic: this was the only plausible mutation that left the eyes unaffected. Köcher and Kopsch (1979) reported an albino from Fremdiswalde, Germany (PCRcr197302100). It was described as having a completely white plumage, yellowish legs and a yellowish beak. The colour of the eyes was not mentioned. Albinism was not plausible: the record was from October and thus certainly concerned a fully grown and independent individual. The eye colour was not mentioned and might have been normal. Total leucism may have caused the appearance.

19 additional aberrant grebes followed up to the end of the century. Piersma (1984) analysed the plumage of a Great Crested Grebe that had drowned in a fish net at Lake IJssel, Netherlands, in December 1979 (PCRcr197901101). Its body feathers were normally coloured, but its wings were pale brown and diffusely barred. The bars in wing coverts, alula feathers and remiges were corresponding and seemed to have grown simultaneously. Piersma considered that they were growth bars. These are faint, alternating light and dark bands on feathers; one dark plus one light bar correspond in general to 24 hours of feather growth (Hill 2006). They do not normally exist in grebe feathers and may have been caused by dietary problems affecting melanin production. Knysh (2004) reported an albino collected at Lake Gotin', Timanovka, Shostkinsk, Sumy region of the Ukraine, seen in autumn in the late 1980s (PCRcr198x01101). Its plumage looked white and had a light fawn tinge. The colouration was most intense in the head and wing coverts. The crest was of grey brown chestnut, the cheeks and the chin were brownish. The beak and the legs were yellowish to grey brown. The toes had in addition some olive green. The colour of the eyes was not recorded. The causal mutation may have been brown rather than ino, as the chestnut parts of the ruff appeared unaffected. From 16 January to 13 February 1982, Schultze (1983) observed an albino Great Crested Grebe on the river Spree, close to the inflow of Landwehrkanal, Berlin, Germany (PCRcr198201100). The grebe had an entirely snow-white plumage. Its bill and legs were yellowish, the eye colour was not recorded. The long survival into the winter months favoured total leucism, not albinism, as

cause. Woets (1984) observed a Great Crested Grebe present close to the port of Lelystad on Lake IJssel, Netherlands, throughout October 1984 (PCRcr198401101). It was clay or cream-coloured white, somewhat more brownish at the nape, and it had a pinkish beak. The regular winter subdivision of the plumage was still easily detectable in the photo provided. The eyes seemed unaffected. Brown may have caused the individual's paleness. Bullock (in Thiede 2005) followed a leucistic, clay-coloured Great Crested Grebe that was present at Boddington Reservoir, UK, and at a nearby body of water during the breeding seasons from 1984 to 1994 (PCRcr198402200). It also bred on local ponds from 1987 to 1990 and was successful in at least three seasons. Bullock missed this perhaps unique occasion to gain greater insight into the life of an aberrant individual (Thiede 2005). Even his description of the grebe was rather superficial and limited to the light clay-coloured plumage and the light central crown. The individual was certainly not affected by leucism. Brown seemed most plausible, though ino was possible too. At Reeuwijk Lakes, Netherlands, Scheygrond (1985) saw an albinistic juvenile, present there from July to September 1984 (PCRcr198403101). Two photos by R. Brusik showed first the not yet fully grown juvenile in the company of one parent in early July, and then fully grown on 26 July. In the first photo, the very pale plumage appeared to have retained a hue of pigmentation, and the striping in the head was clearly visible. In the second, the grebe looked paler with hardly any striping left, a consequence of sun bleaching. The legs looked pale. The eyes were difficult to assess, but seemed dark. A likely causal mutation was brown. Scheygrond considered the possibility that this was the same individual that was reported later in the same year by Woets (1984) 70 km away. The plumage of the individual at Lelystad-Haven looked darker, however. A priori, the differences in colouration pointed to two different individuals, although the slightly darker feathers could have resulted from fresh moult or from different light conditions in the photos. Fray et al. (2009) reported a sighting of a leucistic grebe at Rutland Water, UK, on 30 August 1985 (PCRcr198501200). As no details were given, the record is best classified under whiteling. Sellin (2009) reported the presence of a schizochroistic grebe inside a larger group of 1,010 individuals at Peenemünder Haken, Germany, for over two weeks in August 1986 (PCRcr198601100). It was the only aberrant Great Crested Grebe he had seen in over 130,000 observations of the species. Its plumage was completely light cream-coloured, but not white. No crest or plumage structures were identifiable. Therefore, Sellin supposed that it was a juvenile grebe. Its bill was monochrome light beige. Its eye colour could not be defined. Dilution would not lead to cream, and ino would affect the bill to a greater extent. Brown appeared to be the best explanation. Wruss (1988) reported three albino chicks from Lake Völkermarkt, Austria. Two of them were recorded from the same brood in 1986 (PCRcr198602200, PCRcr198603200). A completely white adult seen in the following year was registered as one of the chicks that had returned to its native lake. In May 1987, one pullus in a brood of four was again completely white (PCRcr198701200). The parents of all three pulli were probably the same in both years. No soft parts of the descendants were described. All we know is that their plumage was completely white. The real mutation may have been different from albinism, and the return of one chick to the lake a year later makes total leucism more plausible. Bullock (1988 in Thiede 2005) reported that near Boddington Reservoir, UK, a chick (PCRcr198702200) was reared in 1987 by the "leucistic light clay-coloured" grebe mentioned earlier. This had an even lighter plumage than the parent, but it was probably affected by the same mutation.

F. Mayenburg observed an albino raised at one of the ponds in Reeuwijk, Netherlands, in the late 1990s (PCRcr199x01020). It was shot in its year of hatching. This was probably a true albino as it was completely white and had red eyes. Dittberner (1996) reported an albinistic grebe (PCRcr199101200) from Angermünde, Germany, in 1991. He gave no description and the record cannot be verified. In Fray et al. (2009), the sighting of a leucistic individual at Eyebrook Reservoir, UK, in September 1995 was mentioned (PCRcr199501200). As no descriptive details were added, the record was classified as whiteling. In Luxembourg, a leucistic Great Crested Grebe (PCRcr199601200) was recorded in 1996 (Heidt et al. 2003). Investigation with one of the observers, E. Melchior, revealed that the grebe was not subject to leucism. It looked pale grey and was possibly diluted. Two aberrant individuals were seen at Lac du Der, France, in successive years (PCRcr199801020, PCRcr199901020). Both were said to have been

Fig. 10: Diluted Great Crested Grebe at Lac du Der-Chantecoq, France, in October 2000 (PCR-cr200001303, photo A. Konter).

Fig. 11: Ino Great Crested Grebe from Michelbach, France, summer 2002 (PCRcr200201022, photo S. Houpert).

albinos, but neither was described. The species of the individual seen in 1999 might even be wrong as the published text was not entirely clear in this respect. At Rutland Water, UK, a leucistic Great Crested Grebe was observed on 22 December 1999 (PCRcr199902200). No other details were mentioned in Fray et al. (2009).

Excluding my own observations of individuals with minor aberrations, 16 abnormal Great Crested Grebes were reported from 2000 to 2005. For the first record, no precise year of observation was given. A leucistic grebe present for over two years in the Dutch province Limburg was rather white, but not an albino: its eyes were not affected (PCRcr200x01012). The internet photo showed that the plumage was very light. Parts normally coloured in dark grey brown were still detectable and looked very pale grey. In the ruff, a very light chestnut hue was present. The beak was pink. The eyes appeared unaffected. With phaeomelanin (in the ruff) and eumelanin similarly affected, pastel dilution must have caused the appearance. An overall light to middle grey Great Crested Grebe in winter plumage was detected by myself at Lac du Der, Champagne, France, in October 2000 (PCRcr200001303). It had remains of chestnut in its ruff. Its beak was dark pink, its eyes appeared normal (Fig. 10). It was diluted, possibly pastel, although the paleness in the ruff could have been caused entirely by the moult into winter plumage. In the same year, R. Hackert failed to describe an albino from Lake IJssel, Netherlands (PCRcr200002020). A pair on Sailing Lake, Little Paxton, UK, raised two broods in 2000. One chick from the first brood was leucistic (PCRcr200005200, Elloway 2000). No further description was provided, making an assessment impossible.

Near Michelbach, Alsace, France, S. Houpert photographed an albino Great Crested Grebe that was present in July and August 2002 (PCRcr200201022). The completely white bird had a pale flesh pink beak, legs and eye rings (Fig. 11). The iris was not affected to the extent seen in albinism. It was however serous red. The fully developed white crest and ruff pointed to a grebe in at least its second calendar year. The reduced pigmentation of the eyes excluded complete leucism. H. van Grouw (pers. comm.) indicated ino as causal mutation. At the Flevopolders of Lake IJssel, Netherlands, a group of birders spotted an albino in January 2002 (PCRcr200202020), but provided no description. At Bourget Lake, France, A. Faure photographed a diluted individual towards the end of December 2002 (PCRcr200205032). Crest and hind neck of the individual were still rather dark. The back was paler than usual. The grebe had a normally coloured bill and eyes. The flanks were nearly white. F. Malher, who informed me about the sighting, had correctly identified dilution as the causal mutation. During winter 2003/04, a "whiteling" (Thiede 2005) was present at Lake Laach, Germany (PCRcr200301200). Thiede's classification of the observation left the door wide open for all sorts of speculation concerning the causal mutation. Bosselmann's (2005) note on the same individual was clearer: on 28 July 2003, K. H. Euskirchen observed a pair of Great Crested Grebes with four pulli, one of which was completely white. In the autumn, the white youngster disappeared. It was possibly seen again by R. Scheid 10 km further east on the Rhine on 30 November 2003. Bosselmann believed that the white grebe showed up again on Lake Laach in February 2004 and thereafter moved to Lake Kann near Neuwied (distance: 18 km). Given that the bird's eyes were regularly pigmented, it was correctly classified as leucistic. In August 2003, P. Brockman had detected two entirely leucistic Great Crested Grebes, also at Lake Laach. Both were very active and appeared to have normally coloured eyes. Their age was not indicated. One may have been PCRcr200301200, reported by Thiede and Bosselmann. The second (PCRcr200305030) was probably not directly related to the first. As a detailed description was not provided, the causal mutation could not be verified.

A true albino (PCRcr200401012) hatched from normal parents at Lake Svalöv, Sweden, in 2004. It had three normally coloured siblings. Found dead in September, it was investigated by P. Ljungberg who confirmed the presence of all necessary criteria for complete albinism (Söderquist 2004). Forsten (2004) reported two albino chicks (PCRcr200402101, PCRcr200403101) in a brood of four from Raahe, Finland. The photo of one of them as a fully grown, but still dependent juvenile showed a completely white plumage, a fleshy pink beak and light eyes. Both chicks may have been true albinos. C. Schenk photographed

an albino grebe (PCRcr200404021), possibly in March 2004, at an unreported place in Europe. His picture showed a bright white bird that had pale yellowish buff ends to its otherwise white crest and a similar, hardly noticeable tinge in its ruff. Its beak was light pink, the feet flesh pink. The eye could not be checked. It was affected, albeit less than in an albino grebe. Based on bill size, it was a male and this made ino and brown unlikely as causal mutations. Survival over the winter and eye colour excluded albinism. A very strong form of dilution affecting both melanins did not seem right as the hue in the phaeomelanin-based ruff was yellowish and not chestnut. In addition, the same hue was present in the eumelanin-based crest. In spite of the yellowish tints in parts of the ornamental plumage, total leucism was most likely. The yellowish hue might have been due to an unusual deployment of carotenoids. From Hittarp, Sweden, O. Lindberg reported an albino adult present in March 2005 (PCRcr200501022). His photo, from some distance, showed a white adult with a pale pinkish bill. As the pigmentation of the eyes could not be assessed, the main element militating against albinism was the grebe's survival over the winter. Total leucism was therefore more conceivable. K. Svensson saw an albino at Kinneviken, Sweden, in May 2005 (PCRcr200502020). No photo or description were available, and the record was not assessed. K.-E. Karlsson reported an albino chick in a brood of four from Lake Svalöv, Sweden, in June 2005 (PCRcr200503020). Its three siblings were normally pigmented. The pullus may have hatched from the same parents as the one reported in 2004 and was therefore probably a true albino.

Between 2006 and 2010, 14 aberrant grebes were recorded. J. L. Patula reported an albino from Champagney, France, in December 2006 (PCRcr200601020). Its plumage was entirely white. Other details were not given, making an assessment of the record impossible. However, the late observation date does not support albinism. C. Van Rijswijk photographed a juvenile Great Crested Grebe near Rotterdam, Netherlands (PCRcr200602012). In comparison to its accompanying sibling of regular colouration, it had a much paler and more brownish grey striping in its head, and this colour was fading on its back (Fig. 12). It is noteworthy that the bill colour of the siblings differed, the paler plumaged bird lacking darker blotches. Brown may have caused its appearance (confirmed by H. van Grouw, pers. comm.). In February 2006, T. Dyckers photographed a pure white bird with completely pink bill and feet (PCRcr200603012). The colour of the iris seemed unaffected, though this cannot be certified. The causal mutation may have been total leucism. Albinism was excluded, also because survival over winter was not plausible. D. Appleton observed an albinistic bird in winter plumage at Swanton Lake, Morley, Norfolk, UK, in October 2007 (PCRcr200701012). The individual, in intermediate plumage with a short crest and ruff, had regular colouring, but it had scattered white dots predominantly on its upper, less so on its lower back. A few similar dots existed in the backward flanks. Based on bill size, it was a female grebe. Partial leucism might have been at the origin of the piebald pattern. However, it seemed that the white parts were triggered by white ends to feathers rather than by entirely white feathers. So progressive greying was at the origin of this pattern. At Lake Neubrück, Germany, F. Huckenbeck found an entirely white grebe, still with a very prominent crest and ruff in October 2007 (Frede et al. 2008, PCRcr200702131). The entirely white adult had a lighter pink beak than usual and rather bright yellow orange feet. The skin of the outer eye ring and the bare lore line were pink too. Its eyes were difficult to assess, but the iris seemed unaffected and looked chestnut brown. As it was an adult grebe, it must have survived through at least one preceding winter. The individual was probably totally leucistic. An anonymous observer posted a record of a young leucistic Great Crested Grebe in the internet that he had seen at Lake Gentofte, Denmark, in July 2007 (PCRcr200704020). No description or photo were published. A nearly complete albino was reported by J. Hop from Stellendam, Netherlands, in October 2008 (PCRcr200801012). The individual was overall pale greyish brown to greyish beige or tan. At the ruff, it had light orange chestnut stripes, suggesting that it was a juvenile. The beak was pale pinkish, the eyes looked quite normal. The legs underwater were yellowish. As bare parts were affected, except for the eyes, brown could explain this appearance. A grebe photographed at or near the same place on the same day by A. van Berge was considered to have been the same individual. D. Appleton again detected an abnormal bird at Swanton Lake, Morley, Norfolk, UK, present there from February to July 2008 (PCRcr200802012). He

Fig. 12: Immature brown Great Crested Grebe in the company of a regular sibling near Rotterdam, Netherlands, in 2006 (PCRcr200602012, photo Chris van Rijswijk).

believed that this grebe was identical to the one seen in October 2007. Bill sizes on the pictures differed, however, suggesting that the birds were of opposite sexes, the more recent sighting concerning a male. This grebe was in breeding plumage. It had far fewer white dots on its back and did not look piebald. Although no signs of old age were detectable in the head pattern, the white dots in the mantle looked like they stemmed from white ends to a few feathers on the back. This suggested an early stage of progressive greying. On Lake Ijssel, near Enkhuizen, Netherlands, N. Paklina and C. van Orden recorded a leucistic male Great Crested Grebe in full breeding plumage (PCRcr200803032). The individual had white blotches on its otherwise very blackish mantle, but there was no piebald pattern. They were quite equally dispersed on both sides of the back. The normally white face had a strong rufous tinge. Beak and eyes were regularly pigmented (Fig. 13). Progressive greying could explain the white areas on the back. N. D. van Swelm reported an aberrant grebe, again from Stellendam, Netherlands, in October 2009 (PCRcr200901012). The upper parts of the bird, that was in almost full winter plumage, were not pure white, but light brown to cream-coloured. The beak and the eyes looked normally pigmented. It may have been the same bird affected by brown that was already observed there as a juvenile in 2008. In this case winter site fidelity was involved. However, this is speculative and the two records were kept separate. An interesting Great Crested Grebe was observed by H. Klein at Krickenbeck Lakes, Germany, in October 2009 (PCRcr200902022). The photo, taken from some distance, showed a pale grey rather than white bird. Dilution explained the light colour of the plumage. T. Edelsten reported an albino from between Jukbyeonhang and Onyang-ri, Uljin, South Korea, in January 2009 (PCRcr200903020). Several requests to Birds of Korea failed to produce confirmation of the species and a description. Adriaensen et al. (2010) published J. Lambert's observation of a pale grebe from Barrage de l'Eau de l'Heure, Belgium, in November 2010 (PCRcr201001101). The almost completely white individual had retained a medium grey crest, and a hue of grey was present on its back. The beak colour appeared pale, but this could have resulted from the light conditions of the picture. Rather

than leucism, a form of dilution, followed by sun bleaching, caused the paleness. On 9 October 2010, S. Morsch took a picture of an entirely white plumaged Great Crested Grebe (PCRcr201002022) on the Schlei/Baltic Sea in Germany. The grebe had a short crest and no visible ruff. Its bill and its legs were flesh pink. Its eyes were normally coloured. The individual was entirely leucistic.

Since 2011, another 24 abnormal grebes have been added to the register. From Lake Gaishorn, Austria, Heinz reported an albinistic individual in March 2011 (PCRcr201101022). On the photo, the grebe's crest and ruff were slightly paler than usual, but especially the hind neck and the back were of a lighter grey. The flanks were nearly white. Isabel dilution could best explain this appearance, as the phaeomelanin-based ruff looked unchanged. At Wermsdorf, Germany, Michael observed a leucistic juvenile still being fed by its parents in July 2011 (PCRcr201102022). It was the only descendant in the company of the pair. The striping in the head and neck of the not yet fully grown youngster was very pale grey, nearly white, and its back was very light greyish too. Again, dilution caused these conditions. A. Sanchez and M. Velazquez Herranz detected an aberrant Great Crested Grebe near Merida, Spain, in August 2011 (PCRcr201103022). The individual, in breeding plumage, was not white, but rather pale brownish tan to light rusty brown overall. Its ruff appeared comparatively pale, nearly white in the phaeomelanin-based parts. The eyes looked at least slightly affected, though the precise degree could not be assessed. Ino was a plausible cause for the appearance. In September 2011, P. Erlemann noticed a light brown juvenile Great Crested Grebe at a gravel pit near Niederwald, Germany (PCRcr201104020). The colours of the eyes or bare parts were not indicated. The grebe may have been affected by brown, although ino cannot be completely excluded. For a leucistic grebe observed at Lake Vaya, Bulgaria (PCRcr201105020), no description or photo was provided. The observation could not be verified. From Steinhuder Meer, Germany, a flavistic Great Crested Grebe was reported separately by W. Karin and L. Pannek (PCRcr201106010). It was present there from November 2011 to perhaps March 2012. Its body was entirely light cinnamon, with darker tones only in those parts

Fig. 13: Great Crested Grebe at Enkhuizen, Netherlands, in 2008, looking partially leucistic, but most probably affected by progressive greying (PCRcr200803032, photo Natalia Paklina).

Fig. 14: Melanistic Great Crested Grebe at Lake Wolferitz, Germany, in 2012 (PCRcr201201131, photo M. Zutt).

of the head that are generally black. "Entirely" may have included the underparts and the front neck. Phaeomelanism best explained the grebe's appearance. F. Malher informed me about the presence of an aberrant Great Crested Grebe at Lake Val Joly, Willies, France, on 22 February 2011 (PCRcr201107032). The individual had a rather brownish crest and was pale brownish grey on the back. Its ruff and its flanks looked very light with hardly a hue of pale chestnut pigmentation. It had dark eyes and a pink to flesh red coloured bill. The entire hind neck seemed completely devoid of colouration. The more brownish pigmentation and the regular eyes suggested brown as causal mutation.

In June 2012, M. Zutt detected a eumelanistic individual at Lake Wolferitz, Germany (PCRcr201201131). Its crest and its ruff were entirely black, its face was dark blackish-brown and its fore neck and upper breast dusty dark grey with a tinge of chestnut brown. From a distance, the grebe looked entirely blackish (Fig. 14). It had bred successfully with a conspecific in normal breeding plumage, and regular chicks had resulted (Konter 2012a). A perhaps albino Great Crested Grebe was reported by P. Lauri from Nurmijärvi, Finland, in July 2012 (PCRcr201202020). Apart from being white backed, its appearance was not described. It may have been only partially white. All mutations leading to pale or virtually white plumage after bleaching were a priori conceivable. The individual was classified as whiteling. At Peterborough, UK, a pullus affected by leucism or some form of schizochroism was recorded by B.W. in summer 2012 (PCRcr201203012). As a chick and as a juvenile, it was much paler than its two siblings. Especially on the back, it was pale brownish grey. Its striping was darkest on the head, where the grey tones were only slightly paler than usual. Dilution best explained this appearance. On the island of Corsica, France, T. Rossi found an "isabelline" grebe in November 2012 (PCRcr201204012). The normal subdivision of the winter plumage was well detectable, but normally dark parts were rather light brown beige, except for the crest that was darker than the rest of the plumage. The bill was of a pale pink. The eyes were difficult to assess because the photographer was too far away from the bird. They seemed unaffected. The most plausible mutation was brown. At an unknown

place in Italy, P. Faifer observed a leucistic grebe in November 2012 (PCRcr201205022). The bird, still partially in breeding plumage, was pale brownish overall. Its ruff was more orange chestnut, and this implied that phaeomelanin production may have been normal. The bill looked paler than usual. The eyes were not visibly affected by an aberration. The individual had a pale pinkish sheen in its flanks. The causal mutation may have been brown. H. Taavetti reported an albino from northwest Finland, possibly observed there in May 2012 (PCRcr201206022). The grebe was virtually white, except for a hardly detectable light grey hue. Its beak was light pink. The well-developed ruff was nearly white. The eyes seemed normally pigmented. Pastel dilution was a plausible explanation for the conditions observed. In March 2012, A. Smith saw a leucistic grebe near Barnsley, UK, without describing it (PCRcr201207020). The record could not be assessed. In Finland, an albino grebe "with coloured neck and head" was reported in June 2012 (PCRcr201208010). It was shunned by its conspecifics. The lack of detail rendered an assessment difficult. If we interpret "coloured" as "fairly normally coloured", we could conclude that dilution caused the grebe's appearance. D. Cimiotti provided a photo of a juvenile Great Crested Grebe taken at Rademacher Lache, Amöneburg, Germany, on 28 August 2012 (PCRcr201209032). The grebe, in regular juvenile plumage, had retained a strong facial striping. It was normally coloured, except for a bright rusty orange red colouration covering its entire fore neck and upper breast. Its facial striping was in darker rusty orange, and even its hind neck line was bordered in rusty orange. Chestnut melanism was probable.

J. Anderson saw a leucistic Great Crested Grebe at the sea in Kent, UK, in early January 2013 (PCRcr201301020). According to Brian, it was almost completely white, but had some light brown plumage in it. It may have been a bleached brown individual. J. J. Vlug and H. Niesen informed me of an aberrant grebe sighted at Lake IJssel, Netherlands, by P. van der Wielen in March 2013 (PCRcr201302032). The bird, in breeding plumage, showed extensive white mottling in all parts of its plumage. In the crest, some white feathers were interspersed. The ruff was streaked with white. Big white blotches were present on the back and, to a lesser extent, in the flanks, giving these parts

Fig. 15: Great Crested Grebe at Lake IJssel, Netherlands, in 2013, possibly affected by progressive greying (PCRcr201302032, photo P. van der Wielen).

a piebald look. The grebe had a normal pink beak and normally coloured eyes (Fig. 15). Progressive greying best explained its appearance. M. Griffiths observed an interesting Great Crested Grebe within a group of non-breeders at Engine Pool, West Midlands, UK (PCRcr201303022). From 8 July 2013 on, the individual was present for at least three days. The grebe's plumage was paler overall, displaying varying brownish shades. It showed no pure white patches. The paleness did not mask the overall breeding plumage pattern. Really dark tones were mostly absent, and this led to lighter feathers also in the crest, the crown and the nape. The bill was slightly paler than usual. The legs too seemed pale, though the observer remained uncertain in this respect: he was only able to get a one-off brief glimpse of the bird's legs. The eye colour was difficult to judge. The photo provided confirmed the observer's description. Brown best explained the grebe's appearance. At Speicher Schiedungen/ Hohenstein, Germany, J. Scheuer detected an albino pullus (PCRcr201304021) on 7 September 2013. It was in the company of its regular parents and of two regular siblings. Its pinkish legs and bill and the pale red eyes proved albinism. An aberrant individual was reported from a lake south of the river Lahn in Hesse, Germany (PCRcr201305021). The photo by D. Jürgens showed a grebe in breeding plumage with regular pigmentation of its crest, ruff and other head and neck plumage. Its body looked as if it belonged to a different species. Its back was very pale, largely white with few grey blotches. The flanks were even lighter, virtually white. A form of dilution and sun bleaching appeared plausible. From an unknown place in Finland, Captain Morgan reported an overall pale brownish adult in summer 2013 (PCRcr201306022). The photo showed the grebe engaged in head shaking with a regular conspecific. Its crest and its hind neck were pale brown beige. Its ruff was nearly white and showed just a light hue of rusty colouration. The eye colour was not well visible on the photo; it may have been affected. The beak was pink. The mantle was very pale brownish cream. As the quality of both melanins was reduced, the causal mutation was ino. In July 2013, F. Rust reported an aberrant individual from the Vorster Busch Nature Reserve, Mönchengladbach, Germany, that was present there for four weeks in summer (PCRcr201307022). The same grebe may have been previously present at the nearby Lakes of Krickenbeck. It was overall very light coloured and its plumage was pale grey in those parts that are normally dark grey to blackish. Its ruff too was very pale: it was hardly visible. The bill was pink. With both forms of melanin affected, the individual was plausibly subject to pastel dilution. P. Lorgé drew my attention to a record published on the internet. At the nature reserve of Virelles, Belgium, G. Raison observed an abnormal Great Crested Grebe on 11 November 2013 (PCRcr201308022). The grebe, in non-breeding plumage, was very pale on the photo, but not white. Tinges of beige brown were clearly visible in the crest and in the mantle. They were somewhat paler in the neck. The individual had a rather light pink bill and the feet looked flesh coloured or pinkish. The eye colour looked paler than usual, perhaps pinkish, on the photo. The degree to which bare parts were affected suggested ino as causal mutation.

My own observations of minor abnormalities include ten individuals of the nominate form displaying obvious deviations from ordinary plumages. Three or four of them were cases of progressive greying. The first individual was observed at the Haff Réimech Nature Reserve, Luxembourg, towards the end of April 2002 (PCRcr200204305). An individual in breeding plumage looked as if its moult was incomplete. This impression resulted from the presence of white feathers in its grizzled ruff. In addition, its nape showed much white, and only a thin line of dark feathers subsisted in its centre. The appearance of the grebe had not changed one month later, and its appearance was attributed to progressive greying. Three further observations were obtained during my studies of colonial breeding in Great Crested Grebes undertaken at the marina of Enkhuizen, Lake IJssel, Netherlands, between 2000 and 2008. The first two cases resembled the preceding record from Luxembourg. In March and April 2002, a grebe in breeding plumage, with white mottling in its ruff and a pale nape that only had a thin darker central stripe, was present for several weeks (PCRcr200203303). In March and April 2003, a largely similar individual was observed (PCRcr200302303). Its ruff had more white feathers at the onset and its nape was mostly white. For both grebes, progressive greying caused the unusual white areas. In the third example from Enkhuizen, the cause was less obvious. The individual, present in March and April 2003, looked a bit different (PCRcr200303303, see cover photo 1). In spite of its mostly pale nape and its rather short ruff and crest, it seemed to have completed its

Fig. 16: Adult Great Crested Grebe in breeding plumage with rusty chestnut upper fore neck, Enkhuizen, Netherlands, 2005 (PCRcr200509303, photo A. Konter).

Fig. 17: Australian Crested Grebe with bright rusty orange upper breast and fore neck, Lake Pearson, New Zealand, 2006 (PCRau200601303, photo A. Konter).

moult: neither crest nor ruff had grown longer after four weeks. The grebe displayed predominantly whitish feathers over the entire area of the ruff, and chestnut or blackish feathers seemed to shine through only scantily. Overall, the ruff looked very pale. It is unlikely that a genetic mutation caused this aberration. Progressive greying would not have inhibited feather growth, so that hormonal disorder appeared most plausible. All three grebes from Enkhuizen were seen displaying with partners in full breeding plumage, but none was later observed incubating in the colony. Two of the grebes were chased by conspecifics in regular breeding plumages that thereafter took their place in the pair bond.

The other six records concerned individuals displaying high degrees of mainly rufous hues or blotches in their face, fore neck, upper breast and/or sometimes belly. In some other grebes not included here, the hues were less striking and less visible. Five examples were of birds in breeding plumage from Enkhuizen. In May 2000, an incubating grebe had rusty chestnut hues in its entire front neck, upper and lower breast, but not on its belly, which was white (PCRcr200004303). The chestnut colour was strongly present in the forward flanks and faded more backward. In April and early May 2005, a similar looking grebe was again incubating in the colony (PCRcr200505303). In the same year, another individual had a completely bright chestnut upper neck (PCRcr200509303, Fig. 16). The colour faded gradually towards the upper breast. The grebe's face showed much light rufous too, and the white area was reduced. In April 2006, a female (based on bill size) had a strong overall presence of rufous feathers in its fore neck and upper breast. The colouration extended into the lower breast and into the flanks (PCRcr200605303). A male grebe observed performing the Discovery ceremony had much chestnut in its fore neck and upper breast. The hues ended sharply at the lower breast (PCRcr200705303). In none of the individuals did any form of staining seem to be involved. Chestnut melanism was held to be the cause. The preceding records were all of adult grebes. The sixth record concerned a juvenile Great Crested Grebe observed at Haapsalu, Estonia (PCRcr200507303). The young bird was fully grown and continued to be fed by one parent. The facial striping typical of chicks was still present. The central part of the fore neck was covered by an intense chestnut blotch that faded towards the upper breast.

Similar minor aberrations also occur in both subspecies, *australis* and *infuscatus*. A striking example was provided by an Australian Crested Grebe in breeding plumage detected in early January 2006. It had bright rusty orange feathers in its lower neck and upper breast, possibly even in its lower breast (PCRau200601303, Fig. 17). It was caring for two small pulli at Lake Pearson, New Zealand. Neither its breeding partner nor the chicks had any comparable pigmentation in their breast or neck.

Again it was not possible to check whether all aberrant Great Crested Grebes mentioned in the publication of Thiede (2005) have been included here, as the author provided no details. In addition to the grebes already reported by King (1973, 1975), Thiede (2005) presented 31 whitish and 5 schizochroistic Great Crested Grebes. Excluding King's and my own records, this register provides more than 36 observations falling within the years investigated by Thiede. Theoretically, all of Thiede's records might have been retrieved, but this is not very likely.

3.11. Horned or Slavonian Grebe *Podiceps auritus*

The register contains only three abnormal individuals of the nominate form *auritus* or Slavonian Grebe, against 20 of the subspecies *cornutus* or Horned Grebe.

Two records of Slavonian Grebes were over 100 years old. A snow white individual was reported by Booth (1876) from Loch Slyn, UK, in 1869 (PAUau186901200). The mutation was not qualified. The timing of the observation, in April, suggested that the bird was at least in its second calendar year. It was in the company of a normally coloured partner. The survival over winter proved that the grebe was not albinistic, but perhaps totally leucistic. Other mutations leading to white feathers after sun bleaching were plausible too. The second Slavonian Grebe (PAUau190x01200) was obtained as a skin from a collector. Place and date of collection are unknown. The record was published in a list of albinistic birds with the

remark that only the dorsal part of the plumage was of a dull white (Petit 1909). This excluded albinism as causal mutation. As no other change in colour was mentioned, brown and ino appeared unlikely. The lustreless white pointed to a form of dilution, with head and neck plumage hardly affected, as most plausible cause. With additional details, it may have been possible to definitively exclude partial leucism and progressive greying. In August of 1949, a true albino juvenile was collected in Karkku, Finland, and donated by K. Tuori to the Museum of Natural History, Luomus (PAUau194901032). The mounted skin showed a completely white plumage with yellowish bare parts (feet, bill and loral line). The glass eyes imitated the albinistic condition and showed a serous red colouration. A fourth record published by King (1985), who gave a very detailed description and classified it as an aberrant Slavonian Grebe, is discussed in section 3.23. The individual was presumably a hybrid.

Unlike the Slavonian Grebes, the vast majority of Horned Grebe records were of more recent date. Only three observations were older. A grebe shot at Quannicassee Marshes, Michigan, USA, probably in 1883 (PAUco188301200), was described as perfect albino (Eddy 1885). The author of the note may only have seen the stuffed bird and was not able to judge the colour of the iris. Anyway, the late date of collection of the skin leads to great doubts as to the correct identification of the underlying mutation. A grebe collected at Barr Lake, Colorado, USA, in 1931 was classified as partial albino Horned Grebe by Weller (1959) and King (1973). The species identification was wrong, and the Denver Museum, where the skin was mounted, identified it as an Eared Grebe. This assessment was confirmed by J. Fjeldså (pers. comm.). The individual is now in the register Eared Grebe PNIca193101112. King (1973) reported another partial albino Horned Grebe (PAUco196501100) from Long Island, New York, USA, that showed up there in two consecutive years, in 1965 and in 1966, each time in February. The individual was described as pure white, streaked on the back and with buff on the sides. The timing of the observation implied that the grebe was in winter plumage. The report itself was silent in this respect. In combination with sun bleaching, the mutation brown could have led to the streaks on the back. Before becoming dull white overall, dusky shades may have left an impression. Ino remained possible too, but there was no mention of bare parts or the eyes being affected. The impact of brown on these is less visible.

Three aberrant Horned Grebes were observed in the 1990s. An individual (PAUco199201200) from Nickamixon State Park, Pennsylvania, USA, observed on 22 February 1992, had a totally white head and neck. It may have been correctly identified as partially leucistic (French 1992), but progressive greying cannot be excluded. A grebe (PAUco199501200) from Mountain View, California, USA, was labelled schizochroistic, but was not further described (Yee et al. 1995). The record cannot be verified and is simply renamed 'diluted' here. A partial albino (PAUco199801200), again not described, was reported from Santa Clara, California, USA (Roberson et al. 1998). Between March and June 1998, the grebe was seen by several observers, and all qualified it as either partial albino or leucistic or partially leucistic. Though albinism could be ruled out as a cause, partial leucism, brown, dilution and ino all remained possible explanations.

The next seven records in the register stemmed from the first decade of the 21st century. A sighting of an albino Horned Grebe (PAUco200201020) from the state of Washington, USA, could not be verified. No details were given and I did not succeed in contacting the observer. A partially leucistic individual (PAUco200401010) was observed close to Turpin Unit of Farmington Bay at Great Salt Lake, Utah, USA, in August 2006 by K. Purdy and J. McIntyre. K. Purdy provided a complete description of the grebe. Its plumage was mostly white with small black blotchy marks on the back and on the sides. The grebe's neck was of a pale, washed-out orange. Its horns were the palest yellow, and the only really dark parts of the "helmet" were on the lower ends on either side of the bird's neck. Its eyes were laser-beam red, as was the bare line running down from the eye below the lores to the beak. The beak itself and the feet were both generally dark grey to black. In late August, this grebe may already have been moulting and the breeding plumage was certainly showing wear. This complicated the assessment of the underlying mutation. The description suggested that bare parts and the eyes were not affected, but that the presence of both melanins was reduced. Bleaching had then led to partially

Fig. 18: Horned Grebes in winter plumage at Lake Hefner, Oklahoma, USA, in 2007: a normal (left) and a brown individual (right) (PAUco200701011, photo Patricia Velte).

whitish feathers. Due to the washed out orange neck and the normal conditions of bare parts, a form of dilution rather than ino was a possible explanation. A Horned Grebe from Etobicoke, Ontario, Canada, was extremely light coloured (PAUco200601012). Jamuudsen's photo on the internet showed a bird in faded breeding plumage with almost completely white flanks and upper breast. The fore neck was mottled in white and pale chestnut, and white blotches were present in the cheeks and chin region too. The horns were light yellowish, the surrounding (normally blackish) feathers of the head middle grey. The mantle was light grey and looked a bit like floured: no really dark parts were detectable. The red eye and the dark bill with the light tip looked normal for the species. The grebe's pale appearance was more a consequence of the mottling with white feathers than of a form of pastel dilution. Progressive greying best explained the conditions. In October 2006, a grebe seen at Mono Lake, California, USA, was initially thought to be a Horned Grebe, but later identified as an Eared Grebe by Jehl (2007) (see PNIca200603111).

Three aberrant Horned Grebes were recorded in 2007. The first (PAUco200701011) was reported by P. Velte from Oklahoma, USA. It was in non-breeding plumage and looked like a pale brownish grey or beige grey version of a regular bird. Parts of its bill were pink. The grebe thereby differed from the conspecific in its company. The eyes were dark red. The feet were partially pinkish (Fig. 18). H. van Grouw (pers. comm.) suggested that brown was the most plausible cause. The second individual (PAUco200702121), recorded in Ontario, Canada, was in the company of a regularly coloured mate (Cherriere 2007). It resembled PAUco200601012. Its bill was slightly paler than usual. Overall it looked like a pale version of a normal conspecific in breeding plumage. Only the bare line leading from the bill to the eye and the eye itself seemed to be pigmented like the accompanying ordinarily coloured individual. The fore neck and the flanks displayed only a light tinge of rufous. The back appeared darkest grey. The white horns dominated the appearance of the head. The grebe was most probably affected by a form of pastel dilution. The last bird (PAUco200703022) from 2007 was observed at Colfax in New Mexico,

USA. It was a light grey version of a Horned Grebe in non-breeding plumage. The internet photo was of poor quality, so that other details remained hidden. A form of dilution appeared likely.

On 10 February 2008, M. St. Saveur noticed a strange looking Horned Grebe (PAUco200801022) at Salter's Grove in the Gaspee section of Warwick, Rhode Island, USA. The internet photos showed an overall pale brownish to buff grebe in winter plumage. The beak was slightly pale, partially flesh coloured. The iris was of a pale pink and lighter than usual. This indicated that the colour of the iris in this species is not entirely non-melanin-based. The upper head and the back had a buff brown tinge which seemed to be present in diluted form in the flanks. The lower face and the front neck were cream coloured beige and not white as would normally be the case in a winter bird. This may have been due to the start of the moult into breeding plumage. As the eyes were visibly affected, ino rather than brown was responsible for the individual's appearance.

The last eight records in the register were added from 2010 on. A Horned Grebe (PAUco201001020) observed by B. and S. Steele at Grant Lake, California, USA, in October 2010 looked very sun bleached. Without additional details, it was not possible to really assess the cause. If the plumage was overall simply paler, a form of pastel dilution may have been responsible. An individual (PAUco201101303) discovered by myself on Lake Ewauna, Oregon, USA, in May 2011 appeared to be in breeding plumage although the horns were not well developed. It was covered with white blotches all over, especially on the flanks, the upper breast, the lower neck and the lower face. In this respect, it resembled a partially leucistic grebe (Fig. 19). Jon Fjeldså (pers. comm.) suggested a case of arrested or irregular moult, which could have been caused by a physiological irregularity or disease. The plumage was as usually seen from August on, when the summer plumage has been subject to wear and the grebes start their moult into winter plumage. A Horned Grebe (PAUco201102022) reported by S. Hampton from Davis, California, USA, in October 2011 had an interesting head pattern. At first glance, his photo simply showed a bird in moult at this late date. A second look and a comparison with the conspecific in non-breeding plumage in its vicinity revealed differences in the head patterns. The mostly whitish area of the face reached far up into the very upper crown. It also seemed to restrict the dark nape to an unusually thin dark line. The white facial area had some pale grey smudges. A kind of sickle-shaped dark field extended vertically from the rear of the ear to the throat. It was separated from the hind and side of the neck by a white area. The patterns were identical in both sides of the head. The mantle of the individual looked dark and showed no white feathers. The bill was normally coloured. The eyes were difficult to assess; a priori, they were not affected. The reason for the aberrant look of this grebe may have been partial leucism. In April 2012, K. Payne and T. Bronson observed a partially leucistic Horned Grebe (PAUco201201010) at Prickett's Fort State Park, West Virginia, USA. Apart from the darker back, the rest of the bird's plumage was whitish, including its head and neck, where no dark parts were detectable. The individual is included in the register as either partially leucistic (other mutations were not plausible) or subject to progressive greying. Without additional details, it was not possible to opt for one of the two possible explanations. An abnormal Horned Grebe (PAUco201202010) was recorded by C. Sloane, S. Sommershoe and S. Zipperer near Paris, Tennessee, USA, in November 2012. The grebe's plumage was very washed out and looked pale grey in the normally dark parts of the plumage. It is likely that this individual was subject to dilution rather than leucism. On 13 July 2012, G. W. Beyersbergen photographed a Horned Grebe (PAUco201203022) carrying one chick on its back at a pond in the south-west of Edmonton, Alberta, Canada. He mentioned no aberration for the individual. His photo showed a grebe in slightly worn breeding plumage with red-brown pigmentation in the parts which are usually blackish. As a consequence, the chestnut red neck did not deviate that much from the brown colour of the nape and the head. Phaeomelanin dominated the entire plumage. The pigmentation of the eyes and of the bill was unaffected. The causal mutation was phaeomelanism. It is likely that the plumage of the belly, hidden in the photo, was affected too. On 15 April 2013, R. B. Young recorded a Horned Grebe (PAUco201301022) at Farmington Bay, Utah, USA, that he thought to be still in moult. J. McIntyre suggested that it could be partially leucistic. The grebe displayed complete ornamental features in the head part, with fully grown pale golden horns

Fig. 19: Horned Grebe with unexpected moult pattern for the time of the year, Lake Ewauna, Oregon, USA, May 2011 (PAUco201101303, photo A. Konter).

and a black helmet. The grebe's upper breast and lower fore neck were almost completely white. Chestnut feathers only covered the upper fore neck. The flanks were mostly white mottled with isolated darker blotches. White feathers were also scattered over the back. A photo of possibly the same bird taken the preceding January showed a comparable pattern on the back and in the flanks. It seemed plausible that this individual was affected by progressive greying. A grebe seen east of Las Vegas, USA, on 8 April 2013 was initially wrongly identified as a Horned Grebe; it was an Eared Grebe (PNIca201306022). L. Wilson Neish observed a possibly leucistic Horned Grebe (PAUco201303022) at Penticton Marina of Okanagan Lake, British Columbia, Canada, on 14 October 2013. The photo showed an adult grebe that might not yet have completed its moult into winter plumage. All head feathers were very short. The bill was mostly flesh coloured pink and had a dark culmen. The eyes were red. The dark blackish brown back and hind neck and the mostly white flanks with a bit of grey and rufous mottling displayed regular conditions. The upper breast and the fore neck were about completely white, corresponding to the regular non-breeding plumage. A small pale rufous area subsisted to the side of the lower neck. The facial plumage was almost completely white. The white area reached well into the nape and seemed to interrupt the dark hind neck stripe. The white feathers continued above the eyes and reduced the area of the usually darker upper head plumage. A greyish dot was visible at the height of the ear. The blackish plumage of the fore head was interspersed with white feathers. The appearance may have been caused by partial leucism. Progressive greying seemed less likely as the symmetrical white patches were restricted to the upper neck and head: no white feathers were detected in the lower neck or on the back in places where they did not belong.

My own observations in Canada and Scandinavia include a few individuals that in the middle of the breeding season were in complete breeding plumage and displayed fully developed horns and helmet feathers. However, white feathers were present to varying degrees in their upper breast and partially in the lower neck. The examples are not included in the register. Comparable patterns can be observed in other grebe species with

coloured fore necks. The phenomenon is worth mentioning though. One possible reason for the condition could have been young age. In this case, second-calendar-year birds would not necessarily have full breeding plumage. Like younger Eared Grebes, these *auritus* grebes had rather pale yellow horns.

A comparison of the compilation of aberrant Horned Grebes contained in this register with the report of Thiede (2005) showed that all records by King (1973) were reflected in both studies. The three whitish Slavonian/Horned Grebes added from Thiede's own register might not be included here unless they were all of the subspecies *cornutus*. As Thiede did not publish any details, his additional records were impossible to retrieve or verify.

3.12. Red-necked Grebe *Podiceps grisegena*

The register contains a total of 22 aberrant Red-necked Grebes of the subspecies *grisegena* and ten of the subspecies *holboellii*.

Five records of the nominate form were from the 19th century. The oldest (PGRgr184801032) was shot at Yarmouth, Norfolk, UK, in January 1848. Photos of the skin received by courtesy of H. van Grouw showed a very pale, but not white, plumage that had cream brown tinges (Fig. 20). The causal mutation was identified by H. van Grouw as brown (pers. comm.). The next Red-necked Grebe was collected in Sussex, UK, in 1879 (PGRgr187901200). It was said to have been white, almost an albino (Gurney 1879). This restriction should exclude albinism as causal mutation. All other mutations which under the effects of sun bleaching can lead to virtually white plumage remained possible. The third grebe (PGRgr188701100), also from the UK, and killed in the eastern counties, was described by Gurney (1887) as an all-white bird with a sandy tinge. It could have been either a brown or a light ino individual. A female (PGRgr188801100) of unknown origins, but possibly collected in Germany in May 1888, was described as having a big unclearly delimited pure white spot on its hind neck (Hennicke 1903). This may have resulted either from a shock or from partial leucism. A final assessment was difficult without having seen the skin. Chernel de Chernelháza (1907) reported a fully albinistic Red-necked Grebe (PGRgr189801100) shot on Lake Velencze, Hungary, in August 1898. A priori, his description fitted with a real albino, except for the conditions of the eyes. The whole plumage was white; the bill, the legs and the feet were orange. The lead-grey colour of the iris appeared not to be sufficiently affected either for albinism or for ino. Possibly, a sun bleached brown individual had been shot.

Another seven abnormal Eurasian Red-necked Grebes were reported in the course of the 20th century. They did not include an incomplete albino mentioned by Weller (1959) with reference to Chernel de Chernelháza (1907). The latter author seemed to have described only a single case of complete albinism in this species, and this was discussed above. The earliest Red-necked Grebe of the century was from near Dzhulek, district of Shieli, Kazakhstan (PGRgr193801030). The female, with an entirely white plumage, was collected by Dementiev on 5 December 1938. I. V. Fadeev, curator of birds, informed me of the presence of the skin in the collection of the Darwin Museum, Moscow. The skin had a yellowish bill and yellowish feet. Although the colour of the iris was not mentioned on the label, the glass eye mimicked the albino condition. The individual may have been affected by albinism. Survival of an albino into December is however challengeable. Assuming that the eyes were affected as suggested, light ino becomes most plausible. An adult grebe (PGRgr194801100) was observed at Lake Neuchâtel, Switzerland, in the winter of 1948/49. It was described by Fragnière as a partial albino with an entirely pure white back. Head, neck, wings and flanks had the ordinary colouration. This was also the case for the bare parts and the eyes. The back did not look entirely white because of the folded wings that drew a coloured V on the mantle (Géroudet 1949). The description fitted with partial leucism. If progressive greying were the cause, we might have expected unusually white markings in other areas of the integument too. Next came a chick from Weißer Lug, Saxony, Germany, hatched second in a brood of four (PGRgr195x01201). The year of observation was not mentioned by Drechsler (1951), but should have been roughly 1950. The chick was said to be an albino with completely white feathers. The photo showed a pullus, with the stripes of the face, fore neck and

upper breast in medium brown grey, whereas those of the crest, hind neck and back were very light rusty chestnut and fading downwards. The feet and the beak were flesh coloured, the iris pale reddish. The appearance thereby corresponded quite plausibly to light ino. The text and the photo provided by Drechsler (1951) were contradictory: at hatching, he spoke of an entirely white pullus. The pigmentation cannot have appeared after hatching. Whatever the mutation, the effects are either present from the beginning or they remain absent. Drechsler's text suggested the presence of a single abnormal grebe. His description and the photo, though, fitted best with two separate birds. There are two solutions to this contradiction: either there was more than one aberrant Red-necked Grebe (several authors have interpreted Drechsler's work in this sense) or the light ino chick turned white with sun bleaching, and this was the appearance reported by Drechsler. A juvenile Red-necked Grebe (PGRgr195501101) reported from Fideris, Switzerland (Sage 1956, Walkmeister 1956), in 1955 was qualified as partial albino with mostly white feathers on its back, wings and flanks. On the black and white photo, its head and hind neck appeared unaffected, whereas the back seemed mostly white, but also presented several darker blotches. The grebe had landed on firm ground, and the author of the note was able to investigate the juvenile from close up. He did not report any abnormalities in bare parts or in the eye colour. As the plumage of the head looked unaffected, one may assume that the white feathers on the back stemmed from sun bleaching. Adding the presence of darker blotches, the most plausible explanation for the grebe's appearance was dilution. The grebe may have been affected by partial leucism or dilution or even progressive greying. A record of an abnormally coloured Red-necked Grebe (PGRgr196601020) from Löderburg, Germany, in 1966 cannot be assessed as no description was provided. Scholl observed a partially albinistic grebe (PGRgr197001100) near Kiel, Germany, in 1970, 1971 and 1974. It bred successfully in at least two years (Thiede 2005). The individual was not further described, except that the head was a bit mottled and looked white. Without additional details, progressive greying or partial leucism may likewise have caused the white feathers in the head of the individual. A partially albinistic chick (PGRgr198401100) hatched at Landin, Brandenburg, Germany, on

Fig. 20: Mounted skin of a brown Red-necked Grebe collected at Yarmouth, UK, in 1848 and now at the Natural History Museum, Tring (PGRgr184801032, photo H. van Grouw, copyright NHM, Tring).

18 June 1984 from regularly coloured parents (Dittberner 1996). It was present there at least until mid-August. While the body of the juvenile bird was completely white, it retained the characteristic head striping for the species and it displayed a chestnut red colouration in its neck. The description suggested that eu- and phaeomelanin production was regular in the head and neck, but that no melanin was delivered to the back. It remained unclear whether the appearance of the pullus changed over time, or whether it already hatched with completely white body feathers. As the neck is not red in pulli of the species, it is

conceivable that the description referred to the fully grown juvenile. Fading of the back plumage over time became plausible, and dilution was a possible explanation. Partial leucism appeared less likely.

From 2000 on, a further 10 aberrant Red-necked Grebes were detected in Europe. A grebe with almost no pigmentation (PGRgr200001030) was reported from Allskog, South Sweden, by P. Axelsson (pers. comm.). It was present there almost every year from 2000 to 2010. The individual displayed no rufous chestnut at all. There were shades in blackish and grey tones in those parts of the plumage that are normally coloured. Other parts were white. The beak had a yellow spot and this suggested normal pigmentation. According to the description, phaeomelanin based colouration of the neck was virtually absent, and eumelanin dominated parts of the plumage were very faded. Pastel dilution affecting both melanins was probably responsible for the mostly light grey plumage. Three of the next four aberrant Red-necked Grebes were recorded in Finland by J. Aalto. The first (PGRgr200101030) was present in Särkisalmi in May 2001. It was labelled "partial albino", corresponding to partially leucistic. No additional details were available. On 12 June 2002, Berger and Hoffmann filmed a young grebe at Zichow, Uckermark, Germany (PGRgr200201022). The chick was almost completely white. It had however a light shadow of some red brown colouring in its upper head and hind neck. There was a pale rufous hue on the breast. The beak was entirely flesh coloured. The eyes were difficult to assess, but they seemed affected. The grebe was more than half-grown and was accompanied by a regular sibling and normal parents. It appeared quite lively. Brown was a plausible causal mutation. PGRgr200301032, again reported by J. Aalto, was seen at Siikalahti in May 2003 and July 2004. The photo showed an individual in breeding plumage with a normal colour subdivision, except that the colours were overall paler than usual. The fore neck was of a light chestnut and the back more pale grey brown. The crest seemed almost unaffected. The bill and the eyes displayed a normal pigmentation. The grebe's slightly faded appearance made a light form of pastel dilution plausible. J. Aalto's third record concerned a partially white individual (PGRgr200401032) seen in Kirkkoranta in 2004. The grebe, in breeding plumage, had a dark crest with a few white feathers. It had a completely white upper breast and lower front neck and an almost completely chestnut upper neck. Its back and flanks were mostly white and mottled with small blotches of a darker colour. The bill was yellow at the base and had a dark culmen. The iris was yellow, indicating that the grebe was in its second calendar year. In spite of its young age, the pattern suggested progressive greying, perhaps a hereditary form, as a cause for the white parts in the plumage. In April 2008, R. Svensson reported a partial albino (PGRgr200801022) from Björkeröd, Sweden. The grebe was in breeding plumage and had a mostly snow white crest: only a few feathers retained a dark pigmentation. The brow above the beak was darker, but it too had white feathers. Two or three tiny white patches appeared on the shoulder. Other parts of the integument, including the bill and the eyes, showed the ordinary breeding colouration. The individual might have been subject to progressive greying. Towards the end of March 2009, a Red-necked Grebe in regular breeding plumage was engaged in platform courtship with an albinistic partner (PGRgr200901022) at Maribosøerne, Denmark. U. B. Nielssen's photo, published on the internet, showed a mostly white individual with an overall pale yellowish bill that had no black parts. The eye colour was pale yellowish. The grebe may have been in its second calendar year. In its plumage, darker patches were only visible at the hind crest and lower back, and there were grey shadows locally on the wings. The grebe was not albinistic. A strong form of pastel dilution may have been responsible for this pale colouration.

In 2010, grebe PGRgr200001030 (discussed earlier) attempted unsuccessfully to breed at Allskog, South Sweden, with another "pigment-free" individual (PGRgr201001030). P. Axelsson (pers. comm.) described this second Red-necked Grebe as almost white when the wings were folded. As both grebes looked quite alike, they may have been siblings hatched from the same parents in different years. In this case, both may have been affected by the same mutation, probably a form of pastel dilution. The next abnormal grebe (PGRgr201101022) was reported from Pfaffensee, Hesse, Germany. It was observed in April 2011 and 2012 by T. Sacher and C. Kleinert. S. Stübing informed me that the same individual was again present in May 2013. Despite several attempts to find a partner in all three years, it was unable to establish a stable pair bond and to

Fig. 21: Brown Red-necked Grebe at Pfaffensee, Germany, in 2012 (PGRgr201101022, photo T. Sacher).

Fig. 22: Successful breeding of a diluted female Red-necked Grebe at Tunkwa Lake, Canada, in 2005 (PGRho200501022, photo K. T. Karlson).

Fig. 23: Possibly melanistic Red-necked Grebe from Wabamun Lake, Alberta, Canada, in 2012 (PGRho201201303, photo A. Konter).

breed. According to the photo (Fig. 21), the grebe resembled PGRgr200301032 discussed above. The bill was regularly coloured in the yellow parts, but looked faded in the usually black parts. The colour of the eyes remained hidden on the photo. In contrast to the Finnish individual of 2003, the crest of this grebe was of a darker brown. The back was of a similar, but lighter, brown. The underlying mutation may have been brown. On 27 April 2012, L. Klinteroth observed a partial albino (PGRgr201202022) near Brunnby, Sweden. His photo showed an individual in regular breeding plumage with an almost completely white crest and bigger white blotches on the mantle. The eyes and the bill were unaffected. The individual resembled PGRgr200801022 seen in the same region in 2008. It differed in having more white blotches on the back and in having blackish feathers mixed into the white parts. The 2012 individual was therefore best classified under progressive greying.

My own observations of minor deviations from regular patterns in European Red-necked Grebes in Schleswig-Holstein, Germany, from late March to mid-April in different years included a few individuals observed in April that were in full breeding plumage, except for their largely white upper breasts and lower fore necks. Their moult may not yet have been completed. They were not included in the register.

Palmer (1962) thought that "more or less albinistic birds" were not rare among populations of North American Red-necked Grebes. However, there were far fewer records of aberrations from the subspecies *holboellii* – in total only ten – than from the nominate form. Three observations concerned the 20th century. All three were made in the years just prior to Palmer's publication, and they may have strongly influenced his view. Weller (1959) reported two juvenile albino Red-necked Grebes (PGRho195401100, PGRho195402100) from Delta Marsh, Manitoba. The siblings were in the company of one adult with ordinary plumage. One bird was collected; its examination proved complete leucism. The plumage lacked any pigmentation. The bill and the feet were yellow. The iris was brown and unaffected. King (1975) was informed by a letter from R. W. Storer that a female Red-necked Grebe (PGRho195901100) had been found dead near Fort Qu'Appelle, Saskatchewan, in May 1959. It was normally plumaged, except

for a scattering of white feathers between the black feathers from the crown to the lower back and a concentration of white feathers at the lower hind neck. The colouration of the bare parts was not mentioned. The underlying cause might not have been a mutation, but rather progressive greying. After this individual, there were no more records of abnormalities in the subspecies until 2005.

In 2005, D. Young and K. T. Karlson photographed a pale Red-necked Grebe (PGRho200501022) in the company of a normally plumaged partner and two normal offspring at Tunkwa Lake, British Columbia. On the photos, both partners appeared to be of comparable size. The shorter bill of the light individual indicated that this was possibly the female. Although the individual under review looked quite pale, light greyish tones were easily detectable in the normally dark blackish brown coloured parts of the plumage, especially in the crest. The bill was of a regular yellow with more black in the upper mandible, the eyes were dark (Fig. 22). Rather than albinism, a form of pastel dilution with an almost complete reduction of phaeomelanin and a strong decline of eumelanin may explain the appearance of this grebe. In 2006, D. Young reported another whitish grebe from the same place which he thought to be a yearling of the 2005 grebe. However, in 2005 a priori only normally coloured offspring were reported. Also, K. T. Karlson's photo of the 2006 individual showed no real differences to the 2005 grebe, except that the grey tones were slightly stronger. This was most probably the result of less sun bleaching in the 2006 season. Therefore, both records probably concerned the same bird. In 2008, a slightly more colourful individual was seen at Tunkwa Lake by D. Young. As the breeding success of the diluted grebe was not monitored from 2006 to 2007, it is difficult to say whether the grebe first seen in 2005 was again present or whether perhaps a descendant had returned to the place. Based on the fact that in 2005 only regular offspring were reported and that grebes tend to mate with the same partner in successive years if they were successful in rearing chicks, there is a fair chance that the mutation of the whitish grebe was recessive and that this pair may have been unable to produce diluted offspring. I conclude that the 2008 bird was again the same as in 2005. Its plumage had simply been less exposed to sunlight so far in that year.

A photo of an incubating Red-necked Grebe (PGRho200701022) published by K. T. Karlson and taken in British Columbia, Canada, on 1 July 2007 showed partially leucistic traits. The bird was in regular breeding plumage, except that it displayed a strong mottling with white feathers on its upper breast and lower fore neck. It is unknown whether the white feathers were present earlier in the season or whether they were of recent appearance. Besides partial leucism, the white areas may have been related to early moult or progressive greying. On 18 November 2008, B. Whitney photographed a possibly juvenile Red-necked Grebe (PGRho200801022) in flight at Port Townsend, Washington, USA. His photo showed a grebe in very dark black winter plumage. Its head, face, neck and back were entirely black. The dark black colour of the face extended far down, but did not include the chin region, which was white. The neck appeared to be entirely black, and not greyish, as can be the case in young individuals. Even the flanks were rather dark, and there was dark mottling on the belly. The lower mandible was mostly yellow while the upper mandible was partially black. The yellow eye ring was prominent, indicating that it was a first calendar year bird. It may have been affected by eumelanism.

For the next two records, no precise date of observation was indicated. The year may have been 2010 or thereabouts. C. Evans photographed a leucistic individual (PGRho201x02010) at Kempenfelt Bay, Ontario, Canada. The Red-necked Grebe, in winter plumage, was rather pale greyish in its crest, hind neck and back. It was plausibly diluted. For brown or ino, the tinges were too greyish. A totally snow white Red-necked Grebe (PGRho201x01022) with normal eyes was photographed by J. Meche at the sea near Bellingham, British Columbia, Canada. Unfortunately, the photo was no longer available and the record could not be verified. The observer's label of partial albino was changed to completely leucistic. In July 2012, I saw a possibly partially melanistic Red-necked Grebe (PGRho201201303) at Wabamun Lake, Alberta, Canada. The black crest and the normally dirty whitish area of the cheeks were not separate, and the darker plumage of the crest continued downward until nearly reaching the chin. Additional dark smudges, though less prominent, were in the neck (Fig. 23). Feathers coloured by eumelanin seemed to overrun their typical borders. It cannot be totally

excluded that this was triggered by oiling rather than melanism, though other plumage parts did not look dirty. The last record concerned a white Red-necked Grebe (PGRho201301022) seen nesting with a normal conspecific at Kenosee Lake, Saskatchewan, Canada. S. Quigley and S. Shadick provided photos that showed a bird with entirely white plumage and an almost entirely yellowish bill. The eye colour could not be really assessed, but looked dark on the photo. This excluded albinism, and a true albino should anyway not have survived over winter. The grebe was plausibly affected by total leucism; no hue of any colouration was detectable in its plumage. The nest of the pair was destroyed by a storm on 27 June. The white grebe was again observed a few days later, but it was not reported to have made a second breeding attempt.

3.13. Black-necked or Eared Grebe *Podiceps nigricollis*

The different plumage stages of *P. nigricollis* grebes are among the best studied of all grebe species. Drawing on Stresemann and Stresemann (1966), Cramp & Simmons (1977), Prinzinger (1979), Storer and Jehl (1985) and Cullen et al. (1999) we can make the following statements, which are of importance for the overall assessment of aberrations:

- Juveniles have a brownish tinge on head, neck and even back. Legs and feet are olive green to greenish yellow. The iris is tan with a brownish tint. Winter birds with a brownish rather than a greyish upper plumage may not be affected by a mutation like brown: they are just predominantly juveniles.
- In their first spring, the plumage of subadults is often mottled in brown and black. The flanks are more brownish. The ear tufts are often paler than in older conspecifics. In addition, these subadults may not moult completely into breeding plumage. Instead, they may exhibit a mixture of regular breeding and non-breeding plumage. Some individuals may keep their winter plumage throughout spring and summer. Others can display white feathers in the face, chin, front neck, upper breast and flanks to varying degrees. Their feet are blackish green to grey green. Their iris is usually orange to orange red. In spring the iris and soft parts of subadults become quite similar to those of adults, which makes it increasingly difficult to distinguish subadults with partially white face, neck, upper breast or flanks from adults affected by partial leucism (or progressive greying), unless other plumage parts are affected too.
- Adults in their third calendar year and older have an overall black breeding plumage. The feet are blackish to blue grey, sometimes with greenish yellow markings. The iris is usually bright red, sometimes paler orange-red. The pre-breeding moult ends mostly by mid-April, but some individuals complete it only well into May. The delayed completion of the breeding plumage in some adults adds to the difficulty in assessing partial leucism (or progressive greying) in the species.

Finally, the melanins in the plumage are alkali-soluble. Long stays on alkaline lakes, as happens with *nigricollis* grebes, may result in faded and worn plumage (Storer & Jehl 1985). Hence, not all light coloured plumages, especially if the paleness is limited to those areas most in contact with the water, may have resulted from genetic mutations. They may simply have suffered from habitat conditions.

With these limitations in mind, we can now set about assessing aberrant *nigricollis* grebes in the register. They were by far the most numerous among all cases, totalling 207 individuals subdivided into 71 European Black-necked Grebes, 134 Eared Grebes and 2 African Black-necked Grebes.

3.13.1. Aberrant Black-necked Grebes *Podiceps nigricollis nigricollis*

Only two abnormal Black-necked Grebes were registered during the 19th century. Rokitansky (1952) reported an individual from Lake Velencze, Hungary, collected there on 24 April 1883 (PNIni188301102). Its neck colouration recalled that of a Slavonian Grebe in breeding plumage: the front neck was chestnut red. Only its central part displayed a slight darkening. The chin was black. The skin is today at the Museum of Natural History in Vienna. The photos received by courtesy of H.-M. Berg, collection manager, showed a Black-necked Grebe with golden yellow

Fig. 24: Skin of an erythromelanistic Black-necked Grebe from Lake Velencze, Hungary, collected in 1883 and now at the Natural History Museum, Vienna (PNIni188301102, photo H.-M. Berg, Naturhistorisches Museum, Vienna).

to light chestnut ear tufts and a dark chin. The upper breast and the lower fore neck had a rusty chestnut pigmentation. Due to mottling with blackish feathers, the plumage was gradually darkening in the upper front neck. Even the back and the wings of the grebe were interspersed with some rufous feathers (Fig. 24). The individual was affected by erythromelanism. The National History Museum in Prague holds a skin (PNIni189801032) collected at Koprnik, Czech Republic, in July 1898. J. Mlikovski, bird curator at the museum, kindly sent me some photos of the skin (Fig. 25). The grebe must have been a juvenile as it displayed no visible crest or ear tufts. Upper head, hind neck and mantle were very pale with a prominent brownish beige tint. The lower face, the fore neck, the flanks and the belly were of a silky cream white. The bill and the feet were yellowish. After analysis, van Grouw identified the causal mutation as brown (pers. comm.).

In the first half of the 20th century, eight abnormal grebes were added. Chernel de Chernelháza (1907) described a partially albinistic grebe (PNIni190201100) shot at Lake Velencze, Hungary, on 4 April 1902. The ordinarily entirely black head and neck were speckled with white feathers, especially in the nape, the face and the lower fore neck. The "upper surface" (Chernel de Chernelháza probably meant the back) was almost quite white and other parts unaffected. The text was not very clear. Which other parts were unaffected? Did the author mean the eyes and the bare parts? The white speckling in the head and fore neck and a probably quite white back suggested progressive greying as a cause for the grebe's appearance. The journal of the North Staffordshire Field Club, UK, published a photo of a partially leucistic Black-necked Grebe (PNIni190801131) shot in the region in 1908 (Coburn 1910). C. Slawson from the Staffordshire Ecological Record was kind enough to search for the article and to provide me with a copy. The individual was recorded at Norton Pool, now known as Chasewater Reservoir, by G. H. Clarke on 28 September 1908. It had a curious marking on the back stemming from stripes of white along the feathers of the mantle and scapulars. These were also visible on the black and white picture of the mounted skin. Partial leucism was a possible cause. However, the description suggested that scapular feathers were not entirely white, as would have been the case with leucism. Therefore, progressive greying seemed more likely, and this was in line with the impression left by the photo. At Haselbach ponds, Germany, a male (PNIni191101100) in normal breeding plumage was shot on 31 May 1911 (Gerber 1944). It had a white spot in the middle of its black upper fore neck that extended from the chin down towards the breast for about 30 mm and laterally to below the cheeks. One year later, a similar male (PNIni191201100) with a smaller white chin spot

Fig. 25: Mounted skin of a brown Black-necked Grebe from Koprnik, Czech Republic, 1898 (PNIni189801032, photo Pavel Kameník).

was detected on the same ponds (Gerber 1944). Both grebes were collected for the Museum of Natural History, Leipzig. It was not mentioned whether one or both grebes were subadults. Both may have been partially leucistic or alternatively subject to progressive greying. Figure 26 gives an example of an Eared Grebe displaying the conditions described by Gerber (1944).

Gerber (1944) analysed the extent of white feathering in the chin and fore neck region of 11 additional skins held by the Leipzig Museum and found that five of them had very few white feathers in the chin region: these could not be seen in the field. The remaining six had no white feathers at all. The white feathers at the chin could be related to age rather than to a genetic mutation. In Pachutken, near Riesenburg (today Prabuty), region of Gdansk, Poland, a pure white individual (PNIni191801200) was observed on 23 August 1918 (Tischler 1941). It was collected for the bird observatory at Rossitten. No other details were given and no mutation was indicated. The individual was registered as whiteling. At Rossitten (Rybatschi) near Kaliningrad, Russia, a white Black-necked Grebe (PNIni191901200) with a weak grey-brown upper side was collected in the summer of 1919 (Tischler 1941). It was not described further. The causal mutation may have been brown. On 28 August 1926, an entirely white Black-necked Grebe (PNIni192601030) was collected near Horde (Urda), West Kazakhstan. Its skin is now at the Darwin Museum, Moscow. I. V. Fadeev, curator of birds, reported the specimen to me. The feet and the bill of the individual were yellowish. The colour of the iris was not recorded. The individual may have been either albinistic or totally leucistic. Beckmann (1964) reported a completely white male (PNIni192801200) from the ponds of Kühren, Schleswig-Holstein, Germany in 1928. The grebe seemed to have been present over a longer period of time. Without additional details, the individual is best registered as a whiteling.

Seven abnormal Black-necked Grebes were registered between 1950 and 1980. At Hattrop Ponds, Westphalia, Germany, a chestnut-throated individual (PNIni196901200) was observed by H. Petzold on 16 August 1969. Harengerd (1971) gave no additional details. Erythromelanism was plausibly involved. Ringing activity at Lake

Fig. 26: Eared Grebe in breeding plumage at Tule Lake, California, in 2011, with white chin spot as described for Black-necked Grebes by Gerber (1944) and Dittberner and Dittberner (1984) (Photo A. Konter).

Felchow, Angermünde, Germany, between 1973 and 1977 procured the next six records (Dittberner & Dittberner 1984). Five males (PNIni197x01100, PNIni197x02100, PNIni197x03100, PNIni197x04100, PNIni197x05100) were in breeding plumage. They all had a white chin spot up to 10 mm wide. No such white "star" was displayed by females. As with the records of Gerber (1944), either partial leucism or an age-related cause were conceivable. On 18 June 1974, a female displaying strong mottling with red-brown feathers in its otherwise black neck was caught (PNIni197401100). From a distance, the neck appeared entirely chestnut. In addition, all normally black feathers of the lower wing had a reddish pigmentation, and even the flanks had a chestnut hue that was stronger than usual. Erythromelanism appeared obvious in this case.

In the last 20 years of the 20th century, eight aberrant grebes followed. At the outflow of the river Angitola from the lake with the same name, Calabria, Italy, Paolillo (1988) observed a complete albino (PNIni198401100) with a light beak in May and June 1984. The eye colour was not mentioned. The individual appeared to be in company of a conspecific in perfect breeding plumage which deposited weeds in front of it. This led to the conclusion that the grebe was an adult in at least its second calendar year. The bird may have been affected by total leucism rather than by albinism. The low survival chances of albinos, especially over the winter and during migration, argued against albinism. Sun bleached brown or ino could not be excluded. The grebe was not reported to have bred. At the same place, Paolillo (1988) detected a light coloured individual (PNIni198402100) on 18 June 1984. Except for having been paler than nearby conspecifics, no details were provided. If we interpret pale as meaning that that ordinarily blackish feathers were grey, a form of dilution may have caused the lighter plumage. From near Lochristi, East Flanders, Belgium, Verroken and Verroken (1987) reported a Black-necked Grebe with a chestnut-red breast and lower neck (PNIni198403100). It was present there from 30 August to 8 September 1984. The bird was moulting. When first observed, the lower half of the fore neck and the upper breast were chestnut-red, the upper neck was greyish and the chin and the throat were already whitish. The flanks did

Fig. 27: Diluted Eared Grebe in winter plumage at Salinas de San Pedro del Pinatar, Spain, in 2005 (PNIni200523232, photo A. J. Hernández Navarro).

not show any red tones. As the moult progressed, the extent of chestnut in the neck and the breast had greatly diminished by 8 September. Erythromelanism was at the origin of the neck colouration. On south Padenghe beach of Lake Garda, Lombardy, Italy, A. Rossi detected a partial albino (PNIni198901200) in October 1989 (Micheli & Busetto 1989). At El Hondo near Valencia, Spain, a leucistic individual (PNIni199301020) was observed on 23 April 1993. Both records remained without description and were best classified under whiteling. At the Bendimahi Delta, Eastern Turkey, G. Kirwan and M. Davies found a partially albinistic Black-necked Grebe (PNIni199302100) on 22 May 1993. Kirwan (1995) described the plumage as normal on head and neck (glossy black with golden-yellow ear-tufts). It was otherwise almost entirely white, except for the tail region and the tertials that were stained buff. The more whitish parts may have been heavily bleached. As the head region had retained a black pigmentation, brown and ino could be excluded as causal mutations. Leucism seemed unlikely as the whitish parts had retained some buff hues. A kind of pastel dilution was very plausible. Whereas many conspecifics around were paired, this individual was apparently unpaired. Koop (1995) reported two red-throated grebes from Schleswig-Holstein, Germany. At Schellbruch near Lübeck, an individual (PNIni199401100) was present from May to June 1994. It seemed to have returned to Schellbruch and nearby Lake Dassow in May 1995. The chestnut-red colouring of its fore neck, upper breast and flank feathers was similar to that of Slavonian Grebes. In 1994, it was paired and fledged two chicks. The individual (PNIni199402100) present at Lebrade ponds near Plön from 2 April to 13 May 1994 had a slightly paler chestnut-red fore neck and did not breed there. In both birds, the flanks had a brighter chestnut sheen than usual for the species. Erythromelanism was the root cause for the aberrant plumage of both.

In the early 21st century, the sightings of abnormal Black-necked Grebes soared. Between 2000 and 2003 there were five records. For one observation by J. Garzón at Laguna de Medina near Cadiz, Spain (PNIni200x01030), there were no details. Even the year of the record was not given, but could have been 2005 or slightly earlier. The

Fig. 28: Black-necked Grebe appearing diluted, in reality affected by progressive greying, in the company of a conspecific in regular breeding plumage at Santa Pola, Spain, in 2005 (PNIni200501022, photo A. J. Hernández Navarro).

observer simply indicated that he had seen a leucistic/albinistic bird. No assessment was possible. Near Cadiz, I myself found an individual (PNIni200001303) with a more brownish and partially buff overall plumage in the second half of April 2000. Its ear tufts were golden yellow. Its beak was paler than usual, as were the eyes. The grebe was affected by brown. At the Wagbachniederung, Germany, another grebe seemed still to be completely in winter plumage in late April 2002 (PNIni200203303). Only a vague indication of the ear tufts was detectable. One possible explanation was a subadult that had completely skipped the pre-breeding moult of that year. Otherwise, hormonal disorder or disease may have prevented or simply delayed its pre-nuptial moult. The only aberrant individual (PNIni200301232) in 2003 was reported from Mallorca, Spain, by L. Ventoso (Hernández Navarro 2005). It was declared as leucistic. A photo taken from some distance showed a bird in a quite pale breeding plumage. No date for the observation was given. The individual had a medium grey crest, whitish ear tufts and was very pale in its lower face. The hind neck was pale greyish, the fore neck very pale, nearly white. The mantle was pale grey and had some virtually white areas. The flanks were whitish with a hardly noticeable hue of chestnut. Pastel dilution was the most plausible explanation for the grebe's appearance. At Argilière de Ploegsteert, Belgium, T. Tancrez photographed a juvenile (PNIni200302032) in August 2003. It had a tan orange brown iris. Its crest was very dark brown, except for a few isolated white and chestnut feathers. Its lower face was dirty white. Its bill was pale grey to flesh coloured. The plumage of the neck was mostly pale reddish brown, turning to dark grey brown approaching the upper breast. The centre of the upper breast was whitish. The grebe's back was heavily mottled with dark grey brown, pale chestnut and white feathers. The latter appeared to dominate. The flanks were pale and similarly mottled as the back. The individual was either affected by partial leucism or progressive greying. If the latter, the process of greying had started at a very young age. It may then have been a hereditary form.

In 2004 there was just one record. On the Moulouya river at Mohamed V Dam, south of Zaio, Oujda-Angad Province, Morocco, D. Jerez Abad and R.

Ramirez Espinar detected an albino (PNIni200401020) in a group of 361 Black-necked Grebes on 1 February. They failed to describe it. Virtually every mutation was conceivable in this case.

The year with by far the most records, 26 in total, was 2005. Half of this number was generated by successive visits to Salinas de San Pedro del Pinatar, Murcia, Spain. A. J. Hernández Navarro (2005) counted 2 leucistic grebes in a total of over 100 on 12 March, 7 in a total of 51 on 16 April, 5 in a total of 16 on 24 April, 3 in a total of 14 on 28 April, one in a total of 4 on 19 May, one leucistic grebe on 8 June and one in a total of 47 on 7 August. As most grebes were photographed, a careful examination of the pictures made it possible to fix the total number of individuals at 13. Theoretically, there could have been less (double counting of birds in moult that, after moult completion, looked different; or the same bird displaying different degrees of bleaching over time) or more (single counting of different grebes looking identical, missing photos).

In March, a predominantly pale grey grebe (PNIni200503232) was present. Its lower face, front neck, upper breast and flanks were almost completely bright white: these conditions corresponded to those of a bird in winter plumage. Its crest and its hind neck were light grey. Its short and very pale ear tufts were hardly evident. Its entire back was light grey with some darker feathers shining through. The edges of the wings were also dark. The iris was of a regular red. The beak was ivory to light grey and the legs were grey. Progressive greying was a plausible explanation for this pigmentation. In parallel, a second leucistic grebe (PNIni200504232) was reported for the same date. It looked quite similar to the preceding bird and the two could hardly be told apart. Again, progressive greying was likely. On 16 April, an almost completely white grebe (PNIni200505232) was recorded. In its crest, it displayed a light shade of yellow grey, and yellow tinges were detectable in the region of the ear tufts. The bill was pale grey and partially yellowish: it was lighter than usual. The eyes were red. Pastel dilution might best explain these plumage conditions. Progressive greying at a very developed stage could not be completely excluded. Seven additional aberrant individuals were simultaneously present on 16 April. Six of them showed comparable pigmentation patterns (PNIni200506232, PNIni200507232, PNIni200508232, PNIni200509232, PNIni200520232, PNIni200521232). They were all more or less grey black in their head and upper neck plumage and paler grey to whitish on their back. Their ear tufts were all yellow; in some grebes they looked a bit pale. The fore necks and flanks were mostly white. Some individuals had a slight chestnut hue in the flanks. The grebes differed mainly in the degree of darkness in head parts. All six grebes appeared to have been subject to pastel dilution, though the degrees of perceivable dilution differed. In all of them, eu- and phaeomelanin quantities delivered to the plumage were below normal levels. The last record of 16 April concerned a female grebe (PNIni200522232) in breeding plumage with very golden and well developed ear tufts. Head, hind neck and mantle were black, the chin, front neck and upper breast white. It was not a young grebe with incomplete pre-breeding moult, as the individual had the red eye of an adult. It was classified as partially leucistic individual. No photos of the five leucistic grebes observed on 24 April were provided. Thus, it was not possible to assess in how far they differed from the grebes observed earlier in the year. They were not counted for this study. On 8 June, a further aberrant grebe (PNIni200523232, Fig. 27) was added. Its overall appearance was comparable to that of PNIni200503034, except that it was overall of a slightly darker grey. It still displayed a winter subdivision of the plumage and was whitish in its lower face, front neck, upper breast and flanks. It was pale grey in its upper head, nape, hind neck and back. Its eyes were of a perhaps slightly pale red (less intense than in adults) and it had a light grey beak. No ear tufts of any colour were detectable. The date of observation was too late in the season for a grebe entirely in winter plumage and too early for a completed post-breeding moult. The only plausible mutation here was dilution. However, in this case sun bleaching would have whitened the back quicker than the neck and lower face. Progressive greying appeared a possibility: the greyish plumage was interspersed with white feathers. However, it seemed unlikely that this would have triggered a plumage subdivision perfectly matching the winter conditions. In the end, no convincing cause could be found. In August a quite similar, but even darker grey, bird (PNIni200524232) was present. It was palest on the mantle, and this time its paleness was not due to isolated white feathers. The grebe may therefore have been affected by dilution.

Fig. 29: Almost entirely white Black-necked Grebe from Cabezo Beaza, Cartagena, Spain, in 2005 (PNIni200519032, photo A. J. Hernández Navarro).

Other sightings of aberrant Black-necked Grebes occurred in southern Spain in the same year. These were all considered to concern birds different from those observed at Salinas de San Pedro del Pinatar. It is just possible, though, that some individuals had migrated and had already been recorded previously at San Pedro. At Santa Pola, Alicante, F. Atienzar observed an albino (PNIni200501022) at some distance on 29 August. According to his report, the grebe was completely white. A. J. Hernández Navarro provided a photo (Fig. 28) of probably the same bird, showing that the individual had a pale greyish upper head and a light grey back. The wings were of a regular black pigmentation. Its beak was pale grey flesh coloured, the eyes red. Its flanks were entirely white and there were no yellow ear tufts. The black wings ruled out dilution, brown and ino as causal mutations and made progressive greying most plausible. M. Rouco detected a leucistic grebe (PNIni200502022) at Azud de Riolobos, Salamanca, in September. It was of a darker and more uniform grey than the grebe from Santa Pola. The remains of its ear tufts were pale yellow. Except for the whitish forehead, its head, hind neck and back were middle grey. The face, chin, front neck and flanks were already white: the grebe was moulting into winter plumage. The individual was probably affected by dilution. At Salinas de Ibiza, A. García Ríos observed four leucistic grebes in a group of 33 on 24 April. The photos provided showed that PNIni200510030 was in a very pale breeding plumage. It had a pale grey to whitish crest and face, pale yellowish ear tufts, a pale grey to whitish fore neck, a slightly darker hind-neck and a white upper breast. Its back was mostly middle grey and fading in some parts. Its flanks were almost completely white. The beak and eyes had a regular colour. PNIni200511030 resembled the preceding bird, but was slightly paler overall. This was due to a more whitish fore neck and upper breast and a much lighter back. Both these grebes were subject to progressive greying. PNIni200512030 was darker grey in its upper parts and resembled a grebe in faded non-breeding plumage. It had a middle grey upper head, a whitish face and fore neck and a middle grey hind neck. The region of the ear tufts looked white. The grebe's back was mottled with white and greyish feathers. Its flanks were virtually white. Its beak was slightly paler than usual. The eyes had a regular pigmentation. Overall it seemed that the

Fig. 30: Two Black-necked Grebes near Cartagena, Spain, in 2005, affected by progressive greying (photo José Lacalle).

paler colouration was triggered by the mottling with white feathers, which plausibly originated from progressive greying. PNIni200513030 looked similar to PNIni200512032, but was darker in its head and hind neck. Its back had less whitish parts and looked more grizzled, suggesting that again progressive greying had been at work. One further aberrant Black-necked Grebe was present on the photos but was not mentioned by the photographer. It was an erythromelanistic mutant in breeding plumage with a rufous chestnut neck (PNIni200528022).

At El Portil Lagoon of Odiel Marshes near Huelva, one partial albino (PNIni200515020) and one leucistic grebe (PNIni200514020), perhaps an albino, were detected in early May by S. Emmerson and J. Spick. The partial albino was not further described and cannot be assessed. The second grebe was completely white with two small blackish lines in the flanks; it had red eyes. The eye colour suggested adulthood. The blackish lines in the flanks indicated that feathers in the wing not exposed that much to the sun had retained their colouration. Therefore, the whiteness of the individual could have been triggered bleaching. Albinism was ruled out as causal mutation. The solution "whiteling" was adopted for this individual. A. Binns observed two albinos at El Portil Lagoon on 23 May. He did not describe them at all, but we can assume that they were the same as seen by S. Emmerson and J. Spick. J Garzón reported a leucistic grebe (PNIni200518030) from the same marshes in September. He gave no further details, making an assessment impossible. At the Estación Depuradora de Aguas Residuales of Cabezo Beaza, Cartagena, E. Perez Romero saw an almost entirely white grebe (PNIni200517232) in July. The photo indeed showed an almost completely white bird with few very pale greyish shadows in the upper head and on the back. Its beak was pale grey and a bit yellowish. Its eyes were of a slightly pale red, but this impression may have been come from the surrounding white feathers. Pastel dilution caused this appearance. From the same place, a leucistic individual was reported in October by A. J. Hernández Navarro and A. Fernández-Caro (PNIni200519032). It cannot be excluded that this was the same bird already seen in July as both looked quite similar. However, in this grebe's upper plumage no

grey hues were detectable. One photo showed the individual with open wings: the lesser wing coverts proved to be mostly dark whereas the remiges were mostly white. With folded wings, the dark areas were no longer visible: they were protected against bleaching from sunlight by flank and shoulder feathers (Fig. 29). The pigmented area of the wings was greyish, though very dark. On some photos, the red iris revealed a light pink sheen. This effect was attributed to the light conditions and the surrounding white feathers. Dilution was the most plausible cause for the grebe's appearance. Two additional aberrant grebes were together when detected by J. Lacalle in the region of Cartagena (Fig. 30). Both were largely white with some dark grey to black markings. The first (PNIni200526022) showed a well-developed white crest and prominent, virtually white ear tufts with a pale yellow hue. Its face was mostly white. Isolated blackish feathers showed up in its nape, and a dark grey blotch extended on the side of its upper neck from the chin region towards the centre of the hind neck. Other parts of its neck were mostly white, except for isolated dark feathers. The back was mostly white with darker areas in the region of the lower back belonging to the wings. The beak was light grey to pale yellowish. The eyes were pale red. The second grebe (PNIni200527022) did not differ much. It lacked elongate feathers in the crest or in the ear region. It showed more extensive mottling with blackish feathers in the upper head and lacked the dark blotch on the side of the neck. The perceivable differences were minor, however. The presence of blackish pigmentation that was dispersed over the entire plumage, suggested an advanced stage of progressive greying. The distribution of the blackish feathers differed clearly in both individuals from patterns observed in dilution or partial leucism.

The number of records fell to four in 2006. All were again from Spain. In January, A. Fernández-Caro detected a pale Black-necked Grebe (PNIni200601032) at Balsa de Regadío del Campo de Cartagena. The bird, in winter plumage, was still rather dark grey on the upper crest and hind neck, but pale grey and fading to virtually white on its back. The lores, the lower face, the fore neck and the flanks looked completely white. The beak was pale yellowish flesh coloured. On the photo, its red eyes were in shadow and difficult to assess. Dilution was responsible for the grebe's appearance. The next three observations were from Salinas de San Pedro del Pinatar, Murcia. V. Hernandez Gil reported an aberrant individual in April (PNIni200602022). The bird's plumage was rather light to medium grey overall with more white in the fore neck, upper breast and flanks. The crest was darkest, though not black. The ear tufts were very pale yellowish. The mantle was mottled in white and grey. The eyes were red. The bill was of a pale grey. The mottling of the plumage with white feathers was responsible for the pale appearance of the grebe. It resulted from progressive greying. Two records by A. J. Hernández Navarro were from autumn. In September he observed a female in winter plumage with a very pale back (PNIni200603032) in a group of 430 grebes. According to the photo, its crest and its hind neck were dark grey black. The colour faded at the shoulders. The back was much paler, virtually white in parts, especially towards the rump. The regular colour in the head and neck and the bleached appearance of the back may have been caused by dilution. On 11 October one grebe (PNIni200604032) of a total of 444 had a similar appearance. To judge by its more brownish black head and neck plumage and the paler red orange eyes, it was a juvenile male. It had a pale yellowish grey beak. The entire back was heavily mottled with white feathers, creating an overall pale greyish impression. Head and neck were regularly pigmented. A likely cause for the faded back colour was dilution.

In 2007, three abnormal *nigricollis* grebes were reported. At Aydinlar, Turkey, K. Malling Olsen observed a leucistic grebe (PNIni200701010) on 21 May. Its plumage was pale greyish-brown overall. It displayed traces of the normal summer head. According to the few details provided, the grebe may have been diluted. The description was, however, too imprecise for a final assessment. J. Hering (2010) registered a pale individual (PNIni200702201) at the Crater Lakes of Wau, Libya, in December. The grebe displayed the normal winter subdivision of the plumage with a white lower face, fore neck, upper breast and flanks. Its upper head, hind neck and back were very pale, but not white. These parts had a mix of grey or blackish and whitish feathers, plausibly caused by progressive greying. The third record concerned a paired grebe in breeding plumage (PNIni200704303) detected by myself in the Wagbachniederung, Germany, in April (Fig. 33). Its black neck, shoulders and upper mantle

Fig. 31: Pair of Black-necked Grebes at the Wagbachniederung, Germany, in 2008, with the individual to the right displaying leucistic traits produced by progressive greying in the upper breast and back (PNIni200805303, photo A. Konter).

were interspersed with white feathers. Its flanks were quite pale, also due to mottling with white feathers. Progressive greying was a likely cause.

Two records were added to the register in 2008, one in 2009 and none in 2010. All three additions were own records from the Wagbachniederung, Germany. An observation in early May of 2008 was of a Black-necked Grebe male (PNIni200801303) in full breeding plumage. It had some chestnut feathers in its lower front neck. They extended from there to the flanks. Its overall plumage pattern in this area was quite curious. In the central part of the upper breast, a blackish semicircle rose from the waterline. The feathers above and immediately surrounding it were rusty chestnut, with some white feathers shining through. Further up, the fore neck was entirely black. Other plumage parts were regular for the species. The uncommon areas left an impression of incomplete feather growth, perhaps following a shock, rather than of chestnut melanism. The second grebe (PNIni200805303) of 2008, seen in early May, seemed at first glance to be in perfect breeding plumage. Two areas looked as if they had received a spill of white paint. To the side of the lower breast originated a kind of winding white line, about 1 cm wide. It continued upward into the lower central fore neck. The folded wings had a larger whitish patch reaching from the flank to the central back (Fig. 31). As the pattern was due to white edges to feathers rather than by entirely white feathers, progressive greying had plausibly been at work. On 25 April 2009, a paired female grebe (PNIni200901303, Fig. 32) in perfect breeding plumage had a lot of rufous chestnut feathers in its upper breast. They continued into the lower fore neck. It was affected by erythromelanism.

The aberrant Black-necked Grebe count was three in 2011. A perhaps leucistic individual (PNIni201101020) from the region of Valencia, Spain, seen in March 2011, was briefly mentioned in an ornithological forum. F. Atiénzar described it as entirely white without giving further details. An anonymous observer recorded an albino (PNIni201103020) at Cape IJzeren on Texel, Netherlands. He too gave no description. Similarly, Eloy did not describe a leucistic grebe (PNIni201104020) seen at Estación Depuradora de

Fig. 32: Pair of Black-necked Grebes at the Wagbachniederung, Germany, in 2009, with the individual at the back displaying erythromelanism in its upper breast (PNIni200901303, photo A. Konter).

Fig. 33: Pair of Black-necked Grebes at the Wagbachniederung, Germany, in 2007, with the individual to the right affected by progressive greying and displaying a lot of white feathers in its fore neck, upper breast, flanks and shoulders (PNIni200704303, photo A. Konter).

Aguas Residuales of Cabezo Beaza, Spain, in May 2011. He simply stated that the bird was white. All three sightings could not be assessed and were registered as whitelings.

No abnormal Black-necked Grebes were reported in 2012 and only one in 2013. At Laguna Petrola near Albacete, Spain, an abnormally coloured individual (PNIni201301022) was present on 22 April 2013. Photos by R. Torralba Zapatero and A. Bazán Hiraldo showed a grebe apparently in breeding plumage with light grey to whitish plumage in the parts usually black. The head remained most pigmented, but it was paler than usual. The ear tufts were pale yellowish, nearly white. The eyes had the usual red colour and the beak was dark. The front neck, upper breast and flanks were palest. It was in the company of a conspecific in regular breeding plumage and was probably the female in the pair. Pastel dilution best explained these conditions.

During my observations at the Wagbachniederung, Baden-Württemberg, Germany, in springtime of the years 2001 to 2011, I always found one or more individuals that, at first sight, were in complete breeding plumage. A second look proved that they had white feathers on their chin, fore neck and/or upper breast, occasionally even in the flanks, to varying degrees. They resembled the grebe in Fig. 33, except that their mantle was not affected and their chin was generally white. These birds looked like partially leucistic individuals. According to Storer and Jehl (1985), they were subadults, which may moult only partially into breeding plumage in their second calendar year. Several of these grebes, monitored for three or four weeks in different years, showed no change of appearance during this time. A few had glowing red eyes, suggesting that they were not subadults. Most of them were courting and some were observed nest building. It is not known whether they bred. None of these individuals were included in the register.

3.13.2. Aberrant Eared Grebes *Podiceps nigricollis californicus*

Only seven aberrant Eared Grebes were reported from North America prior to 1950. The oldest record was from near San Pedro, California, USA. On 30 September 1886, an immature male in perfect albino plumage (PNIca188601200) was shot there and collected by W. H. Wakeley (Grinnell 1898). The grebe was not further described and cannot therefore be assessed. Albinism may be excluded because of the late collection date. For a skin (PNIca19xx01200) mounted in the office of Bear River Wildlife Refuge, Utah, USA, neither date nor precise place of collection were available. King (1975) was informed of its completely white plumage in a letter by R. W. Storer. Storer having been a renowned ornithologist and specialist in grebes, we can assume that the absence of pigmentation did not result from bleaching. Other details were not given. The individual may have been either a true albino or totally leucistic. Another letter received by King (1973) from H. Friedmann reported partial albinism in a male in breeding plumage (PNIca191501202) shot at Marshall Lake, Coconino County, Arizona, USA, on 2 July 1915. The skin is now at the US National Museum. The record was already mentioned by Weller (1959), who simply stated that the grebe had albinistic features. The online database of the museum indicated that the grebe was a female collected by E. A. Goldman. The photos received by J. R. Saucier from the museum showed an overall whitish bird with a darker head. The entire head to just below the chin was mottled in white and dark grey brown. The ear tufts were slightly paler than usual. While some feathers had a normal yellow or chestnut yellow pigmentation, others looked whitish. The bill and the feet were unaffected. The whole neck was much paler than the head. The back and the flanks were virtually white. Underlying feathers were shining through and proved to be hardly affected. The edges of the wings were prominent and dark blackish brown (Fig. 34). The plausible cause for the grebe's appearance was progressive greying. Wyman (1918) reported a pure albino (PNIca191801200) observed by Mr. Howard at Baldwin Lake, San Bernardino Mountains, California, USA, in 1918. No description of its appearance was given.

Weller (1959) mentioned a partial albino Horned Grebe, later corrected to Eared Grebe (PNIca193101112), collected at Barr Lakes, Adams County, Colorado, USA, on 18 June 1931 and now at the Denver Museum of Natural History. A. Doll from the museum and J. Fjeldså (based on photos provided by A. Doll) confirmed that the species was *nigricollis* and not *auritus*. The male was described as mostly pure white with normally pigmented wings, except for some dusky scapular feathers. A. Doll's photos of the skin showed a

Fig. 34: Skins of an individual affected by progressive greying (at the back, PNIca191501202) and a normal Black-necked Grebe in the collection of the US National Museum (photo J. Saucier).

mostly cream white grebe with pale straw hues in its upper head, in the region of the ear tufts and on the upper back. A few small pale grey brown patches were present in the lower hind neck and on the back. The dark brownish black edges to its wings suggested that feathers hidden with folded wings had retained much of their pigmentation. The coverts were whitish with few very small darker blotches. The feet were pale yellowish, the beak pale grey to pale yellowish. The plumage of the back resembled PNIca191501202 (Fig. 34) and hence recalled progressive greying. The pigmentation of the head plumage and even more of the bare parts differed completely. Ino, brown and dilution could be ruled out as causal mutations, primarily because the wings were regularly coloured. A form of progressive greying that also affected the bare parts may have been at work (confirmed by H. van Grouw, pers. comm.). Allen (1940) observed an albino (PNIca193901200) at Dumbarton Bridge, California, USA, present between 29 July 1939 and 10 February 1940. Carter (1942) mentioned that this grebe was present there in 1941/42 for the fourth consecutive winter season. We have to doubt whether it really was the same grebe at Dumbarton Bridge each year. The individual was described as almost pure white with rosy coloured eyes. No other character traits were mentioned (Allen 1940). The eye colour suggested that these were affected. The grebe was probably a juvenile in 1939, when it was first observed. The rosy colour of the iris suggested that the eyes were affected. As the plumage may not have been pure white, ino became a possible explanation for the individual's appearance. Stott (1948) detected an albino (PNIca194701200) at Mono Lake, California, USA, on 24 August 1947. Although he saw it at close range, he did not mention any details in his publication, except to say that it was swimming in a group of normally coloured conspecifics. The record could not be assessed.

For the next 30 years and more, no further aberrant Eared Grebes were reported until Jehl (1985) boosted the count with his publication, adding 56 records of "leucistic" grebes. Unfortunately, his definition of leucism differed greatly from the one used for this study. For Jehl, leucism was the loss of a particular pigment or of all pigments in feathers, but not in soft parts. In contrast, for

van Grouw (2006, 2013), a complete loss of all melanin, but not of other pigments, in affected plumage is a pre-condition of leucism. In addition, soft parts may be affected, but not the eyes. The differences are far reaching. The colours of the plumage in grebes are predominantly, perhaps even exclusively, melanin based. In theory, Jehl's loss of pigment could therefore be seen as the same as loss of melanin. Whether bare parts were affected or not could be considered a minor detail. In practice, however, Jehl did not assess the loss of any one pigment, but the loss of colouration. He did not target the cause and simply concentrated on the effect. Whether an appearance resulted from a complete loss of melanins, altered oxidation, or a qualitative or quantitative reduction in the melanins produced did not matter to him. His different patterns of leucism simply described visible effects on colours in the field, irrespective of the underlying causes. He ignored progressive greying and the effects of sun bleaching. He did not differentiate genetic causes from others. He generally assumed that bare parts were not affected. As a result, not all the grebes in a particular category may have been affected by the same mutation. Indeed, for some of the records, there may even have been no mutation at all responsible. Jehl's general approach was that of a bird watcher, considering only the visible effects without reflecting on possible underlying causes. This lumping together according to appearance within a particular category ignored individual differences. This leaves us today with a problem: birds affected by different causes, genetic or not, may have been included in the same category; similarly, birds affected by the same cause may have been classified in different categories. To give an example, Jehl's type 1 covers (a) a completely leucistic grebe, (b) a strongly diluted grebe which has gone virtually white due to sun bleaching and (c) an individual in an advanced stage of progressive greying. Another diluted individual with freshly moulted feathers is included as a type 3, 4 or 5 individual. Similarly, different stages of progressive greying are placed in different categories. There is at any rate a good chance that a majority of Jehl's records concerned progressive greying rather than leucism. If, despite the deficiencies of Jehl's method, we still want to proceed, we cannot escape making an overall assessment per type and subtype of leucism as defined by him. For each category, we will have to find the most plausible explanation. Nevertheless, we have to bear in mind that not all grebes of a particular type were necessarily affected by the most likely underlying cause.

In his surveys of Eared Grebes at Mono Lake, California, USA, between 1980 and 1984, Jehl counted and classified aberrant individuals according to six types of leucism, each subdivided into a main category and a subcategory A. His first main category comprised a priori pure white and essentially white plumaged grebes, whose wings were presumed to be white. There were 10 such records: 2 from 1980 (PNIca198001104, PNIca198002104), one from 1981 (PNIca198101104), one from 1982 (PNIca198201104), 4 from 1983 (PNIca198301104, PNIca198302104, PNIca198303104, PNIca198304104) and 2 from 1984 (PNIca198401104, PNIca198402104). A pure white plumage may result directly from albinism, total leucism or from a final stage of progressive greying. It may be an indirect consequence of sun bleaching in grebes affected by dilution, brown and light ino. The grebes in this category were said to have been essentially white. The examples provided in a black and white photo showed first, a skin with a few light shades of colouration, and second, a skin with dark wings. There are too many possible explanations for the appearances of the grebes in this category. A majority of the records may have concerned progressive greying. Without having the opportunity to investigate individual data, the best solution is to classify all ten records as whitelings. The only cause that can be excluded is albinism: grebes staging at Mono Lake have to migrate, and the bad eyesight of albinos makes long migration distances implausible.

Jehl's type 2 grebes were white with grey smudges on head or hind neck or both. The ear tufts, if present, were white or very pale yellow. The pigmentation of the wings was variable, and the remiges or coverts could be pigmented. The example in the photo showed much darker remains of colouration in the wings than in the head. In 1980, one grebe (PNIca198003100) corresponding to this condition was detected. There were 2 in 1981 (PNIca198102104, PNIca198103104), 5 in 1982 (PNIca198202104, PNIca198203104, PNIca198204104, PNIca198205104, PNIca198206104), 7 in 1983 (PNIca198305104, PNIca198306104, PNIca198307104, PNIca198308104, PNIca198309104, PNIca198310104, PNIca198311104)

and one in 1984 (PNIca198403100). The presence of greyish smudges excluded albinism, brown and ino as causal mutations. Together with the paleness of the ear tufts, they pointed to dilution as a plausible cause. Progressive greying was an alternative explanation. A more detailed description of individuals could have helped to segregate the underlying causes. In a few grebes, partial leucism may have been present. However, this mutation is generally rare and could therefore be the correct cause in only a minority of cases at best. Dilution and progressive greying were finally adopted as plausible explanations, and progressive greying may have been correct in the majority of cases.

Type 3 grebes had white body feathers with occasional grey feathers on the back or the rump. The grey colouration was not easily detectable except at close range. The wings were dark except for normally white parts. Black or grey markings showed up on the crown or the nape, often extending around the ear tufts or onto the chin. The ear tufts, if present, were golden to pale yellow. The two grebes of this type in the photo proved that the wing colour was still very dark. Similarly dark areas were present in the heads: they were however whitish in most parts. The first two individuals of this type (PNIca198105104, PNIca198106104) were registered in 1981. One was added in 1982 (PNIca198207104) and one in 1983 (PNIca198312104). The most plausible explanation for type 3 grebes is progressive greying. The overall appearance of the plumage was grizzled or piebald.

In individuals of type 4, the grey pigmentation was evident on the back; the black or dark area on the neck was more extensive; it was present laterally and to the front. The wings were dark. The example featured in the black and white photo had a blackish head and neck. The individuals were overall very pale or even white in the back plumage. In 1981, 3 grebes corresponding to these criteria were found (PNIca198107104, PNIca198108104, PNIca198109104); in 1982 it was only one (PNIca198210104); in 1983 it was 6 (PNIca198313104, PNIca198314104, PNIca198315104, PNIca198316104, PNIca198317104, PNIca198318104), followed by 2 in 1984 (PNIca198404104, PNIca198405104). Individuals of this type were rather black in many pigmented parts, including in those parts where partial leucism is most expected. This excluded partial leucism as a plausible cause. We have to conclude that in this category too a majority of the individuals were subject to progressive greying, hence displaying a more grizzled back plumage. One or other of the grebes may have been subject to a form of dilution.

Grebes of type 5 had a black head, neck and chest and golden ear tufts. Their back and their wings were dark. The rest of the body, including face, chin and flanks, was white. The specimen on the photo displayed a strong mottling of whitish and blackish feathers, especially on the back. This made this part look quite light coloured overall. Individuals in this category, 3 in total (PNIca198319104, PNIca198320104, PNIca198321104), were only detected in 1983. All three individuals were already present in July, suggesting that they were summering individuals that did not breed that season. Two reasons for not migrating to breeding grounds may be put forward: youth or old age. While youth and partial moult could explain the white parts in the neck, upper breast and flanks, it does not explain the mottling in the back. This could have been caused by progressive greying.

Type 6 aggregated piebald Eared Grebes that could appear uniformly grey at a distance. In reality, their plumage was a mixture of grey and white feathers in all upper parts, and their wing pattern was variable. One bird of this type (PNIca198211104) was recorded in 1982 and 3 (PNIca198322104, PNIca198323104, PNIca198324104) in 1983. The interspersing of whitish feathers in all plumage parts made the individuals look more pale grey, but this was not a consequence of dilution. Progressive greying was the plausible cause.

While in the main categories pigmented plumage was in grey to black tones, it was in brownish or tan tones in the sub-categories A. In type 2A, the predominantly white plumage had brown or tan smudges in the head or neck or both. The ear tufts were white to very pale yellow, the wings brown or tan to variable degrees. One individual of this type (PNIca198104104) was found in 1981. Individuals of type 3A had predominantly white plumage with occasional brown or tan feathers on the back or rump. Their wings were dark except for normally white areas. They had brown or tan markings on the crown or at the nape, often extending around the ear tufts and onto the chin. The ear tufts themselves were golden or pale

yellow. In 1982, two of these grebes were observed (PNIca198208104, PNIca198209104). In grebes of type 4A, brown or tan plumage was evident on the back, and the brown or tan area on the neck was more extensive and laterally present. The wings were dark, other parts white. In 1981, three Eared Grebes (PNIca198110104, PNIca198111104, PNIca198112104) fell into this category. Grebes with a tan or brown head, neck and chest, golden ear tufts, a dark back, tan or brown wings and the rest of the body white were of type 5A. There was one individual (PNIca198113104) of this type in 1981. Possible causal mutations in all type A grebes were brown and ino. As eye and bare part colours were not recorded, a differentiation between the two mutations was not possible. Differentiation could have been by reference to the colouration of the ear tufts or the flanks for those grebes that were not in (partial) winter plumage. Unfortunately, no details of individual records were provided. As brown should generally be more frequent than ino, the majority of the grebes may have been subject to brown.

In the year of Jehl's publication, a complete albino juvenile (PNIca198501101) from Russell Lakes, south-central Colorado, USA, seen between 1 and 16 August 1985, was reported by Schreur (1987). Most of the time, it was accompanied by a normally coloured and similarly sized conspecific assumed to have been its sibling. According to the description, it had a white plumage except for a dorsal dark area between the wings: this was thought to have resulted from staining. The feet were yellowish, and this was attributed to carotene colouring. The bill was pink, as was the iris. The description suggested that light ino was the causal mutation. Thereafter, only few sightings occurred until the end of the century. Jehl (2007) added two leucistic grebes from Mono Lake, California, USA, captured for banding in September 1995. On the black and white photo, one (PNIca199501101) appeared to be entirely white. It may have had a regular bill. Its eyes and its feet were difficult to assess. Albinism can be excluded, and total leucism seems unlikely, as no effect on bare parts could be ascertained. The grebe is best classified as whiteling. The second individual (PNIca199502101) looked virtually white, but it had some hues of possibly tan or pale grey pigmentation in its head plumage. The back was hidden on the photo. The eyes could not be definitively assessed, but they looked pale, possibly pink, on the photo. The individual may have been light ino. On 18 November 1995, A. Smith photographed a pale Eared Grebe (PNIca199503022) at the causeway to Antelope Island on Great Salt Lake, Utah, USA. M. Moody from the Utah Birds Record Committee provided me with a photo. This showed a grebe in winter plumage with still quite dark grey feathers in the upper head and hind neck. The back was of a much paler grey and partially whitish. The bill was pale yellowish. The eyes were red. Dilution would lead to these conditions. At the Henderson Bird Viewing Preserve, east of Las Vegas, Nevada, USA, a juvenile albino Eared Grebe (PNIca199801030) was detected during a field trip of the Red Rock Audubon Society on 2 October 1998. J. A. Branca, who advised me of the record, had no description of the bird. It may have hatched at the preserve and was with other juveniles of the same size. The causal mutation could not be further assessed. Plausibly, it was not albino, due to the survival of the individual into autumn.

A final two records may still date to the 20th century. The head of the first (PNIca199x01201) was displayed in a photo (Jehl 2007), and the context of the article suggested that it was taken at Mono Lake, California. Bill and eye colour were regular. The entire plumage was white. As the eyes were a normal red, albinism was impossible. Total leucism, ino and brown could be excluded as the bill was not affected. Theoretically, entirely sun bleached dilution remained possible. A final stage of progressive greying seemed more likely. All that Jehl (2007) revealed about the second leucistic Eared Grebe (PNIca199x02200) was that it was captured at Mono Lake and that he had seen it nesting in Oregon, USA. Knowing Jehl's definition of leucism, this grebe may have been affected by almost any mutation or even progressive greying.

With the 21st century, the numbers of single records of aberrant Eared Grebes increased again, with eight observations up to 2005. At the causeway to Antelope Island, Great Salt Lake, Utah, USA, a white individual (PNIca200201200) was detected in April 2002. According to the Utah Division of Wildlife Resources (2002), the albino grebe was completely white. As it appeared to have survived at least over the preceding winter, total leucism seemed more plausible than albinism. However, other mutations remained possible. T. Lenz recorded an albino in a group of 20-30 conspecifics

Fig. 35: Melanistic adult Eared Grebe in winter plumage displaying a white patch in the hind neck, Huntington Beach, USA (PNIca200602, photo R. Vasudev).

at Big Soda Lake, Churchill County, Nevada, USA, in June 2003 (PNIca200301010). The observation was published in Fridell and Summers (2004). The ear tufts of the individual had a bit of creamy-yellowish feathering, but otherwise the plumage was almost completely white. The small bill was black. According to this description, albinism was unlikely, and the colouration of the ear tufts and the bill also excluded total leucism, ino and brown. Pastel dilution and progressive greying remained possible. N. Davis photographed an albino (PNIca200302012) near Antelope Island on Great Salt Lake in autumn 2003. His picture showed a completely white bird. The bill was dark and silver grey. The eyes were unaffected. Progressive greying appeared most plausible. At roughly the same place and time, M. G. Moody observed a partial albino in winter plumage (PNIca200303012). Its lower face, chin, fore neck and flanks were completely white, while the crown, hind neck and mantle were middle to dark grey mottled with white. The back appeared palest. The bill was generally pale and more yellowish at the onset. The red eyes appeared to be normally pigmented. Progressive greying best explained the grebe's mottling. M. G. Moody also reported an entirely white Eared Grebe (PNIca200304012) from Great Salt Lake, Utah, on 5 October. The grebe's bill was slightly pinkish. On the picture, the iris looked pinkish too. As an albino is not expected to survive independently, ino best explained these conditions. J. McIntyre spotted a leucistic grebe (PNIca200401020) well offshore on the causeway to Antelope Island, Great Salt Lake, on 16 October 2004. He was unable to provide a description. The distance to the bird may have been too far and the record could not be assessed. At the Lancaster Sewage Ponds, Antelope Valley, California, USA, F. Gilliland observed a nearly albino grebe with a dark bill (PNIca200501200) in August 2005 (Feenstra 2005). Without additional details, the underlying cause could not be defined. It was certainly not albinism. From the Henderson Bird Viewing Preserve east of Las Vegas, Nevada, USA, J. A. Branca reported a "blonde" grebe (PNIca200502020). Blonde indicated that the grebe was more tan and bleached than white, making brown and light ino plausible mutations for the appearance.

Fig. 36: Progressive greying in its final stage in an Eared Grebe at Mono Lake, California, in 2006 (PNIca200603111, photo Jim Dunn).

Eight records followed in the next two years. Off Woodley Island Marina, northwest California, USA, P. Bitton detected a leucistic Eared Grebe (PNIca200601012) on 22 January 2006. It had an almost all-white head with dark cheek patches and a dark streak on the top of the head. The body and wings were dark above. The dark pigmentation was not further qualified. Partial leucism or progressive greying were possible explanations. R. Vasudev photographed an aberrant individual (PNIca200602022, Fig. 35) at Huntington Beach, Orange County, California, USA, on 28 January 2006. His photo showed a grebe with a completely dark blackish crown and face. It was paler on the chin and immediately above. No ear tufts were detectable. It had the red eyes of an adult. Its bill had a dark culmen, and it was light grey in between both mandibles. The front and the sides of the neck were more brownish black in the upper parts and darker farther below. The mantle was completely black. The flanks were mottled black and white and looked quite dark. The most curious feature of its plumage was a rather large white blotch beginning at the level of the lower nape and extending downward on the hind neck. At this time of the season, the individual should still have been in winter plumage or at best in a transitional moulting stage. The absence of the ear tufts supported this assumption. The presence of blackish facial and fore neck feathers was plausibly caused by melanism. This cause would not, however, explain the white blotch in the hind neck. It may have been caused by partial leucism or it may have been the consequence of a shock received in the hind neck. Between 7 and 15 October, an abnormal grebe (PNIca200603111) was recorded by several people at Mono Lake, California, USA. All photos showed an entirely white bird with a light grey to pale flesh coloured bill and red eyes (Fig. 36). Its legs were dark. The species was discussed at length, but finally identified as Eared Grebe (Blumin 2007, Jehl 2007). Blumin noted that its behaviour differed from that of conspecifics, and Jehl added that it was an adult male. Total leucism was plausible, though bare parts were not affected. According to H. van Grouw (pers. comm.), progressive greying was the cause. At Oak Hammock Marsh, Manitoba, Canada, I detected a grebe in breeding plumage caring for a small chick in July 2006 (PNIca200604303). It had a bright chestnut upper breast. The fore neck itself was black with a less noticeable tinge of chestnut

in the lower parts. Its flanks were entirely bright chestnut. Erythromelanism was at the origin.

From Benton Lake National Wildlife Refuge, Montana, USA, an abnormal individual (PNIca200702022) was reported on 21 June 2007. The bird, in breeding plumage, was overall paler than usual, but not white. The ordinary distribution of colours in the breeding plumage was easily detectable, except for the flanks, that were almost entirely white. The grebe's crest was still rather dark, but no longer black. Its ear tufts were pale yellow to white. The neck was pale grey and the back was even paler. The bill looked dark and the legs were steel grey. The iris was glowing red. Pastel dilution and sun bleaching best explained these conditions. East of the marina on Antelope Island, Great Salt Lake, Utah, USA, P. Beneke saw a leucistic Eared Grebe (PNIca200703010) on 18 September 2007. Its plumage was mostly white with just a bit of grey mottling. The head had some grey and black feathers. Most of the neck was quite white. Progressive greying could have caused this appearance. V. Murayama photographed a curious individual (PNIca200704022) at the Salton Sea, California, USA, on 6 May 2007. The grebe was mottled and streaked overall in white and black, suggesting that the white feathers did not stem from bleaching. It displayed a darker head and upper neck with more blackish feathers in these parts and a pale back with more white feathers in this area. Its lower cheeks, chin and upper breast were completely white. A few red golden yellow feathers were present in the region of the ear tufts. The tufts themselves were much reduced in size and the white and black feathers underneath were prominent. The paleness of the plumage was due to the unusual presence of white feathers, that were present everywhere. The bare parts and the eyes had a normal pigmentation. Progressive greying was a plausible explanation for this appearance. At an unknown place in Mexico, M. Peck photographed a pale coloured Eared Grebe (PNIca20070501) within a group of conspecifics in winter plumage on 29 October 2007. The individual had a pale grey upper head and was virtually white on its back, except for a hardly visible grey hue. It had red eyes and was yellowish at the base of its bill. Front neck and flanks were entirely white. Dilution was a plausible explanation for the pale plumage.

In 2008, thirteen aberrant Eared Grebes were reported. G. Babbitt detected a whitish grebe (PNIca200802022) at Gila Bend Power Plant Pond, Maricopa County, Arizona, USA, that he classified as an albino. It was present there from May until at least late in August. The bird's wings showed a pale grey colouration, and light greyish hues were detectable in the head of its otherwise whitish plumage. It had a light grey beak and its eyes were red. Dilution was a possible cause of the reduced pigmentation. At the south end of Salton Sea, southwest of Obsidian Butte, California, USA, Robin detected a leucistic grebe (PNIca200803020) on 23 October 2008. He failed to describe it. It is included in the register as a whiteling. M. Brown photographed a quite pale grey and partially white individual (PNIca200804022) at the Guadalupe sewage ponds, California, USA, on 15 June 2008. This grebe was middle grey in its crest and paler grey on the back. Its ear tufts were yellowish white. Front neck and flanks were virtually white. It was pastel diluted. From Santa Barbara County, California, USA, S. Walter reported an albino (PNIca200805022) seen on 7 April 2008. It looked entirely white and had a light, flesh coloured beak. The eyes were red. The individual was at least in its second calendar year and displayed a developing white crest. Total leucism appeared plausible. In June 2008, Adrian observed four leucistic Eared Grebes from the causeway to Antelope Island, Great Salt Lake, Utah, USA. He described only the first of them (PNIca200813022) as almost entirely white, with the exception of the back of the head and around the throat. Its pale grey crest was still elongate and the ear tufts were pale yellowish. The head plumage had retained a rather strong grey tint, especially in the nape. This tint continued into the upper neck. The bill and the eyes were regularly coloured. The lower neck and the back were of a slightly greyish white. The description indicated pastel dilution as a plausible cause. Adrian's three remaining records (PNIca200814020, PNIca200815020, PNIca200816020) could not be assessed and must therefore be classified as whitelings. C. Conard (2008) mentioned an albino Eared Grebe (PNIca200817220) seen at the Consumnes River Preserve, California, on 11 October 2008. No other details were available. The late observation date ruled out albinism, otherwise the cause remained unknown. C. Conard also informed me about the next two sightings. G. Chaniot reported a totally

albino individual (PNIca200818030) seen at some distance on Borax Lake, California, on 5 November 2008. He confirmed that he had not detected any hue of any other colour in the grebe's plumage, that looked really snow white. The grebe was too far away for a detailed description. The survival into November proved that the individual was not a true albino. It may have been totally leucistic, perhaps even simply extremely bleached or in an ultimate stage of progressive greying. L. Hug saw a nearly complete albino (PNIca200819030) at Soda Bay resort on Clear Lake, California. For this record, no other details could be obtained and it could not be assessed. Albinism was however ruled out as the record was obtained on 9 November. On 12 September 2008, an almost completely white Eared Grebe (PNIca200820022) was photographed at Eagle Lake, Lassen County, California, USA. The photo showed a virtually white plumage except for a cream brown or tan hue on the upper head. There was a similar but paler hue on the back. The bill was almost entirely yellowish to flesh-coloured whereas the eyes looked pinkish. Ino best explained this appearance. A photo of an unusual individual (PNIca200821022) was taken at San Francisco Bay National Wildlife Refuge, Fremont, California, USA, on 18 April 2008. The grebe, in breeding plumage, had a fully developed crest and regular ear tufts. The bill was black and the eyes were red. Pale or even whitish plumage surrounded the base of the bill and covered the chin. The feathers underneath the yellow ear tufts were rather white. The lower neck was quite light red brown, the upper breast more whitish with some pale grey dots. The entire plumage looked soaked. A simple case of incomplete moult seemed unlikely. No genetic mutation really fitted. Vitiligo, considered to be part of progressive greying, might serve as an explanation (H. van Grouw, pers. comm.).

Five Eared Grebes, four of them declared as leucistic, were reported in 2009. At Moore Park on Lower Klamath Lake, Oregon, USA, H. Fuller detected an individual with white feathers (PNIca200901020) among numerous conspecifics in breeding plumage on 24 May 2009. The extent and location of the white feathers were not indicated. The grebe was qualified as whiteling. M. Rackley reported a pure white bird (PNIca200902022) from Clear Lake, Lakeport, California, USA, on 4 April 2009. Its bill was light grey and in part slightly yellowish. Its legs in the water looked pale grey. Its eyes were perhaps slightly pale red, but this impression may have been due to the light conditions of the photo or the surrounding white feathers. The greyish feet of the grebe suggested they were hardly affected, if at all. Due to its adulthood and the timing of the observation, the individual was not an albino. If totally leucistic, the bare parts should have been affected, but this was not the case. Progressive greying seemed possible. At Salt Pond A12, Alviso, California, USA, a white individual (PNIca200903022) was observed among a group of breeding plumaged Eared Grebes on 19 May 2009. The photo by A. Sinha proved that the grebe was not really white in most plumage parts, but simply pale. Normally black plumage looked pale grey to whitish. The fore neck was fairly white and the flanks were pale rufous. The ear tufts were yellowish white. The beak was dark. The eyes could not be assessed. The grebe's appearance was best explained by dilution. G. Reis saw a leucistic individual (PNIca200904020) near South Tufa, Mono Lake, California, USA on 7 October 2009. It was with about a million other Eared Grebes. It was spotted several times. Apart from its being white and qualified as leucistic, no details were given. The individual was included in the appendix under whiteling. At Henderson Bird Viewing Preserve near Las Vegas, Nevada, R. Michal took a picture of an individual with a chestnut red fore neck (PNIca200905021) on 5 July 2009. The grebe, in complete breeding plumage, carried two chicks on its back. Its upper breast and entire fore neck were chestnut red. The cause of the aberration was erythromelanism.

Eight aberrant grebes were added in 2010. My own trip to Utah, USA, in July produced five of them. At Strawberry Lake, an overall rather pale grebe in breeding plumage (PNIca201002303) was observed on 22 July. It looked floured, especially in the face, in the fore neck and on the back. Crest and nape were darkest. Its ear tufts were light yellow, its flanks light rufous. This suggested that phaeomelanin was present in low quantities only. At the onset, its beak was yellowish. Its upper breast was rather white. From a distance, the back was bright white and looked bleached. At closer range, some darker feathers were detectable in the wings. Pastel dilution was a plausible explanation for this integument. From the causeway to Antelope Island on Great Salt Lake, I detected three whitish grebes among over 1,000 on 11 July.

Fig. 37: Eared Grebe at Great Salt Lake, USA, in 2010, plausibly affected by progressive greying (PNIca201003303, photo A. Konter).

The first of them (PNIca201003303) appeared entirely mottled with white and darker grey or black feathers. Its forehead, cheeks, chin and short ear tufts were mostly white though. Light yellow feathers were visible at the tufts. The crest and the nape were still rather dark grey. The neck was mostly white in front and on the sides. A narrow dark line was present at the hind neck. The beak was yellowish and darker at the culmen and the tip. The mantle was heavily interspersed with white and darker feathers. Its flanks were not much different and likewise quite light coloured, though a light chestnut hue had survived there. The darker feathers in the plumage seemed not much affected and did not look bleached (Fig. 37). They may have been really black and only looked paler because of the mottling with white. Therefore, progressive greying was a plausible explanation. The second individual (PNIca201005303) was darker, more blackish, especially in the head, the hind neck and on the mantle. The mantle was slightly paler than the head. The upper breast and the fore neck were of a lighter grey and partially white. The flanks were mottled in black, beige brown and white. The ear tufts were of a dirty yellow. The beak appeared to be light at the base, but looked dark overall. The iris was red. In most parts of the plumage, pale to whitish feathers were present. The grebe was in moult, which explained part of its appearance. It was otherwise probably affected by progressive greying. The last specimen (PNIca201006303) at the causeway was still in breeding plumage and displayed an elongate crest and ear tufts. It had, however, a whitish appearance, just as if floured, and closely resembled the individual seen earlier at Strawberry Lake. Its face was completely white and its crest was paler than it should have been. The ear tufts appeared light yellow to whitish. The beak was dark. The iris was of a regular red. The grebe's neck and back were pale and partially white. The flanks were quite light, nearly white, though interspersed with chestnut and greyish hues. The individual was possibly affected by dilution. At Farmington Bay of Great Salt Lake, I observed on 1 July 2010 a grebe in breeding plumage (PNIca201010303) where the plumage of the neck and the upper breast was interspersed with chestnut feathers. The red brown colouration reached nearly up to the chin. Erythromelanism seemed indicated. The grebe was caring for a chick, a few days old.

Fig. 38: Aberrant Eared Grebe at Tule Lake, California, in 2011, possibly ill (PNIca201106303, photo A. Konter).

At Gutierrez Ranch, Crook County, Oregon, USA, C. Gates, K. Owen and S. Staats detected an all-white individual (PNIca201007020) except for a dark wash on the neck. No other details of this grebe, seen on 16 August 2010, were available. The dark wash on the neck excluded albinism and forms of leucism as causal mutations. The colour of the hue in the neck was not mentioned. A final assessment was not possible. From the Sewer Ponds at Bishop, California, USA, C. Howard provided a photo of his sighting of a lone albino (PNIca201009022). The female grebe, seen in mid-August 2010, was overall very whitish, though the normal winter subdivision between darker and whitish plumage parts was detectable. The grebe was completely white in its lower face, front neck, upper breast and flanks. It had, however, a very pale grey upper head and hind neck. In its mantle remains of what might initially have been pale grey pigmentation were detectable. Its bill was pale steel grey. Its eyes were difficult to assess on the photo, but they looked red. The bird was affected by dilution. Another Eared Grebe (PNIca201011022) was observed at Tule Lake National Wildlife Refuge, California, USA, on 22 June 2010. B. Bouton's picture showed a grebe in breeding plumage with a quite regular head and upper neck pattern and colouration. The ear tufts were golden yellow, the remainder of the head and upper neck plumage quite dark. The pigmentation first faded slightly in the lower neck and then mostly failed in the upper breast. The back was of a uniform pale grey. The flanks were pale grey to white, with only few tinges of pale rufous. The bill was dark. The glowing red eye indicated that the individual was at least in its second calendar year. It was in the company of a normally pigmented partner. The paleness of the back and flanks argued in favour of pastel dilution. Due to the reduced levels of melanin protection, feathers in regular contact with the water could have suffered from longer stays in alkaline lakes.

In 2011, ten more abnormal Eared Grebes were recorded. R. Wolf photographed a slightly leucistic individual (PNIca201101022) at Shoreline Park, Mountain View, Santa Clara County, California, USA, on 20 March 2011. It was in full breeding plumage and displayed golden yellow to chestnut golden ear tufts. In the black parts of its plumage, white spotting or lining was visible at the chin and at the cheeks. There was strong mottling with

white feathers on the black upper breast and lower front neck. These white feathers extended slightly into the rufous flanks. They were not comparable to the conditions observed in an incomplete moult, as can occasionally be observed in subadults. They rather matched those observed in progressive greying. M. Todd provided a picture of a leucistic grebe (PNIca201103022) from West Wendover, Elko Co, Nevada, USA, present there on 20 August 2011. The bird was at some distance and appeared to be completely white on the back, possibly a consequence of sun bleaching, and whitish on the upper breast. The neck and the head looked dark, rather black, except for the pale yellowish ear tufts. The bill looked dark. The photo was from too far to see the colour of the eyes. Judging by its long beak, the bird was a male. Pastel dilution seemed a possible explanation for this appearance. The next record was from Upper Klamath Lake, Oregon, USA. In May 2011, I observed an adult in complete breeding plumage with a mostly bright rusty orange upper breast (PNIca201105003). The colour continued into the lower fore neck, where it became less visible, due to the simultaneous presence of blackish feathers there. The colour was lighter than the chestnut red occasionally observed in different individuals. It is therefore not certain that it was caused by erythromelanism. On Lower Klamath Lake, California, USA, an Eared Grebe in complete breeding plumage (PNIca201107003) was engaged in nest building with its partner in May 2011. It displayed an intense chestnut tinge on its upper breast and lower fore neck. The simultaneous presence of black feathers in this area, predominantly in the central part, meant that the neck of the grebe still looked quite dark and did not much resemble that of a Horned Grebe. The neck was affected by erythromelanism. The last two records were from neighbouring Tule Lake, California, also from May 2011. The first bird was quite "funky" (PNIca201106303). It had a rather short crest and ear tufts that both looked shaggy. In addition, the ear tufts were brownish yellow at the onset and became whitish further backward. White feathers were interspersed in the otherwise dark chin and cheeks. The beak was light grey and darker at the culmen, the eyes were red. The nape showed mottling with white and dark feathers. The hind neck appeared to be more brownish grey. The fore neck and breast were pale to whitish. The back was middle grey, not black. The flanks were predominantly white and held some pale grey feathers (Fig. 38). Some characteristics of the individual's appearance gave the impression that this Eared Grebe might have been ill or old. It might still have been in moult, which would explain part of its appearance. The faded colour of the back suggested dilution. Several causes may have contributed to the grebe's unusual plumage. The second individual (PNIca201111303) was in full breeding plumage. It resembled PNIca201101022. Its plumage was shining black in the head, neck and back, it had fully developed yellow ear tufts and bright chestnut flanks. It had red eyes and a blackish bill. On the lower front neck and upper breast, it showed mottling with white feathers, probably stemming from progressive greying. It displayed with a conspecific with which it appeared to be firmly paired. R. P. O'Donnel photographed a pale Eared Grebe (PNIca201113022) at Great Salt Lake, Utah, on 8 October 2011. From a distance, the individual looked virtually white. A closer look revealed the presence of greyish hues. These were visible in the crest, where they produced the normal winter subdivision between dark and white feathers. The tinge was much paler in the neck and on the back. The bill looked pale grey, the eyes were red. The individual was affected by a form of dilution. On 16 July 2011, M. Forsman photographed a rather red brown Eared Grebe (PNIca201114022) at Ventura Marina, California, USA. The photo showed an individual in normal breeding plumage with a partially chestnut red lower fore neck and upper breast. Chestnut hues were also present in the hind neck and on the back. The grebe was body shaking, thereby displaying the pigmentation of its belly: the feathers were completely brownish red, a bit darker than those of the flanks. The glowing red eye suggested that this was an adult grebe. It had a dark bill and golden ear tufts. The bird was affected by phaeomelanism. On the neck and upper breast, the effects were similar to erythromelanism. At Bolsa Chica Ecological Reserve, California, USA, a grebe in full breeding plumage (PNIca201115022) was photographed on 1 May 2011. It was a male with golden red ear tufts. Its upper breast and lower front neck were mostly chestnut red, indicating the presence of erythromelanism.

The register received three datasets in 2012 and nine in 2013. J. Ruckdeschel reported a white grebe (PNIca201201022) from the causeway to Antelope Island, Great Salt Lake, Utah, USA,

Fig. 39: Diluted Eared Grebe (right) in the company of conspecific in regular breeding plumage at Henry's Lake, USA, in 2013 (PNIca201303022, photo Bill Schiess).

on 8 September 2012. L. Smith's photo showed a pure snow white bird with a dark beak and glowing red eyes. A bare yellow outer eye ring and a deep yellow inner ring to the pupil were detectable. The colour of the iris proved that the grebe was at least in its third calendar year. It was not a true albino. The snow white plumage of the head, neck and body showed no coloured tints. The grebe might have been totally leucistic, but bare parts displayed the normal conditions. Progressive greying at a final stage was therefore the best explanation. In Alberta, Canada, H. Cuthill photographed two aberrant Eared Grebes. At Klein Park, Calgary, she observed a female in complete breeding plumage (PNIca201204021) on 1 June 2012. The individual had its upper breast and the lower half of its front neck covered with chestnut red feathers. The grebe was paired to a regular conspecific. Erythromelanism had caused the red brown feathers in the female's plumage. At Frank Lake, High River, a grebe in complete breeding plumage (PNIca201205021) was carrying two chicks on its back on 15 June 2012. The adult's flanks were almost entirely black with only a bit of rufous shining through. The back seemed to be of a more sooty black than usual. The ear tufts were pale yellow. The paleness appeared to be due to sooty tinges. A form of eumelanism may have caused the darkening.

On 29 May 2013, B. Olsen photographed a leucistic Eared Grebe (PNIca201301022), probably in Utah, USA. The individual was moulting into winter plumage. It was overall paler than usual. Its head and its hind neck were still rather dark. The short ear tufts were yellowish white. The eyes were red and the bill slightly light. The regions of the chin and the front neck were whitish with a brownish hue to the sides. The flanks were mostly white. The back was entirely pale grey mottled with white. Dilution was probably at the origin of the appearance. At the Salton Sea, California, USA, D. Guthrie observed a white Eared Grebe (PNIca201302032) on 17 July 2013. The observer's photo showed a mostly cream white adult. The iris had slightly pale red colour, perhaps an effect provoked by the surrounding white feathers. The bill was dark and had a light tip. The bare line between it and the eyes was pink. The predominantly whitish ear tufts displayed a hardly noticeable yellowish tint. The plumage was

Fig. 40: Diluted Eared Grebe changing to winter plumage at Henderson Bird Viewing Preserve, Las Vegas, USA, in 2013 (PNIca201302022, photo Christina Nycek).

greyish at the nape. In the hind neck, the colour was more washed. Some grey blotches showed up in the otherwise white back. The individual was neither an albino nor leucistic. With the bill visibly unaffected, pastel dilution best explained the grebe's appearance.

Around 11 July 2013, B. Schiess noted a partially leucistic Eared Grebe (PNIca201303022) at Henry's Lake, Idaho, USA. The photo provided by the observer showed an individual in the company of a regularly pigmented conspecific (Fig. 39). It had a dark grey crest and upper neck and a slightly paler bill than usual. The eye colour was of a more blurred red. The ear tufts were yellowish white. In the lower neck, the dark feathers were interspersed with white marks, especially in the hind part. The back was strongly mottled with whitish feathers and appeared floured. Similarly, the flanks were very light and showed only a very weak hue of light chestnut. The grebe was plausibly affected by a form of pastel dilution. On 14 July 2013, L. Myers saw a pale Eared Grebe (PNIca201304022) at Mono Lake, California, USA. Her photo showed a whitish grebe with a dark grey upper head and hind neck. The ear tufts were very pale yellow. The fore neck and the flanks were almost white. The back was mostly white with some darker pigmentation shining through. The eyes and the bill appeared to be normally pigmented. A likely mutation was pastel dilution. On 20 May 2013, D. Delaney photographed an Eared Grebe (PNIca201305022) at John E. Poole Wetland, St. Albert, Alberta, Canada. His photo showed a grebe in breeding plumage with a chestnut red lower fore neck and upper breast. Its red eyes proved adult status. The bill was black. The golden ear tufts had a big chestnut red tinge in their lower parts. Erythromelanism had caused the chestnut feathers in the fore neck and upper breast. A more greyish Eared Grebe (PNIca201306022) was present on pond 7 at Henderson Bird Viewing Preserve, Las Vegas, USA, between 30 July and at least 4 August 2013. The photo, by C. Nycek and received via C. Titus, showed an overall pale grey to whitish plumage. The grebe had a whitish face and a grey nape. Its eyes were slightly pale red. Its dark bill had a white tip that caused it initially to be wrongly identified as a Horned Grebe (PAUco201302022). A closer look at the bill showed that the colouration was fading in other

Fig. 41: Eared Grebe in breeding plumage with much white in its fore neck, upper breast and flanks, Little Manitou lake, Canada, 2008 (PNIca200810303, photo A. Konter).

Fig. 42: Diluted African Black-necked Grebe at Fickland Pan, South Africa, in 2004 (PNIgu200402305, photo A. Konter).

parts too, and the white tip was more related to the change into winter plumage. The mostly whitish neck showed dark grey in its extreme upper part and was lighter further downward. The flanks were mottled in light grey and white. The feathers of the back were pale grey (Fig. 40). The causal mutation was plausibly dilution. Progressive greying seemed less likely as no really dark grey or black plumage parts were detected. At Salt Pond A12 in Alviso, Santa Clara Valley, California, USA, an aberrant Eared Grebe (PNIca201307020) was recorded on 19 October 2013 by B. Reiling. Except for the indication leucistic, no details of the observation were provided, and the aberration could not be assessed. At Bear River Migratory Bird Refuge, D. Getty photographed an adult grebe in full breeding plumage (PNIca201308022) on 21 April 2013. The entire upper plumage was black. The individual had long golden yellow ear tufts and an elongate black crest. Isolated white feathers were prominent in the ear tufts. The glowing red eye indicated that the bird was in at least its third calendar year. It had a dark bill. However, the partially white feathers at the chin and at the lower neck, that became even more prominent at the upper breast, did not fit. In addition, isolated white feather patches were present in its chestnut flanks. Although the grebe looked leucistic, progressive greying seemed a more plausible cause. On 26 September 2013, M. Hearell photographed a rather pale grey Eared Grebe (PNIca201309022) at the Agricultural Issues Center of Davis, California, USA. The grebe was already in non-breeding plumage. It was darkest on the upper head. Its lower face, front neck and flanks were white except for light greyish hues in the flanks. The eyes were of the usual red for adults. The bill was pale and slightly pinkish. The sides of neck and the back were pale grey to white. The hind neck stripe was a bit darker. The grebe was subject to dilution.

In all my observations of Eared Grebes in Canada and in the USA throughout eight breeding seasons, I have always encountered several individuals displaying the conditions expected by Storer and Jehl (1985) in subadults (see Fig. 41). As with their European conspecifics, I have adopted only one example for the register. The eye colour of the individual in Fig. 41 (PNIca200810303) suggested that it was not a subadult. Also the ear tufts were not of a pale yellow, as should be the case in subadults, and ornamental feathers were fully developed. The issue merits further discussion and probably investigation. There seems sufficient evidence to state that not all of these grebes are subadults. PNIca200810303 was observed at Little Manitou Lake, Saskatchewan, Canada, on 27 May 2008.

The register of aberrant Eared Grebes is probably not complete, and many sightings may not have been reported at all, as abnormally coloured individuals might not be that uncommon (Jehl 1985). During his studies at Mono Lake, Jehl (1985) usually made censuses of the Eared Grebes at intervals of three or four weeks. He found that "leucistic" – or rather aberrant – grebes were rare at Mono Lake among spring migrants. In March or May of the years 1981 to 1983, he noted not a single aberrant individual among ca. 42,000 birds counted. In 1984, there were two among ca. 26,000 grebes. Jehl estimated that spring presence of abnormal individuals was no more common than 1:15,000-20,000. This ratio increased in the summering population to 1:5,000-8,000 in the years 1981, 1982 and 1984. In 1983, abnormally coloured grebes were exceptionally numerous, with at least 13 in a summering population of 6,000 (1:460). In mid-August and September, the ratio seemed to approximate to 1:15,000. Irrespective of the underlying causes for an unusual appearance, Jehl's data proved that aberrant individuals were more numerous in the summering population. Jehl believed that this population is composed mainly of one- and two-year-old birds. He thought that the conspicuous whitish individuals were quite safe at Mono Lake, where predation was essentially nil, whereas they were more susceptible to predation on the breeding grounds. The analysis of Jehl's data showed that a majority of his records concerned progressive greying: affected summering birds were probably older birds and the reason for their stay over the breeding season may have been related to old age rather than to safety.

In a more recent article, Jehl (2007) stated that all-lake censuses among autumn populations at Mono Lake, California, in the 1980s and 1990s might produce 10 to 15 aberrant grebes in a day, with a maximum of 24. As no individual data for these grebes were given in the article, they could not be integrated into the register of this study. Since Mono Lake holds about half of the North American population in autumn, Jehl (2007) estimated the frequency of aberrations – of various degrees – as 1:100,000-150,000. This is in line with

Dave Marquart's statement that he can see at Mono Lake Tufa State Natural Reserve, where he is a State Park Interpreter, anything between one and four pure white Eared Grebes each autumn (pers. comm.). The rather low percentage of Eared Grebes with a predominantly white plumage would fit a pyramidal age structure and supports progressive greying as a cause for the aberrations.

3.13.3. Aberrant African Black-necked Grebes *Podiceps nigricollis gurneyi*

Two aberrant individuals were of the African subspecies *gurneyi*. At Walvis Bay, Namibia, a very pale Black-necked Grebe (PNIgu20xx01022) was photographed on an unknown date. The photo showed a bird that was predominantly pale greyish in its head and virtually white on its back and in the flanks. It was darkest in the crest, the nape and upper neck. It was nearly white on the forehead and in the lower fore neck. The ear tufts were pale yellowish to white and the beak was pale grey. The eyes could not be assessed. Pastel dilution may have caused the grebe's appearance.

The second record was from South Africa. It was obtained during my visit of 2004. At Fickland Pan, Wakkerstroem, an overall pale grey individual (PNIgu200402305) that was moulting into breeding plumage was present on 21 October. Judging by its beak size, it was a female. Its head, neck and back were of a rather uniform pale to middle grey. The fore neck, the upper breast and the flanks were more whitish or cream coloured. In most parts of the plumage, pale chestnut brown hues could be observed. The crest was well developed, the ear tufts were still short and their yellow colour was not very prominent. The bill was dark. The eyes were of a regular red and had a yellow outer bare ring (Fig. 42). The individual was subject to a form of pastel dilution.

During both trips to South Africa in the breeding seasons of 2004 and 2005, I encountered a few Black-necked Grebes in incomplete breeding plumage. They had some white feathers on the chin, the fore neck and/or the upper breast. As with European conspecifics in similar conditions, they may have been subadults.

3.14. Silvery Grebe *Podiceps occipitalis*

A leucistic Silvery Grebe (POCoc199401121) of the nominate form was mentioned by Fuentes and González-Acuña (2011). In the text, the grebe was not further described except for having been whitish. The individual photographed by H. Kocksch near San Vicente, Chile, in mid-August 2004 showed a fairly regular head and neck pattern and a progressively fading grey plumage from the lower hind neck towards the rump. From the middle of the back on, the feathers were virtually white. The flanks were completely white. Dilution rather than leucism had caused the aberration.

Additional records were added by myself. Two sightings were confirmations of Fjeldså's and Krabbe's (1990) statement that on some lakes, Silvery Grebes are stained ferruginous on the breast. Two individuals of the subspecies *juninensis* (POCju199801303, Fig. 43, POCju200401303) and seen at Sajama National Park, Bolivia, served as examples. They showed a quite intense rusty orange colouration leading into the front neck on their upper breast. Further Silvery Grebes with lighter orange hues that were present there in 1998 and 2004 were not included in the register. They proved that the degree of brightness of the unusual colour is quite variable, even in one and the same population. By no means all grebes on this body of water were visibly affected.

An interesting sighting at Sajama National Park in 2004 was that of a Silvery Grebe with pale yellowish feathers fanning out from the ear region (POCju200402303). In all other grebes present, these feathers were greyish or silvery grey, as should be the case for the subspecies *juninensis*. The individual may have belonged to the nominate form *occipitalis*. At a latitude of 18° south, it would have been far outside its normal range of occurrence, which ends sharp at 36° south (Fjeldså 2004). It is conceivable that this grebe joined a wrong group for migration. More speculative is the possibility that atavism was at the origin of its appearance.

NB: Following the application of criteria set out by Tobias et al. (2010), BirdLife is going to split the Silvery Grebe into *P. occipitalis* and *P. juninensis* (Taylor 2014). The current subspecies will then acquire species status.

Fig. 43: Pair of Silvery Grebes at Sajama National Park, Bolivia, in 1998: the partner to the left displaying much rusty orange on its upper breast and lower fore neck (POCju199801303), the other being almost completely white in this area (photo A. Konter).

Fig. 44: Pair of Hooded Grebes at Laguna Encantenadas, Argentina, in 2003: the left individual shows a hardly noticeable hue in its upper breast, while its partner (PGAga200601303) has strong rusty orange tinges there (photo A. Konter).

3.15. Hooded Grebe *Podiceps gallardoi*

Apart from a hybrid (see chapter 3.22), no records of aberrant Hooded Grebes could be found. This may be because of the late discovery of this grebe species (only in 1974), the remoteness of its breeding and wintering grounds, and the limited population size. My own records included an individual (PGAga200601303) seen close to Laguna Encantenadas, Patagonia, Argentina, in late December of 2006. It was in breeding plumage and displayed a rusty orange colouration in its upper breast (Fig. 44). Its partner had a similar, but far less prominent, hue in the same plumage area. During my observations at a breeding colony at Laguna Encantenadas in December 1998, I also noticed a few individuals with a similar and in some cases stronger rusty colouration in the upper breast. In a few, the pigmentation even spread into the lower fore neck. The hue could theoretically be related to incubation and staining from the nesting substrate. However, PGAga200601303 did not seem to have bred so far that season. Alternatively, some substance regularly occurring in the waters visited by the grebes may have been at the origin of the colouring. It did not look as if it could be related to a genetic mutation. The condition may be of more widespread occurrence in the species, although Fjeldså (2004) did not mention it.

3.16. Colombian *Podiceps andinus* and Junin Flightless Grebe *P. taczanowskii*

Of the Colombian Grebe, now considered extinct, no aberrant individuals are known. This is also the case for the shrinking and highly threatened population of the Junin Flightless Grebe. The remoteness of their geographic areas of occurrence and the difficulties of travelling there may be the main explanations for the absence of data in the register.

3.17. Western Grebe *Aechmophorus occidentalis*

There is one older record of an aberrant Western Grebe (Weller 1959, King 1973). The individual (AOCoc195501100) was collected in Manitoba, Canada, in 1955. It had a pure white plumage, pink eyes and very pale cream-yellow bill and feet. Weller (1959) gives no date of collection. King (1973), based on a letter received from the Manitoba Museum, where the skin is now deposited, indicated October. If the time is correct, the grebe was fully grown and not an albino. Instead, it may have been affected by ino, as the pinkish eyes would suggest. Three additional records were published on the internet. Near Brigham, Utah, USA, J. St. Sauver recorded an almost completely white *Aechmophorus* grebe (AOCoc201003022) with just a touch of grey in its plumage on 17 October 2010. The individual was in a group of Western Grebes: it may have been of the same species and not a Clark's Grebe. Without additional details, it was not possible to ascertain the cause for this appearance. A partially white grebe (AOCoc201101022) was observed on Lake Hodges, California, USA, in November 2011 by R. Harrington (Fig. 45). The usually blackish parts of the plumage were all interspersed with white feathers. This gave the individual a grizzled or mottled appearance. Its iris was red, suggesting that the grebe was an adult in at least its second calendar year. The bill was yellowish green to olive, as is normal for Western Grebes. The individual was subject to progressive greying. A very similar looking Western Grebe (AOCoc201201022) was photographed by F. Petersen at Virginia Lake, Nevada, USA, in November 2012. It had a shorter bill and was therefore a female. We can rule out the possibility that these were the same bird, although their plumages looked quite identical. There was a time interval of exactly one year between the observations, and the second record occurred about 750 km north of the first. Judging by its less intense red eye colour, the Nevada individual was a subadult. The distribution of the white feathers suggested progressive greying as a cause for the grebe's appearance. In that case, either the eye colour, as reproduced on the photo, was misleading or progressive greying had started at a young age.

Fig. 45: Western Grebe affected by progressive greying, Lake Hodges, USA, 2011 (AOCoc201101022, photo Robert Harrington).

Fig. 46: Mating of a Western Grebe (AOCoc200902303), with strong rusty orange tinges in its lower fore neck, its breast and its belly, and a Clark's Grebe at Lake Almanor, California, in 2009 (photo A. Konter).

Fig. 47: Possibly melanistic Western Grebe at Tule Lake, California, in 2009 (AOCoc200905303, photo A. Konter).

In some Western Grebe populations, the white plumage of the breast and neck may change to rusty orange tinges during the breeding season. For example, at the nesting colony of Lake Almanor, California, USA, many Western Grebes displayed rusty patches in their upper breasts in 2009. At times, they extended into the upper neck. They were often present on the belly too. The intensity and the area covered by the unusual colouration were quite variable. Examples adopted in the register generally had strong hues. The first grebe (AOCoc200901303) was a female. It may have been an intermediate between a Western and a Clark's Grebe. Although its eyes were completely surrounded by black feathers, as is normal for Western Grebes, its bill was really yellow and not greenish. However, it was not orange yellow, as is the case for purebred Clark's Grebes. The individual had a big and bright rusty chestnut patch extending from the upper breast towards the belly. The second (AOCoc200902303) was a male paired to a Clark's Grebe. The pair was nesting (Fig. 46). The rusty chestnut colouration in the male was very intense. It reached up from the breast to cover over half of the fore neck. It was present over the entire belly, where it was more washed. The third individual (AOCoc200904303) was a nesting female with a balanced distribution of the rusty chestnut tinge over the lower fore neck, the breast and the belly. In all Western Grebes seen to have a tinge, the most intense colouration was always on the upper breast. The belly could remain virtually unaffected or could display a more or less intense tinge. I noticed that the strange pigmentation was not always shared by both partners in a pair. At Drews Reservoir, Oregon, where no nesting was recorded, not a single grebe with a rusty tinge could be found. Also at East Park Reservoir, California; Lake Ewauna, Oregon; or Lake Shastina, California, no such grebes were found in July and August 2009. In the post-nesting population at Moore Park, Upper Klamath Lake, Oregon, no grebe displayed an intense presence of rusty tinges. In a few birds, only a light tinge was observable. In some grebes, the tinge was equally intense in the upper front neck than in the upper breast. At Tule Lake, California, the grebes present, whether caring for offspring or not, hardly had any rusty blotches. In July 2010, the vast majority of the Clark's and Western Grebes nesting at

Unit 1 and Turpin Unit of Farmington Bay, Great Salt Lake, Utah, USA, showed no intense rusty patches. This suggested that in most birds, the tinges were, if present at all, rather pale and not easily detectable in the field. Similarly, at Pelican Lake, Manitoba, Canada, in almost all the adult Western Grebes caring for young in early August 2006, rusty tinges appeared to be absent from the upper breast and the neck. In a few birds, a pale orange shadow was present. The preceding examples concerned populations that had either already bred or were incubating. The presence or absence of rusty hues may then have depended on the nesting substrate. However, in the pre-nesting population at Upper Klamath Lake, Oregon, at least some grebes presented a more or less intense rusty breast in May 2011. So the colour may not – or at least not always – be related to the nesting material. It is noteworthy that on Upper Klamath Lake, the most intense rusty orange tints were on the upper breast of a few Clark's Grebes (see 3.18). Theoretically, three origins for the pigmentation are conceivable: staining from the nesting substrate; tinting by substances contained in the water; and genetic mutation. The issue needs further investigation.

In addition to the examples of possible rusty staining, my own observations revealed a few individuals which appeared to display melanistic traits. A Western Grebe (AOCoc200905303) seen at Tule Lake, California, USA, in July 2009 had the black of the crest descending far down and covering the cheeks and the region of the ears. The black feathers of the hind neck also spread into the sides of the upper neck. The male had a yellowish green bill (Fig. 47). There were no character traits pointing to a possible intermediate. At Bottle Hollow Reservoir, Utah, USA, a female (AOCoc201001303) caring for a chick in July 2010 had the regions of the cheeks and the ears strongly mottled with black feathers. It had a regularly coloured bill and displayed no intermediary traits between the two *Aechmophorus* species. At Minersville Reservoir, Utah, USA, a male (AOCoc201002303) showed similar characteristics in its face. It too had no intermediary traits. In a fourth bird (AOCoc201102303) recorded at Upper Klamath Lake, Oregon, USA, in late June 2011, the upper breast or lower fore neck displayed a kind of horizontal greyish band in the very lowest part of the fore neck. It was about 5 cm wide to the side of the neck and narrowed in the central fore neck. It looked like a lateral extension of the pigmentation present in the hind neck, and may therefore have been melanin-based rather than stemming from staining or oiling. The individual was engaged in rushing with a conspecific. All four grebes had plumage and bare parts patterns that corresponded to purebred Western Grebes. Melanism appeared to be the most plausible explanation for the unusual dark areas in their plumages. Western and Clark's Grebes are however known to interbreed (Konter 2009, 2012b, Nuechterlein & Buitron 1998). An alternative explanation may therefore be found with hybridization and back-crosses.

3.18. Clark's Grebe *Aechmophorus clarkii*

The only mention of an aberrant Clark's Grebe in the literature concerned an abnormal bird (ACLtr198601100) at Lake Osakis, Minnesota, USA (Janssen 1986). This individual had a black crest that ended above eye height. However, it connected laterally to the eye with a fine black line that originated to the side of the crest and left a very distinct white area above and in front of the red eye. The bird was in a group of 11 Western Grebes. Its orange yellow bill was different from that of all other group members and indicated that it was a Clark's Grebe. J. Ratti, who was consulted about the sighting, had never seen anything like it. He classified the record as of a Clark's Grebe with some type of abnormal colouration, perhaps resulting from hybridization (see Fig. 58).

Four records of aberrant Clark's Grebes were on the internet. The first observation dealt with an individual (ACLtr200701022) seen at Bosque del Apache, New Mexico, USA, by D. Streiffert. It had an orange yellow bill. Its eyes were more brown red and indicated that it was a young bird. All parts of the usually blackish plumage were heavily interspersed with white feathers: its plumage was grizzled. The bird resembled both Western Grebes AOCoc201101022 and AOCoc201201022. It was subject to progressive greying. The second grebe (ACLtr200901022) observed at Port Orford, Oregon, USA, by K. Andersson and L. Miller in 2009 was qualified as leucistic. It displayed a mix of leucistic and melanistic traits: it was pigmented in areas normally devoid of colours

Fig. 48: Partially leucistic Clark's Grebe at Port Orford, USA, in 2009 (ACLtr200901022, photo Lois Miller).

Fig. 49: Clark's Grebe in pork pie posture with bright rusty orange colouration in its upper breast, probably stemming from staining, Upper Klamath Lake, USA, 2011 (ACLtr201101303, photo A. Konter).

Table 3: Initially indicated causes of aberrations, and causes for abnormal appearances of grebes identified by this study: total cases, with in parentheses the number of cases prior to 1950.

Final cause / Initial indication	Albinism	Total leucism	Partial leucism	Brown	Ino	Dilution	Melanism	Progressive greying
Albinism	11 (3)	13 (1)		11 (6)	13 (3)	17 (1)		4
Part. albinism			1 (1)	3 (2)	1	4 (1)		7 (3)
Tot. leucism		7		5	2	13		1
Part. leucism			2	9		16		46
Brown								
Ino								
Dilution				2		5 (1)		
Melanism							12	

in this species and vice versa. A priori, the orange yellow bill identified the bird as a Clark's Grebe. However, it lacked the black culmen. The eye colour was red, perhaps a slightly paler red than expected. The forehead was almost completely white. The crest displayed a mix of white and dark brownish grey feathers further back. A kind of brown grey whiskers extended from the ear region over the cheeks to the base of the bill. The hind neck stripe appeared to have slipped into a more lateral position and wound its way down, leaving the lower hind neck white. The upper back displayed a mix of brownish grey and white feathers. The flanks were rather dark. The feet were bright yellow (Fig. 48). It is noteworthy that in K. Andersson's photo, the entire plumage of the grebe looked more dark grey and less brown. This suggested that the pigmented parts of the plumage were not affected by a genetic mutation like ino, brown or dilution. The white parts of the plumage pointed to partial leucism as causal mutation. The pigmentation in the region of the cheeks was still a mystery: a Clark's Grebe should have been white there. The absence of melanin in the bill and in the feet (leading to yellow colours) would challenge the initial species identification: a Western Grebe, in which the bare parts were affected by a mutation, would display yellow bill and feet too, and would have pigmented feathers in the region of the cheeks. Other possibilities are that an altered distribution of the pigments in the head resulted from a form of melanism or from hybridization of a Clark's Grebe with a Western Grebe.

A grebe photographed by V. Murayama at San Joaquin Wildlife Sanctuary, Irvine, California, USA, on 24 September 2012 was recorded as a juvenile Western Grebe. However, the bright yellow bill contradicted the species identification. In addition, the black crest only touched the upper eye, leaving a whitish field above the bare line connecting the bill and the eye. These traits indicated that it was in fact a Clark's Grebe (ACLtr201201022). The photo showed a mostly brownish grebe: all plumage parts normally grey were pale to darker brown, and there was a brownish hue in the flanks. A pale whitish central spot was visible above the eyes. The face, the fore neck and the upper breast were white. The bill was deep yellow without any greenish tinges. The iris was red and appeared slightly pale. A small part of the legs was visible; they appeared to be pale olive. The grebe may have been affected by brown. On 15 June 2013, C. von Rosbach took a picture of a Clark's Grebe (ACLtr201301022) at Tri-City Park, Placentia, California, USA. The individual had a dark black crest and a yellow orange bill. Its iris was of a regular red. Its back was unusually pale grey. No white feathers could be detected. Its flanks were mostly white. A form of dilution was responsible for the light plumage.

As with Western Grebes, my own record of Clark's Grebes included three individuals with varying degrees of rusty orange feathers in the upper breast and/or the neck. An incubating Clark's Grebe (ACLtr200903303) at Lake Almanor, California, USA, displayed a strong rusty orange tinge in its upper breast and belly in 2009. The

colour was lighter in the lower fore neck. In the pre-breeding season of 2011, another individual (ACLtr201102303), this time present at Upper Klamath Lake, Oregon, USA, had a bright rusty orange patch in its lower neck just above the upper breast. A second grebe (ACLtr201101303) on the same lake had the lower fore neck and the entire lower and upper breast tainted in bright rusty orange. As far as could be seen, the belly was similarly coloured. In the pork pie posture, the slight elevation of the feathers in the upper breast and lower fore neck showed that the tint was only present on the upper layer of the plumage: feathers normally covered appeared unaffected (Fig. 49). A kind of staining was the most plausible cause.

3.19. Assessment of initial colour mutation indications

Table 3 compares the causes for aberrant plumages as indicated by the observers to the causes ascertained in the course of this study. Observations from before 1950 were considered separately to allow for our developing knowledge in the field of genetic mutations. The table lists a total of 205 records for which the observer proposed, and for which this study defined, a genetic cause. Additional observations were either not assessable, because of a lack of description, or did not concern genetic mutations, or the record was published without naming a cause for the abnormal appearance of the grebe.

In only 38 cases (18.5%) did the opinion of the observer match the assessment by this study. Of 69 reported cases of albinism, only 11 were correctly identified (15.9%). Albinism was most commonly confused with dilution (17 cases or 24.6%), total leucism (13 cases or 18.8%), ino (13 cases or 18.8%) and brown (11 cases or 16.0%). The term "partial albinism" continued to be used after 1950. Of 16 records in this category, only 4 were of an earlier date. In only 4 cases (25%) was it sufficient to replace "albinism" by "leucism" to get the correct mutation. In 4 cases (25%), the individuals were in reality diluted. Besides "albinism", terms commonly and interchangeably applied by observers are "total leucism" and "leucistic". Of 28 reported cases of leucism, only 7 (25%) proved to have been correctly identified immediately. In 12 cases (42.9%), the individual may in reality have been diluted. In 5 cases (17.9%), it was brown. Partial leucism was correctly used in 2 out of 73 cases (2.7%). Most often, birds qualified as partially leucistic were subject to progressive greying (46 cases or 63%). Another 16 (21.9%) were in reality diluted. In over 30 additional cases not included in Table 3 and where grebes were said to have been leucistic or partially leucistic, the real cause could not be clearly defined. In a majority of these cases, the individuals were plausibly not affected by a form of leucism.

Brown and ino were inexistent in the field: not a single grebe was initially identified as brown or ino. In a handful of older cases, where no mutation was originally indicated, the observers appeared to have had a feeling that "not every white bird is an albino" (van Grouw 2006). They preferred to refrain from naming the aberration and to instead describe the plumage as pale brownish or sandy tinged. Dilution too was of rare occurrence: 7 cases were reported. In 5 cases (71%), the cause was named correctly. Melanism appeared to be the mutation causing the least problems to bird observers. All 12 supposed melanistic grebes were indeed melanistic.

According to the observers, 186 out of 205 aberrations (90.7%) fell into the four categories of albinism and leucism, but in reality only 21 cases (11.3%) belonged to them.

Reading the table column by column, the most striking statement is that 55 grebes were in reality diluted, but only 5 (9.1%) were initially identified as diluted. None of the 58 cases of progressive greying was initially identified. The age related change in plumage pigmentation was most often mistaken for partial leucism (46 cases, 79.3%) or partial albinism (7 cases, 12.1%).

3.20. Numbers of aberrant grebes per species and their distribution in time and space

Figure 50 shows the distribution of aberrant grebes per species. Over 44% of the observations concerned Black-necked/Eared Grebes. This is not surprising, as the species is by far the most numerous species of grebe in the world (Fjeldså 2004, Jehl & Johansson 2002). Cullen et al. (1997)

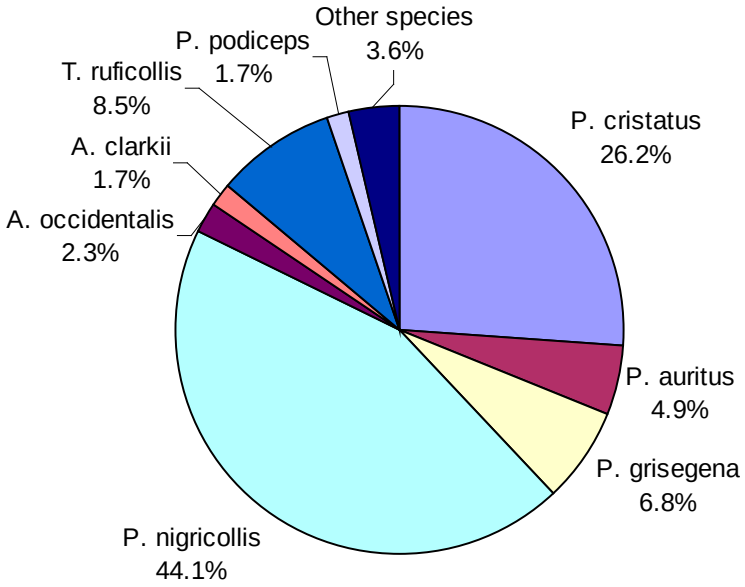

Fig. 50: Distribution of all sightings of aberrant grebes according to species.

estimated the North American population at roughly 4.1 million in 1997. The indication for the Eurasian population is "in excess of 150,000" (O'Donnel & Fjeldså 1997), but numbers of more eastern subpopulations have not been investigated. Overall numbers may exceed five million, as numbers for the nominate form might be greatly underestimated (Fjeldså 2004). The 207 aberrant *nigricollis* grebes were subdivided into 71 Black-necked (34.3%), 134 Eared (64.7%) and two African Black-necked Grebes (1%). These figures imply that, considering population sizes, aberrations are far more common in the nominate form than in the *californicus* subspecies. However, a majority of the records in both subspecies concerned progressive greying. This could then suggest that *nigricollis* grebes either have a better chance of living longer or the signs of ageing become visible earlier in Europe than in North America.

26% of the records dealt with Great Crested Grebes. The species is widespread and numerous in most parts of Eurasia. The nominate form may count over 300,000 individuals (O'Donnel & Fjeldså 1997), perhaps even up to a million, as numbers of eastern European and Asian subpopulation are poorly known. According to Fjeldså (2004), 340,000 pairs breed west of the Ural mountains. Abnormal Little Grebes represented ~8.5% of all sightings. This species is widely distributed in Eurasia and Africa. Population numbers are not well known, neither for the nominate form, nor for the subspecies. With between 700,000 and two million individuals (O'Donnel & Fjeldså 1997), Little Grebes could globally exceed the numbers of Great Crested Grebes.

79% of all records in the register stem from three grebe species (*P. nigricollis*, *P. cristatus*, *T. ruficollis*). They are also overall more numerous than most other species. With 500,000 individuals in Australia and New Guinea (O'Donnel & Fjeldså 1997), Australasian Little Grebes could be the fourth most numerous species of grebe in the world. However, aberrant conspecifics only accounted for less than 1% of the sightings.

Auritus (4.9%) and *grisegena* (6.8%) grebes, both of which breed in more northerly regions of Eurasia and North America, are well represented in the register. According to O'Donnel and Fjeldså (1997), both species have about the same population sizes, with Horned Grebes and Hoelboell's Red-necked Grebes counting over

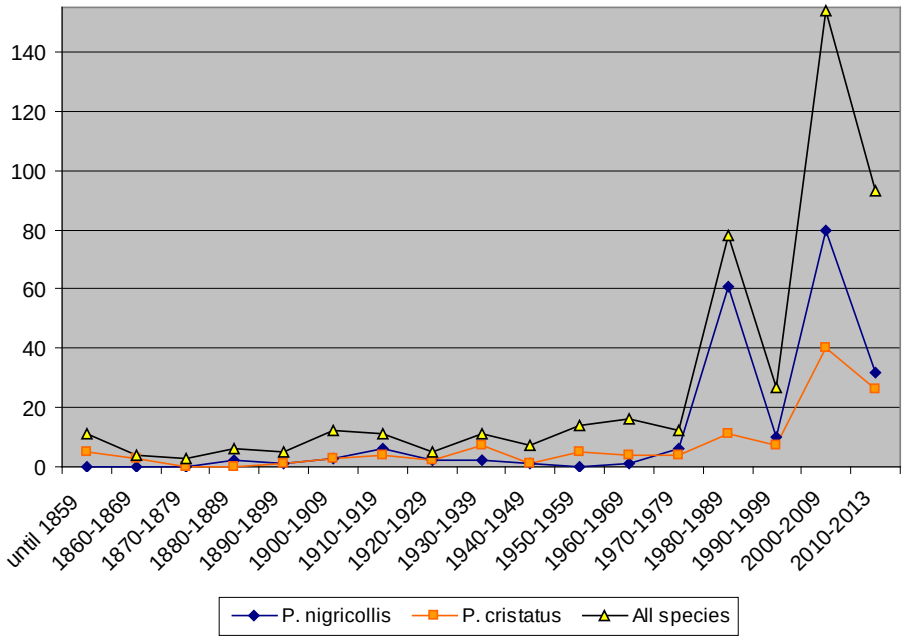

Fig. 51: Sightings of aberrant grebes per decade.

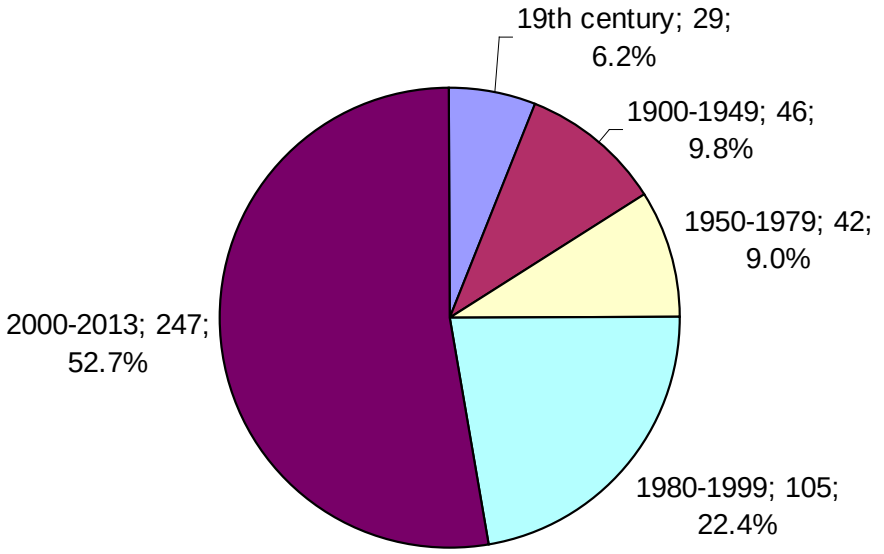

Fig. 52: Distribution of sightings of aberrant grebes of all species per time interval (variable), with indication of time period, numbers and percentages.

100,000 individuals, and Slavonian Grebes and Eurasian Red-necked Grebes accounting for 50,000 to 100,000 individuals. North American populations are possibly slightly bigger in both cases. We might then have expected more aberrant specimens for these two species too. This held true, though, only for *auritus*: 20 Horned and 3 Slavonian were aberrant. For Red-necked Grebes, 22 abnormal birds were counted in Europe and only 10 in North America.

Aechmophorus Grebes are quite common in more western parts of North America and have a total population in excess of 120,000 individuals (O'Donnel & Fjeldså 1997, Storer & Nuechterlein 1992). Aberrant individuals represent only 2.3% (Western Grebe) and 1.7% (Clark's Grebe) of the register's total. According to this study, aberrations are likely to occur relatively more often in Clark's than in Western Grebes. And indeed, Western Grebes are about ten times more numerous. Pied-billed Grebes are widespread in North and Latin America, from Canada to Argentina. Their total population is unknown. Abnormal individuals from this species represent 1.7% of the records.

Other species contributed together 3.6% of the aberrant individuals (including 0.9% for Australasian Little Grebes). Species limited to South America (White-tufted, Titicaca Flightless, Great, Colombian, Silvery, Junin Flightless and Hooded Grebes), from where the family may have originated and where seven endemic species occur, contributed only six aberrant individuals (1.6%). This number included four cases of probable staining. A genetic mutation was only implicated in one record of a Great Grebe and in one record of a Silvery Grebe. Some South American species are quite common (Great Grebe – over 50,000 ex.; Silvery Grebe – 100,000 ex. of the nominate form, O'Donnel & Fjeldså 1997).

In the time distribution of the records (Fig. 51 & 52), we see that the number of sightings of abnormal grebes remained quite low until the 1970s. Before 1979, only 117 or 25% of the records in the register occurred: per decade, generally fewer than 10 individuals were recorded. In the first half of the 20th century, more aberrant individuals were reported (9.8%) than in the following 30 years between 1950 and 1979 (9.0%). A slight increase in numbers at the beginning of the 20th century did not last for long. In the 1950s, numbers slowly increased again. They soared in the 1980s with Jehl's (1985) publication on leucistic Eared Grebes in North America (78 records in total or 16.6%). In the 1990s, the volume of observations was again down to 27. Substantial increases occurred then in the 21st century.

Per time interval, 6.2% of the records occurred in the 19th century, another 9.8% in the first half of the 20th century. It is only after 1950 that the pace of observations accelerated to take off in the 1980s. Three quarters of the records occurred from 1980 on. Close to 53% of the records are from the 21st century: 32.8% fell into the first decade and another 19.8% occurred since 2010.

The overall development of sightings closely mirrored the number of records of *cristatus* and even more so of *nigricollis* grebes. This is logical as the two species together represent over 70% of all aberrant individuals found.

The geographical distribution of the records was concentrated largely in western and central Europe and in North America. Exceptions concerned mainly the species that do not occur there: 4 Silvery Grebes, one Great Grebe and one Hooded Grebe from South America, and 4 Australasian Little Grebes, 3 Hoary-headed Grebes and 3 New Zealand Grebes from Oceania. The observations from Oceania included one Great Crested Grebe from New Zealand (PCRau200603303). In addition, one record of a Least Grebe (TDObr196401202) occurred in Central America.

Figure 53 sets out the geographical distribution of records in Europe for Little, Slavonian and Red-necked Grebes. The place of observation was only known for two of the three European records of aberrant Slavonian Grebes. Both records occurred far north, on the breeding grounds of the species. No reports from outside Western Europe were available for this species.

Except for one Hungarian and one Kazak record, all records of Red-necked Grebes of the subspecies *grisegena* were from Western Europe. The majority of them occurred inside their breeding range. Only three observations were reported from further south: two at Swiss wintering lakes and one in Hungary. Three records from 2001, 2003 and 2004 concentrated along the Finnish-Russian border. The aberrant grebes were probably not related, as they were probably affected by different mutations. A loose cluster of records is also visible in the western part of the Baltic Sea:

Fig. 53: Geographic distribution of records of aberrant grebes in Europe (dark red for Little Grebes, green for Slavonian Grebes and blue for Red-necked Grebes; the bigger dark red dot represents seven records of Little Grebes at Lake Constance), except for a Red-necked Grebe from Kazakhstan.

six records occurred in extreme south Sweden (4), south Denmark (1) and the northern German Bundesland Schleswig-Holstein (1). The records occurred in 1970 and between 2000 and 2012. Three of them dealt with a diluted and two with individuals subject to progressive greying. It is likely that both diluted Red-necked Grebes from south Sweden were related.

Records of Little Grebes covered a much wider area than those of the preceding species. Eight of them are not even represented in Fig. 53: they were from too far outside Europe. Three were from India (TRUca187x01100, TRUca199401200, TRUca200401200), three from China (TRUpo200801101, TRUpo201001101, TRUpo201101022), one from Japan (TRUja200901022) and one from Armenia (TRUir200601022). Except for more northerly regions, Little Grebes are widely distributed all over Europe. The observations of abnormal individuals were concentrated largely in a cluster comprising south Germany and Switzerland. This area is used by Little Grebes not only for breeding, but also during migration and for wintering. The majority of the records were of wintering birds, not of local breeders.

The observations for all three species together were concentrated largely in central and northern Europe. It looks as if aberrant grebes in these species hardly occurred in eastern parts of Europe or, with the exception of Little Grebes, in Asia.

In Fig. 54, the European locations of records of Great Crested Grebes are displayed. In addition,

Fig. 54: Geographic distribution of records of aberrant Great Crested Grebes in Europe.

the map contains the place of collection for a grebe in Syria (PCRcr18xx02102). A record from South Korea (PCRcr200903020) and another from New Zealand (PCRau200603303) are not included. European records were not dispersed equally over the entire breeding range of the species. Despite the existence of large populations there, they were absent from Russia, except for an early record from the Curonian Spit. They were also absent from more south-westerly parts of Europe, where the species is a rare breeding bird. There was a major concentration of records in Dutch coastal areas, especially around Lake IJssel. My own records only partially contributed to the high number of observations from there. Many aberrant Great Crested Grebes were reported from central and northern parts of Germany. The German records have a rather scattered distribution. Occurrences concentrated perhaps a bit more along the German-Polish border and, in continuation, along the western Baltic Sea. A final cluster of observations concerned the pre-alpine lakes.

Except for a Libyan record (PNIni200702201), the places of observation of aberrant Black-necked Grebes of the nominate form are indicated in Fig. 55. Their distribution is discontinuous and leaves an empty space between the records from Spain and those from Germany and Belgium. In Spain, quite high numbers of observations concentrated along the Mediterranean coast and the Costa de la Luz. Most other records were from central and northern parts of Europe, predominantly Germany. My own observations were all from northern Baden-Wurttemberg. Other clusters

Fig. 55: Geographic distribution of records of aberrant Black-necked Grebes in Europe, except for a record from West Kazakhstan (with the bigger blue rectangles representing 14 records at Salinas de San Pedro del Pinatar, Murcia, Spain (upper left), 6 records at Cabezo Beaza and Cartagena, Spain (lower left) and 4 records at Salinas de Ibiza, Spain (right)).

existed in extreme north-eastern Germany and in Schleswig-Holstein. Records from the main breeding and wintering areas of the species in more eastern parts of Europe were rare.

For two records of the African subspecies *gurneyi* from Namibia (PNIgu20xx01022) and South Africa (PNIgu200402305), no distribution map was drawn.

Considering the big picture of all grebe species occurring in Europe, the records of aberrant individuals are concentrated in western and central Europe, and are largely absent from eastern parts of the continent and from Asia. This pointed to a possible bias. Several reasons may have led to it. They include the remoteness and problems of access to parts of the more eastern populations, the lower density of observers in some parts there, the perhaps reduced publication opportunities, and language problems. Indeed, records published in languages other than English, German, French, Spanish and perhaps Italian, or that did not at least include a summary in one of these languages, were normally not retrieved during this study.

The North American distribution of records of Horned, Red-necked, Pied-billed, Western and Clark's Grebes is shown in Fig. 56. Most records of Horned Grebes were from more southern and eastern parts of the United States. Records from within the main breeding range of the species further north were rare. Except for a melanistic individual from Port Townsend, USA, all records of aberrant Red-necked Grebes were from Canada and were thus well within the breeding area of the species. The few records of Pied-billed Grebes were scattered all over the United States. None came from Canada.

Aberrant Western and Clark's Grebes were found mostly in south-western parts of North America.

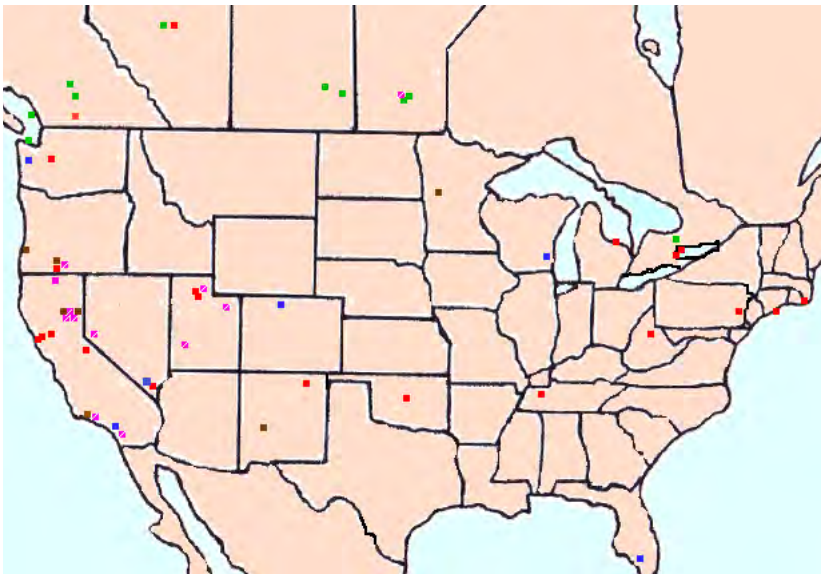

Fig. 56: Geographic distribution of records of aberrant grebes in North America (red for Horned Grebe, green for Red-necked Grebe, blue for Pied-billed Grebe, violet with white line for Western Grebe, brown for Clark's Grebe).

The majority occurred within their respective breeding ranges. Only one record of a Western Grebe concerned Canada. All other observations were from four neighbouring US states, namely California, Oregon, Nevada and Utah. With the exception of two records (New Mexico, Minnesota), sightings of abnormal Clark's Grebes concerned Oregon and California.

With six exceptions, sightings of aberrant Eared Grebes concerned the Unites States, predominately their western parts (Fig. 57). The large majority of the records occurred in California and directly neighbouring locations in Oregon and Nevada, and in Utah. There, the observations were concentrated in five areas:

- in southern California in the region of San Diego and the Salton Sea, a major wintering area,
- in western California around San Francisco, a wintering and breeding area,
- on eastern Californian Mono Lake, a major staging area,
- along the central border between California and Oregon, an important breeding area,
- along Great Salt Lake in Utah, with the lake itself a major staging area and surrounding wetlands used for breeding.

Two observations were from Colorado and two from Nevada. Single records occurred in Montana and Idaho. Five records concerned Canada. Three of them were from the region of Calgary, one was from Saskatchewan and one from Manitoba. A final record concerned Mexico.

Overall, aberrant individuals of North American populations appeared to be recorded far more often on staging and wintering grounds than within breeding ranges. Some breeding sites may be of difficult access, not accessible at all or only seldom accessed because of their remoteness. In

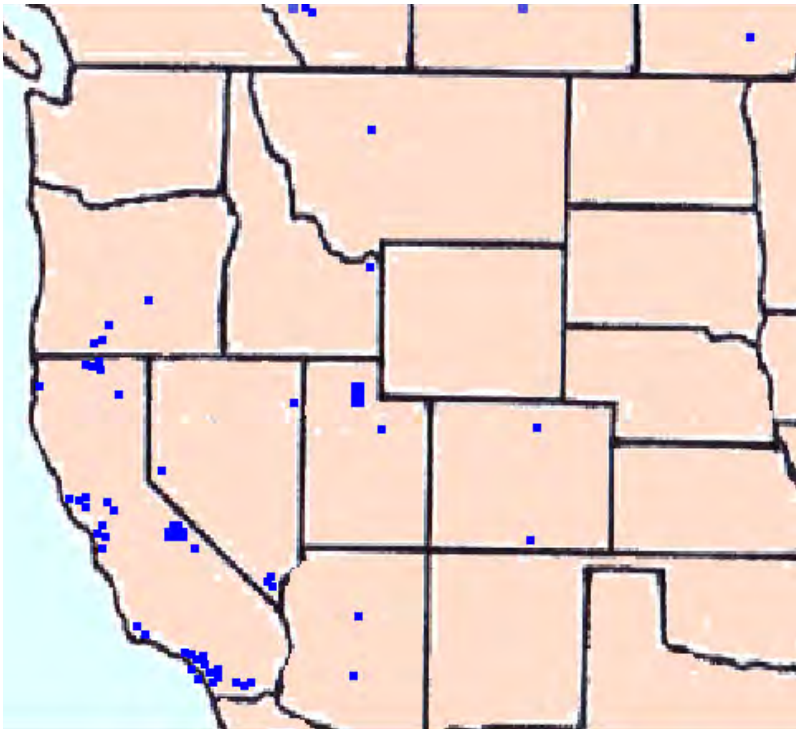

Fig. 57: Geographic distribution of records of aberrant Eared Grebes in North America (with the elongate rectangle in Utah representing 16 records at Great Salt Lake, and the three rectangles forming a stair in central California representing 64 records at Mono Lake), except for a record from Mexico. Two records from Edmonton, Canada have been shifted further south than where they occurred, in the region of Calgary.

most cases, aberrant grebes were only recorded when they were fully grown. Abnormal offspring that did not survive to fledging may have been largely left out of the observations.

Statistical analysis of the occurrences of aberrant grebes does not, in general, enable us to draw final conclusions – regarding neither their frequency nor their distribution. The noticeable increase in reports over recent decades, and especially after 2000, is largely attributable to the use of the internet as a means of publication and communication. It cannot be interpreted as indicating a huge increase in the number of birds affected by aberrations. Similarly, the geographical distribution of observations is expected to be observer- and, at least in Eurasia, language-biased. The overwhelming majority of records stemmed from countries in which interest in ornithology is widespread and well represented in the population, and where birdwatchers are well equipped and interconnected. Most records from outside Europe and North America were reported by travelling western birdwatchers. Local people often have

Table 4: Total records according to grebe (sub)species and mutation.

	Albinism	Total Leucism	Partial Leucism	Brown	Dilution	Ino	Melanism	Erythro-melanism	Chestnut Melanism	Progressive Greying	Other	Whiteling	Total
Common Little Grebe	1	5		3	5	3	4				3	16	**40**
Australasian Little Grebe					3					1			4
Least Grebe							1						1
Pied-billed Grebe		2		1	1	1				1		2	**8**
Hoary-headed Grebe									2			1	**3**
New Zealand Grebe					1		1					1	**3**
Great Grebe						1							1
Great Crested Grebe	9	13	1	26	17	6	3		9	8	5	27	**124**
Horned Grebe			2	1	6	1	1			2	4	3	**20**
Slavonian Grebe	1				1							1	**3**
Holboell's Red-necked Grebe		2		1	2		2			1	1	1	**10**
Eurasian Red-necked Grebe			1	4	6	2				3	3	3	**22**
Black-necked Grebe*				3	20			8		15	14	13	**73**
Eared Grebe		1			18	5	3	7		39	30	31	**134**
Silvery Grebe					1						3		4
Hooded Grebe											1		1
Western Grebe						1				2	7	1	**11**
Clark's Grebe			1	1	1					1	4		8
All species	11	23	5	40	82	20	15	15	11	73	75	100	**470****
Percentages	2.34	4.89	1.07	8.51	17.45	4.25	3.19	3.19	2.34	15.53	15.96	21.28	**100**
% of genetic causes	4.95	10.36	2.25	18.02	36.94	9.01	6.76	6.76	4.95	/	/	/	**100**

* includes two African Black-necked Grebes under dilution
** the total is 470 because one Great Crested Grebe was subject to two genetic mutations.

Table 5: Records with two plausible causes for their aberration.

Plausible aberrations	Record numbers	Totals
Brown or ino	PCRcr18xx01200, PAUco196501100, PGRgr188701100, PNIca198104104, PNIca198110104, PNIca198111104, PNIca198112104, PNIca198113104, PNIca198208104, PNIca198209104, PNIca200502020	11
Dilution or progressive greying	PNIni200505232, PNica198003104, PNica198102104, PNica198103104, PNica198202104, PNica198203104, PNica198204104, PNica198205104, PNica198206104, PNica198305104, PNica198306104, PNica198307104, PNica198308104, PNica198309104, PNica198310104, PNica198311104, PNica198403104, PNIca200301210	18
Total leucism or albinism	PCRcr196201100, PNIni192601030	2
Total leucism or ino	TRUru195801130	1
Partial leucism or progressive greying	TRUru196501100, PAUco201201010, PGRgr197001100, PNIni191101100, PNIni191201100, PNIni200302032, PNIca200601012	7
Partial leucism or age related	PNIni197x01100, PNIni197x02100, PNIni197x03100, PNIni197x04100, PNIni197x05100, PNIni200522232, PNIca200810303	7
Partial leucism or other non-genetic cause	PGRgr188801100, PGRho200701022, PNIni197x01100, PNIni197x02100, PNIni197x03100, PNIni197x04100, PNIni197x05100, PNIni200522232, PNIca200810303	9
Chestnut melanism or staining	AOCoc200901303, AOCoc200902303, AOCoc200904303, ACLtr200903303, ACLtr201101303, ACLtr201102303	6
Melanism or hybridization	AOCoc200905303, AOCoc201001303, AOCoc201002303	3

either little ornithological interest or limited means to circulate their observations. In Eastern Europe, observations may be published more frequently, either in ornithological journals or on the internet. However, unless an internationally wider known language, such as English, is used, most publications will have passed unnoticed.

3.21. Causes of aberrations per grebe species and statistics of mutations

The register contains a total of 469 records. The distribution of the causes of aberrations is displayed in Table 4. One grebe was affected by two different genetic mutations (PCRcr190501100). For 208 grebes (44.3%), a genetic cause was plausibly identified. 70 individuals (14.9%) were subject to progressive greying, and for another 35 (13.4%) either progressive greying or a genetic cause was possible. In 23 cases (4.9%) two, and in four cases (0.9%) three genetic mutations were roughly equally plausible (Table 5). Another 14 grebes (3.0%) were subject to a non-genetic cause, such as hormonal disorder or illness. In 10 cases (2.1%), it was not clear whether the aberration was caused by melanism or staining. For 104 individuals (22.2%), an assessment was not possible, given the limited detail of information.

The most frequent genetic mutation was dilution (82 out of 222 cases or 36.9%), followed by brown (40 cases or 18.0%), total leucism (23 cases or 10.4%) and ino (20 cases or 9.0%). Erythromelanism was represented by 15 cases or 6.8%, melanism likewise by 15 cases. 11 cases (5.0%) dealt with albinism and another 11 cases with chestnut melanism. Partial leucism (5 cases, 2.2%) appeared to be rare. The three types of melanism totalled 41 cases or 18.5%.

The ranking must be considered with care. Indeed, of 470 possible causes, only 295 or 62.8% were identified with a fairly high degree of certainty. These included 73 cases (15.5%) of progressive greying. 100 records (21.3%) could not be assessed: because of a lack of description,

the cause indicated could not be verified at all in 63 cases, and for 38 grebes, the cause indicated was wrong, but the real cause was not identified. For 64 records, two causes were roughly equally plausible. This left ample space for a reshuffled ranking, if it were possible to assign the correct cause to all aberrant grebes. As Table 5 implies, the mutation "partial leucism" in particular might have proved more numerous. Out of 64 records with two plausible causes, 23 proposed partial leucism as one of the alternatives. Dilution was 18 times an alternative. It is, however, likely that progressive greying would have profited most: it was an alternative in at least 25 cases, and it is thought that it was the better alternative in the majority of them.

Though dilution was by far the most numerous mutation, we have to remember that in reality, dilution covers many different mutations, all of which lead to more or less comparable results. In addition, it is possible that not all cases of dilution were correctly identified. The outcome of the assessment depended a lot on the material available. Some descriptions may have been inaccurate or misleading, thereby leading to a wrong identification of the cause of an aberration. In the field, and even on a photo, confusion between progressive greying, dilution and partial leucism can occur. For example, on a photo taken at some distance, a grebe may look uniform pale grey and be classified as diluted. If afterwards we see the grebe from close up, we might notice that the individual is not light grey, but that its plumage is rather grizzled or mottled with darker and white feathers. It could then in reality be affected by progressive greying, in some rare cases even by partial leucism. Also, for the records of Jehl (1985), only a global assessment per category was possible: no detailed descriptions for individual Eared Grebes were provided.

The aggregated results for all grebe species were strongly influenced by the subdivision between the mutations in *nigricollis* grebes. These accounted for 38 diluted individuals, representing 66.3% of all cases of dilution in all species, and 61.3% of the genetic causes of aberrations in *nigricollis* grebes. All 15 cases of erythromelanism were recorded in *nigricollis* grebes. However, the most common cause identified in *nigricollis* grebes was progressive greying (54 cases).

In Great Crested Grebes, the most frequent mutation was brown (26 cases out of 84, or 31.0%), followed by dilution (17 cases, 20.2%), total leucism (13 cases, 15.5%) and albinism (9 cases, 10.7%). An additional 9 indications for albinism could not be verified.

3.22. Hatching, survival and reproduction of aberrant individuals

It is generally thought that deficiencies associated with most genetic colour mutations will have a disadvantageous effect on the individuals concerned – e.g. on their chances of survival or their health in general, and on their opportunities for pairing and breeding.

3.22.1. Abnormal hatchlings: siblings and parents

In genetically recessive abnormalities, a mutation can only be present if inherited from both parents. If normal parents both carry the gene, a mutation will express statistically in one fourth of the offspring. This rule was exactly followed in two Swedish broods of Great Crested Grebes, in which each time one pullus (PCRcr200401012, PCRcr200503020) out of four was affected by albinism. If the partners remain together for breeding, they could consistently achieve the same breeding result. As PCRcr200401012 and PCRcr200503020 hatched on the same lake, it is very likely that the parents were the same twice over. A pair of Little Grebes hatched two broods in the same year: only one pullus in one of the broods consisting of five siblings was albinistic (TRUru200801100). In two other examples, the total number of pulli observed was always less than four: one chick out of two (PCRcr196201100) and one chick out of three were albinistic (PCRcr201304021). In one case, two albinistic pulli were reported from the same brood (PCRcr200402101 and PCRcr200403100), with no mention of regular siblings. All albinistic pulli hatched from ordinary coloured parents. This is obvious, as albinos do not survive to reproduce.

Judging by the examples, the statistical rule predicting 25% of albinos in a brood is not always

adhered to. Moreover, clutches of Great Crested Grebes may consist of up to six or even seven eggs, and those of Little Grebes may be even bigger. Depending on which eggs hatch and which pulli survive the first days, the visible result may contradict the statistical average, even if it applied during egg fertilization.

For the recessively sex-linked aberrations brown and ino, the register contains only four cases in which the parents were normally pigmented, and for which we have knowledge about the composition of the family. Twice a brown chick (PCRcr200602012, PGRgr200201022) had a regular sibling. One ino chick (PGRgr195x01201) had three regular siblings. An ino juvenile Eared Grebe (PNIca198501101) seemed to have only one normally coloured sibling. Most interesting is the case of a brown pullus (PCRcr198702200) that also had one brown parent (PCRcr198402200). In two other cases, the brown individuals (PCRcr193004101, PCRcr193201100) were only detected as juveniles in the company of one adult that was normally pigmented. In the second case, a regular sibling was mentioned.

All remaining examples but one concern leucism. A totally leucistic pullus (PCRcr200301200) hatched from regular parents and had three regular siblings. Twice two leucistic pulli were part of the same brood (PCRcr198602200, PCRcr198603200 and PGRho195401100, PGRho195402100) with no evidence of there being regular siblings. The Great Crested Grebe parents had a regular plumage. For the Red-necked Grebe chicks, only one regular parent was reported. Its partner was not mentioned. One pullus (PCRcr198701200) in a brood of four was entirely leucistic. A partially leucistic (the identification of the cause by the observer could not be verified) pullus (PCRcr200005200) was the only aberrant descendant in two broods by the same pair in the same year. In the latter two cases, the parents were normally pigmented. In addition, one diluted pullus (PCRcr201203012) hatched from normal parents.

For most aberrant grebes in the register, there was information neither about their siblings, nor about their parents. The above examples leave the impression that abnormal grebes were generally unable to pair and to reproduce.

3.22.2. Pairing and reproduction of aberrant grebes

In the wild, the reproduction of aberrant individuals is problematic as they are generally at a disadvantage (Campbell & Lack 1985). Aberrant grebes may have problems pairing with similarly looking conspecifics, which will be rare. Normally pigmented partners could be more readily available, but these are likely to avoid mating with strange looking partners as the resulting offspring could contribute less to their fitness. Nevertheless, the register contains several examples of aberrant adult grebes that were paired or were at least in the company of an ordinarily pigmented conspecific early in the breeding season, though no subsequent breeding was reported. This was the case with a perhaps completely leucistic Horned Grebe (PAUau186901100), a Black-necked Grebe (PNIni198401100) affected by an unidentified mutation, a diluted Little Grebe (TRUja200901022), a diluted Horned Grebe (PAUco200702121) and an erythromelanistic Black-necked Grebe (PNIni200901303). A diluted Red-necked Grebe (PGRgr200901022) was firmly paired and had progressed to platform courtship with its regular partner. In contrast, there were few reports implying pairing problems for abnormal individuals. A brown Red-necked Grebe (PGRgr201101022), present for three breeding seasons, was unable to establish a stable partnership despite several attempts. A diluted Black-necked Grebe (PNIni199302100) seemed unpaired on 22 May whereas others around were paired.

There was a single example of a common breeding attempt by two aberrant partners. The two diluted Red-necked Grebes (PGRgr200001030, PGRgr201001030) may have been closely related. They were not reported to have been successful. Other abnormal grebes were nesting with regular partners and again there was no confirmed success. A totally leucistic Great Crested Grebe (PCRcr197401100) present during the breeding seasons of 1974 and 1975 bred in one year. A brown Red-necked Grebe (PGRho201301022) had its nest destroyed by a storm. For a partially leucistic (in terms of Jehl) Eared Grebe (PNIca199x02200) seen nesting, the result remained unknown.

Successful breeding of aberrant grebes with regular partners was reported more often. A diluted Australasian Little Grebe (TNOno201001101)

bred successfully in 2010 and 2011 and cared for a regular chick in 2011. A diluted Red-necked Grebe (PGRho200501022) bred in 2005 with a normal partner and produced two regular offspring. It was again present in 2006 and 2008, but breeding success was not monitored. From the brood of a melanistic Great Crested Grebe (PCRcr201201131), only normal chicks were reported. A melanistic Horned Grebe (PAUco201203022) produced at least one regular chick. A melanistic Eared Grebe (PNIca201205021) cared for two apparently regular chicks. A perhaps partially leucistic Red-necked Grebe (PGRgr197001100) (or it may have been subject to progressive greying), observed in 1970, 1971 and 1974, bred successfully in at least two of those years. No indication about the pigmentation of the offspring was available. A brown Great Crested Grebe (PCRcr198402200), present during the breeding seasons 1984-1994 and successful at least in 1987, 1989 and 1990, hatched a brown chick (PCRcr198702200) in 1987.

An Eared Grebe (PNIca201010303) affected by erythromelanism hatched at least one normally pigmented chick in 2010. This was also the case for the two chicks of an Eared Grebe with an erythromelanistic fore neck (PNIca200905021). In 1995, a Black-necked Grebe (PNIni199401100), affected by the same mutation, raised two chicks with a regular partner. An Australian Crested Grebe (PCRau200603303) subject to chestnut melanism had two regular pulli with a normally pigmented partner. My own observations of Great Crested, Black-necked and Eared Grebes confirmed that neither erythromelanism nor chestnut melanism were visibly associated with disadvantages when it came to pairing or breeding.

3.22.3. Survival of aberrant grebes

The great majority of the records concerned one-off observations of individuals. In most cases, the age-related information available was limited to whether the observed grebe was a pullus, a juvenile or an adult.

In albinism, the evidence available pointed to generally short survival. In two cases (PCRcr200401012, TRUru200801100) the albinos died before reaching independence. An Eared Grebe (PNIca193901200), initially qualified as albino, was said to have been present in winter for four consecutive years. The individual's plumage was however not pure white, and it was plausibly affected by ino. A Great Crested Grebe (PCRcr197301100) was first seen as an all-white pullus, before it was said to have returned to its hatching region in two consecutive years. It was last recorded in September 1975. There was no positive proof that the 1973 grebe and the 1974 individual were identical. The two observations were treated here as separate records (PCRcr197401101). Also, the completion of several migrations by an albino is unlikely. The description of the 1974 adult fitted well with total leucism, and this mutation was finally adopted as cause. The causal mutation of a Little Grebe (TRUru194802400), said to have been albinistic and perhaps present at the same place in three successive winters, could not be verified: the individual was listed under whiteling. Moreover, it cannot be excluded that these were different individuals present at this wintering site each year. In summary, for all records of longer survival by "albinos", the claimed causal mutation was either challenged or rejected.

Other mutations may have less impact on survival chances. A perhaps partially leucistic Red-necked Grebe (PGRgr197001100) was reported as an adult in the breeding seasons of 1970, 1971 and 1974, suggesting that the individual may have reached an age of at least five years. It may have been older, and the cause of the unusual white feathers in its plumage may have been progressive greying. A totally leucistic Great Crested Grebe (PCRcr197401101) probably hatched in 1973. It was last seen in September 1975. A Pied-billed Grebe (PPDpo199801010) was a regular winter visitor from 1998 to 2001/02. The white feathers in its plumage were possibly the result of progressive greying. Examples of diluted grebes that survived for longer included

- a Great Crested Grebe (PCRcr200x01012) present as an adult near Werselo, Netherlands, for over two years,
- a Red-necked Grebe (PGRgr200001030) seen during the breeding seasons from 2000 to 2010, and thus having at least 10 years of age,
- another Red-necked Grebe (PGRho200501022), observed as an adult at Tunkwa Lake, Canada, in the breeding seasons of 2005, 2006 and 2008; it was at least four years old.

A brown Little Grebe (TRUru198701100) was present in the same area over winter in eight successive years (from 1987 to 1994). A brown

Great Crested Grebe (PCRcr198402200) was seen during the breeding seasons from 1984 to 1994: it had attained at least 11 years of age. A brown Red-necked Grebe (PGRgr201101022) had a minimum age of four years when observed for the third consecutive breeding season in 2013. For a Horned Grebe (PAUco196501100) which was either brown or ino, its winter presence in February 1965 and 1966 indicated that it had reached at least its third calendar year.

An ino Eared Grebe (PNIca193901200), initially wrongly qualified as albino, was said to have been present from 1939 on for four consecutive winters.

Overall, there are too few examples of longer survival by aberrant grebes to be able to draw conclusions. Excluding individuals affected by albinism, that generally do not survive to independence, a few grebes affected by other mutations lived for several years, and even exceptionally for over ten years.

3.23. Records of hybrids

Besides genetic mutations, aberrant appearances may result from interbreeding of related species. The offspring produced by mixed pairings, if viable, are generally believed to display a mix of features belonging to both parental species. In most cases, we would expect hybrids to be easily differentiable from individuals affected by genetic mutations. Close resemblance to the parental species may however sometimes lead to challenges, as their offspring might present characteristics that are not easily discernible from the mutations discussed above. Although the present study focuses on genetic causes of aberrations, a brief review of the records of hybrid grebes will add to the big picture on colour aberrations. In some species, it provides an alternative explanation for the abnormal appearance of individuals.

A grebe species often cited or suspected to have interbred is the Pied-billed Grebe. O'Donnel & Fjeldså (1997) suggested that the Atitlán Grebe *P. gigas* hybridized into extinction, but the IUCN did not mention interbreeding with *P. podiceps* as having contributed to the disappearance of its giant cousin (BirdLife International 2004). LaBastille (1974), who studied the species during its last years of existence, found no evidence for hybridization with Pied-billed Grebes. Surveys at Lake Atitlán late in the 1980s failed to record the bigger *Podilymbus* species, and it was speculated that it might have been replaced by the Pied-billed Grebe, either through competition or hybridization (Hunter 1988). Giant and Pied-billed Grebes resembled each other closely, *P. gigas* being however overall darker. Hybrids could therefore have been darker than *P. podiceps*. However, no melanistic Pied-billed Grebes have so far been reported.

M. Such published a photo of a possible Least x Pied-billed Grebe hybrid on the internet. The individual's heavy beak suggested interbreeding. It was observed at Estero Llano Grande State Park, Texas, USA, in late February 2009. The pigmentation of the plumage did not differ visibly from the regular non-breeding plumage of Least Grebes. The less intense colouration of the iris could be attributable to young age. Least Grebes may occasionally have heavy bills. The bill of the individual in question may have been at the upper limit for the species. Ultimately, indications for a cross were not convincing enough.

Single Pied-billed Grebes show up regularly in Europe. About 50 sightings, predominantly from the extreme west of the continent, were registered in the 20th century (Bräuning 2002). The grebes had no real chance of pairing with a conspecific in Europe. Some individuals nevertheless bred or tried to do so, choosing Little Grebes as partners. At Stithians Reservoir, Cornwall, England, three pulli hatched from such a mixed pair in 1993. The fate of the chicks remained unknown (Parkin & Knox 2010, www.cornwall-birding.co.uk). The Pied-billed Grebe was again at the reservoir for the breeding season of 1994. It again produced three chicks, perhaps with the same Little Grebe. One chick survived to October and a second to 28 March of the next year. A hybrid from 1994 was still seen in October 1995 (Rogers et al. 1995, 1996, www.cornwall-birding.co.uk). P. Hopkins photographed one immature descendant in August 1994. At first glance, it looked more like a Pied-billed Grebe with an unfamiliar facial striping. Its bill was light coloured and only showed remains of the typical black stripe in the culmen. Unfortunately, no photo or description of a fully grown hybrid seems to exist. At Smukkevannet, Rogaland, Norway, a female Pied-billed Grebe cared for a chick in August 2002. The likely father was a Little Grebe.

The intermediate was not described and its fate is unknown (Bräuning 2002, Bunes & Solbakken 2002). A summering individual at Rethen, Lower Saxony, regularly engaged in aggressive interaction with Little Grebes during July and August 2002. Once, it grasped a local Little Grebe by the neck and dragged it into the reeds (Bräuning 2002). The observer assumed that the American guest was defending a breeding territory. Alternatively, he may have witnessed attempted rape. Ultimately, no interbreeding was observed.

A single Pied-billed Grebe was reported from a pond near Saint-Denis-d'Orques, France. It was present there in 2000 and 2001. It regularly attacked Great Crested and Little Grebes and twice built a rudimentary nesting platform. A kind of copulation attempt on the water surface with a Great Crested Grebe was seen once. No mixed pairing was reported (Lapous 2002).

Voous and Payne (1965) presumed hybridization between the endemic Madagascar *T. pelzelnii* and the Little Grebe. The Madagascar Grebe probably evolved out of a stock of *T. ruficollis capensis* that became isolated on the island. When a new stock of African Little Grebes arrived in Madagascar in the course of the 20th century, the isolating mechanism of the endemic species was probably too weak to prevent interbreeding. A possible hybrid *ruficollis x pelzelnii* was described by Benson (1971, Collar & Stuart 1985). It was collected by Betsileo and its skin is now in the collection of the Natural History Museum, Tring. The grebe, in breeding plumage, had a very narrow rufous band passing below its beak. In normal *ruficollis* individuals, the width is about 40 mm. In this individual, the dark greyish plumage of the fore neck extended further up and left only 5 mm to the rufous band reaching the chin. The wing size was 103 mm. At 17 mm, the beak was rather short. A plausibly hybrid chick was reported by Benson et al. (1976). On a pond near Sakaraha, between 29 December 1972 and 5 January 1973, an adult *ruficollis* carrying a pullus on its back was always closely followed by an adult *pelzelnii.* Despite the preceding examples giving indirect evidence for the existence of hybridization between the two species, BirdLife International (2004) concluded that there was no proof of interbreeding.

The now extinct Rusty Grebe *T. rufolavatus* of Lake Alaotra, Madagascar, was also reported to have interbred with the Little Grebe, and individuals "with some characters of the species" were seen on Lake Alaotra in 1986 and 1988 (BirdLife International 2004). Payne (in Voous & Payne 1965) collected five adults and described their plumage characteristics: they were intermediate between *T. pelzelnii* and *T. ruficollis*. Four specimens resembled a Rusty Grebe. The first differed by displaying a large grey chin spot and a brown instead of a yellow iris. The second was pale rufous on the sides of the neck and dark rufous on the sides of the head; its chin was slightly spotted with dark grey. The third grebe was short-billed, pale brown faced and had a dark spotted chin. The fourth individual was brown or pale rufous faced and had a dark grey chin patch. The last specimen resembled a long-billed Little Grebe: it was slightly paler and more buff brown on the sides of the head and it had a light yellow iris. Of 14 specimens in non-breeding or immature plumages with heavily marked and spotted heads, some were not easily assigned to either *rufolavatus* or *ruficollis*. A specimen collected in Madagascar between 1863 and 1921 and now at a Cambridge museum was classified as a plausible hybrid by Benson (1971). The grebe, in pre-breeding plumage, did not deviate from the colour patterns observed in *ruficollis*. The extremely long beak – 24 mm, or 28.5 mm if measured at the culmen – was too long for this species, but well within the size range observed for *rufolavatus* (21-27 mm). According to O'Donnel and Fjeldså (1997), hybridization between *T. rufolavatus* and *T. ruficollis capensis* occurred at least since the 1920s, and even the type specimen of *rufolavatus* had hybrid character traits. Wilmé (1994) reported that surveys at Lake Alaotra in the second half of the 20th century failed to detect purebred Rusty Grebes. Hybrids were also reported by Hawkins et al. (2000), referring to an unpublished report to the Jersey Wildlife Preservation Trust, Madagascar. Delacour (1933 in Voous & Payne 1965) originally assumed the existence of two colour phases in *P. Rufolavatus*; however, Voous and Payne (1965) presented sufficient evidence to qualify individuals of the darker phase as hybrids between *rufolavatus* and *ruficollis*.

Interbreeding between Australasian and Eurasian Common Little Grebes has not been reported. Both species show a complex pattern of replacement in the Indo-Malayan region but overlap only quite locally, with no sign of hybridization (Fjeldså 2004). According to Perennou et al. (1994 in O'Donnel & Fjeldså 1997), the taxonomy of the *novaehollandiae*

group is unclear, and O'Donnel and Fjeldså (1997) recommended urgently reassessing the taxonomic status of all *novaehollandiae* subspecies and clarifying the status of yellow-eyed *ruficollis* subspecies in southern Asia and of intermediates between *T. r. collaris* and *T. r. tricolor* and between *T. r. philippensis* and *T. r. cotabato*. While adult Australasian Little Grebes have bright yellow eyes, those of the Eurasian cousins are chestnut brown. The implications of the variation in eye colour need resolving, as *T. ruficollis* populations in the Asiatic region have yellow eyes, like *T. novaehollandiae*, but they are separated from this latter species by chestnut-eyed populations.

King (1985) reported an aberrant grebe in winter plumage that he initially identified as a rather bulky and thick billed Slavonian Grebe. Simmons (in King 1985) suggested that the individual was a hybrid, presumably with a Red-necked Grebe. This assessment was based on the size of the bird itself and of its beak. In addition, the individual had greyish smudges in those plumage parts that are normally pure white in Slavonian Grebes, but covered with greyish feathers in Red-necked Grebes.

In 1994, Koblik and Tsvetkov (1998) observed a probable hybrid. The adult grebe was caring for one chick on a fish-rearing farm in Moscow district. The general constitution and the ornamental feathers of the parent's head were more like a Black-necked Grebe, while the red-brown colour of the lower neck and the rather massive bill recalled a Slavonian Grebe. The half-grown chick, possibly a second generation hybrid, lacked the usual striping of the head and neck plumage. Instead, its upper parts were monotonous dark grey and its belly was white. Koblik and Tsvetkov (1998) considered the possibility that the adult grebe was a rare erythristic mutant of the Black-necked Grebe, but the comparison with other Black-necked Grebes that bred on the pond, the untypical bill and the colouration of the chick argued in favour of a hybrid between a Black-necked and a Slavonian Grebe. An observation of a mixed pair of the two species on a neighbouring pond in summer 1993 also supported this conclusion. The breeding of the hybrid with a Black-necked Grebe resulted in a more uniformly coloured chick that may have displayed ancestral characters.

In Scotland, a Black-necked and a Slavonian Grebe possibly bred together in 1972 (Dennis 1973). No common nesting was observed. However, the Slavonian Grebe held a territory and was carrying a chick on its back on 13 July. The pullus was fed by a Black-necked Grebe. Both adults also swapped roles. No second Slavonian Grebe was seen on the loch, only further Black-necked Grebes. The presumed hybrid pullus did not obviously differ in appearance from the chicks of Black-necked Grebe pairs around.

Toon (2007) reported mixed breeding of a Great Crested and a Slavonian Grebe from a site in central England in 2006. After displaying together in spring, both built a nest that received four eggs. Two chicks were predated by a Great Cormorant *Phalacrocorax carbo* shortly after hatching. The remaining two eggs did not hatch. The late pairing of both grebes (only in early June) led the author to the reasonable assumption that the interbreeding resulted from an adaptive mate choice in circumstances with limited alternatives: it was not due to species misidentification. A photo of one of the chicks in the publication showed no obvious difference in its facial striping to either pure-bred pulli of Great Crested or Horned Grebes, which tend to resemble each other closely.

McCarthy (2006) mentioned a hybrid *Podiceps cristatus* x *Podiceps grisegena* with a ring number. He added no further details as he could not find a report that was associated with the record. On a pond in Austria, a Red-necked Grebe displayed with a Great Crested Grebe in 1983. Later in the season, both built a nest and incubated in turns. In the end, no eggs hatched and the nest was abandoned (T. Haubner & A. Thaler cited in Dvorak et al. 1993). In Frisia, Netherlands, a Red-necked Grebe courted a Great Crested Grebe in May 1991. No breeding attempt was observed (T. Jager in van Dijk et al. 1994). In North Brabant, Netherlands, a single Red-necked Grebe present for at least three months occupied a completed platform in spring 1989. It tried to convince a Great Crested Grebe to engage in platform courtship, without success (van Diermen 1990 in Van Dijk et al. 1994).

A hybrid between a Hooded and a Silvery Grebe was reported by Storer (1982). It was at least in its second calendar year. Its forehead and lores were grey and its nape black. The anterior part of the crown was whitish, blending with pale

Fig. 58: Possible hybrid between a Clark's and a Western Grebe at Tule Lake, USA, in 2011, with a yellow orange bill typical of a Clark's Grebe and the dark crest reaching far down to touch the eye (photo A. Konter).

straw coloured feathers to the front. There was no sharp demarcation between the head colours as in Hooded Grebes, but mixing of straw coloured and black feathers. The chin and throat were grey. The ear tufts were elongate as in Silvery Grebes, but there were fewer, and they were shorter and paler. No trace of a post ocular wattle was found. The back was dark grey as in Silvery Grebes, and the amount of white in the wings was intermediate between both parental species. The six outer primaries were dark. The white area of the inner primaries was confined almost entirely to the inner web. The pale headed female was apparently mated to a Hooded Grebe. No successful nesting was recorded. As Hooded and Silvery Grebes may form mixed colonies, it is equally conceivable that the intermediate resulted from a mixed pair bond or from a sneaked copulation.

The Junin Flightless Grebe *P. taczanowskii* is endemic to Laguna de Junín, Peru, where it occurs in sympatry with the local sub-species of the Silvery Grebe. Courtship rituals in both are similar. Silvery Grebes have been observed in penguin dancing with Junín Flightless Grebes. So far, there are no observations of mixed pairings, and reproductive isolation could be strong (Fjeldså 1981, 2004).

Between Western and Clark's Grebes, hybridization may be more common than between other grebe species. Both *Aechmophorus* grebes occur largely in sympatry and may form mixed colonies. Also, mixed pairing and breeding has been reported (see Fig. 46). Occasional broods with both Western and Clark's young observed by Ratti may have resulted from parasitic egg dumping (Storer & Nuechterlein 1992) rather than hybridization. The status of individuals with intermediate character traits remains unclear: they could likewise result from interbreeding or from phenotypic variability. Their numbers might be increasing. In 1963, intermediates were few at Bear River Migratory Bird Refuge, Utah (Storer 1965), and they represented only 0.7% of the population in 1975 (n = 3,376; Ratti 1979). They accounted for less than 1% in over 8,000 observations in California, Nevada, Oregon and Utah (Ratti 1981). A survey in northern California and southern Oregon in 2009 showed that percentages

Fig. 59: A Western Grebe female (with a green yellow bill, left) and a probable hybrid male (with a more yellow bill) at Pelican Lake, Manitoba, Canada, in 2008 (photo A. Konter).

of intermediates were increasing: 3.3% of 1,293 grebes assessed clearly had intermediate traits, and another 0.4% did not entirely conform to either species (Konter 2011). The repetition of the study in Utah in 2010 found an aggregated 6.5% or 43 intermediates, while another 7.6% or 46 individuals did not entirely conform to a purebred Western or Clark's Grebe (n = 660; Konter 2012b). The increasing percentages of intermediates were surprising as all studies so far confirmed assortative mating (Konter 2009, 2011b, 2012b, Lindvall & Low 1982, Nuechterlein 1981a, 1981b, Nuechterlein & Buitron 1998, Ratti 1979). However, they also confirmed mixed pairing and breeding. In addition, mixed pairs and pairs comprising first generation hybrids were observed with viable offspring (Nuechterlein & Buitron 1998, Storer & Nuechterlein 1985, pers. obs.). Suspected Western x Clark's Grebe hybrids were also reported from Manitoba and Saskatchewan (Eichhorst & Parkin 1991, Konter 2009).

The intermediate character traits of *Aechmophorus* grebes during the breeding season were related to the facial plumage pattern, more precisely to the location of the dividing line between the blackish feathers reaching down from the crest and the white feathers reaching up from the face (Fig. 58), and to the bill colour (Fig. 59). In intermediates, the dividing line tended often to be not sharply defined, wrongly located or not correspond to the species as indicated by bill colour. In some individuals, the black pigmentation could reach far down into the facial plumage so that a form of melanism might plausibly serve as an explanation too (Fig. 47).

Generally, examples of interbreeding are limited in grebes. Most cases of first generation crosses seem easily identifiable, as they would display a mix of traits from both parents. Confusion opportunities of hybrids with individuals subject to genetic mutations could be limited to "melanistic" individuals, especially in *Aechmophorus* grebes, where interpretation of the abnormal invasion of ordinarily white facial parts by dark feathers remains difficult. The examples provided imply that individual grebes, if confronted with limited mate choice, may hybridize readily. They may occasionally have contributed to the extinction of endemic species with small populations or to phenotypic variability.

4. Discussion

The working hypothesis of this study was that the natural colouration of grebes' integument is almost exclusively due to melanins. Based on the descriptions of aberrant individuals, the well-founding of the initial hypothesis will now briefly be discussed. A table summarizes the findings per grebe species. Some specific aberrations typical of grebes are presented in more detail, before the consequences of genetic mutations on the lifetime history of their bearers and statistical aspects of their occurrences are discussed. A much more theoretical subject is the contribution of colour mutations to genetic variability and speciation in grebes.

4.1. Inferences of genetic aberrations for the natural pigmentation of grebes

The correct identification of aberrations presupposes a good knowledge of the pigments ordinarily occurring in the species or the family of birds investigated. The working hypothesis at the start of this study was that pigmentation in grebes is largely, if not entirely, melanin-based. The results confirmed the correctness of this assumption, at least with respect to the plumage of those species that contributed multiple individuals to the register of aberrant grebes (Table 6). Their feather colouration is due to either one or a combination of both melanins. The genetic mutations identified in aberrant individuals were consistently aligned with expected results in entirely melanin-based pigmentations. For instance, albinistic or totally leucistic, but also sun bleached brown and ino Little, Great Crested, Horned, Red-necked, Black-necked and Eared Grebes generally displayed entirely white feathers. In a few of these individuals, carotenoids had locally replaced the melanins. The delivery of carotenoids was always limited to parts of the head plumage and may have occurred accidentally. Although individuals may be subject to more than one mutation that could occasionally affect colour pigments other than melanins, we cannot assume that every entirely white plumaged grebe suffered from an additional mutation that prevented carotenoids or other pigments ordinarily present from expressing. In addition, changes in carotenoid-based pigments caused by mutations are rare, and carotenoid pigmentation is usually not affected by melanin mutations (van Grouw 2006, 2013). The plumages displayed by individuals subject to brown, ino or dilution were in all cases entirely in agreement with the results expected in entirely melanin-based colourations.

With respect to the pigmentation of bare parts and the eyes, the origins might vary from one species to another. Red-eyed species could rely on pigments different from melanin, and the yellow in the bill and in the bare parts of some species could be triggered by non-melanin based pigments. The conclusions per species are summarized in Table 6.

In Eurasian Little Grebes, aberrant individuals in the register had an entirely melanin-based colouration of their plumage and bill. The bare skin at the onset of the beak could be coloured predominantly by other means. In the yellow-eyed subspecies, the pigmentation of the iris could perhaps rely on colorants like pterins. In Great Crested Grebes, melanins provided all colours of the feathers, bill, eyes and probably legs. There was evidence that phaeomelanin was responsible for rufous parts in the ruff and in the flanks, whereas eumelanin predominantly coloured other parts. We may be reasonably confident that the darker colouration in the bill of Great Crested Grebes is provoked by eumelanin, while pink parts could rely on other pigments. Indeed, brown individuals displayed a lighter pink bill that also lacked a darker culmen. In Horned or Slavonian Grebes, the evidence for an entirely melanin-based colouration was less obvious: the register contained only few examples with a satisfactory description or a good photo. These should nevertheless provide sufficient basis for suggesting an entirely melanin-based pigmentation, considering the close relationship with other *Podiceps* grebes in which melanins are responsible for the entire colouration. Better examples underlined the correctness of the initial hypothesis of melanin prevalence in the colouration of Red-necked Grebes. For Black-necked or Eared Grebes, this evidence was overwhelming, and there were no contradicting examples in the over 200 individuals in the register. The effects of aberrations on the colouration of the species's ear tufts supported Frank's (1939) statement of a melanin-based origin.

Table 6. Contribution of melanins to normal pigmentation and effects of genetic colour mutations (that reduce melanins) per grebe species as resulting from the register.

	Regular breeding/non-breeding /juvenile colouration and effects of genetic colour mutations				
Eurasian Little Grebe	Blackish-brown cap, hind-neck and upper-parts of body eumelanin-based; rufous chestnut cheeks and sides of neck phaeomelanin-based; lower neck and breast dark grey-brown (eumelanin); flanks variable, generally rather dark; belly whitish to variable degrees; eyes chestnut (melanins); yellow gape wattle (unknown origin, but probably not melanin); bill black (eumelanin) with pale tip; feet dark green to olive yellow / **Non-breeding:** crest, hind neck and upper parts of body more brown-black (eumelanin); fore neck and upper breast light brown to beige, occasionally with rusty tinge; gape wattle pale yellow to cream / **Juvenile:** similar to non-breeding; often some warm rufous feathers on side of neck / pigment at origin of yellow bare skin at gape and of yellow-eyed subspecies unknown				
	Albinism: pure white plumage; orange, pale lemon or pinkish bill and legs; pale to serous red iris; in yellow-eyed subspecies possibly less affected; bare skin at gape unaffected, only naturally paler in winter birds	**Leucism:** feathers affected entirely white; bill, legs and other bare parts as in albinism if total, as in albinism or normal if partial; iris dark brown	**Dilution:** eumelanin plumage more greyish to pale grey, may remain rather black in parts with ordinarily high melanin concentrations; phaeomelanin parts faded chestnut (face and upper fore neck); bill, bare parts at onset of beak and feet normally pigmented in the few cases recorded; eyes normally coloured	**Brown:** eumelanin-based plumage overall light brown to beige or cream coloured; chestnut in face and upper neck hardly affected; pink bill in non-breeding plumage; eyes not visibly affected	**Ino:** eumelanin-based plumage overall light brown to beige or nearly cream coloured; chestnut in face and upper neck fading to a rusty tinge; bill and feet more yellowish to orange; iris pinkish or serous, in dark ino effect not well visible; bare skin at gape apparently unaffected
Austral-asian Little Grebe	Blackish cap, black face, throat, hind neck and black-brown upperparts of body plumage eumelanin-based; chestnut patch of ear region leading into sides of neck phaeomelanin-based; other parts of neck dark grey brown (eumelanin); flanks mottled grey-brown and white and upper-breast dark grey brown (eumelanin) appearing faintly mottled with white; yellow eye and gape wattle, probably not melanin-based; dark bill (eumelanin) tipped white; feet dusky green to olive yellow / **Non-breeding:** dark grey brown cap; pale buff grey lower face; white throat; sooty grey-black hind neck and back; greyish upper breast and lower fore neck; whitish on upper fore neck; flanks buff and white; bill bluish to pale yellow; gape cream white / **Juvenile:** similar to non-breeding; more blackish in face; warmer buff in flanks; pale green yellow iris / pigment at origin of yellow eye and bare skin at gape unknown				
	Albinism: pure white plumage, pale lemon or pinkish bill and legs; iris visibly affected, colour of bare skin at gape unknown	**Leucism:** feathers affected entirely white; bill, legs and other bare parts as in albinism if total, as in albinism or normal if partial; iris yellow	**Dilution:** eumelanin plumage more greyish to pale grey, may remain rather black in parts with ordinarily high melanin concentrations; phaeomelanin parts faded chestnut; no effects on bare parts noted	**Brown:** eumelanin-based plumage overall light brown to beige or nearly cream coloured; chestnut in face and sides of neck hardly affected; pink bill in non-breeding plumage; eyes not visibly affected	**Ino:** eumelanin-based plumage overall light brown to beige or nearly cream coloured; chestnut in face and upper neck fading to a rusty tinge or cream; bill and feet more yellowish to orange; iris perhaps more serous, in dark ino no visible effect; bare skin at gape unaffected

	Regular breeding/non-breeding /juvenile colouration and effects of genetic colour mutations				
Great Crested Grebe	Black crown and crest, dark grey brown hind neck and upper parts of body plumage eumelanin-based; chestnut in ruff and flanks phaeomelanin-based; facial area and narrow supercilium white; fore neck and upper breast white, occasionally to the sides variously tinged rufous buff (phaeomelanin); belly silky white; chestnut eye-colour eumelanin-based; pinkish bill; dark parts at culmen due to eumelanin; feet olive green to greenish grey; no other pigments identified / **Non-breeding:** phaeomelanin in reduced ruff and in flanks disappeared; white face; flanks more grey white / **Juvenile:** similar to non-breeding; often some dusky grey remains on cheeks				
	Albinism: Entirely white plumage; pale flesh pink beak with no dark parts; yellowish to flesh pink feet; serous red eyes	**Leucism:** feathers affected all white; bill and feet either as in albinism if total, or as in albinism or normal if partial; eyes chestnut red	**Dilution:** Eumelanin-based plumage pale grey; phaeomelanin-based plumage faded chestnut (only visible in breeding plumage); bare parts may be affected	**Brown:** Eumelanin-based plumage pale brown to light beige; phaeomelanin-based plumage hardly affected; feet including lobes paler; bill pale pink, and generally less dark at culmen; difference to normal pink colour not very marked; iris of about normal colour	**Ino:** Eumelanin-based plumage pale brown to beige; phaeomelanin-based plumage whitish with at maximum a pale rufous hue; bill pale pink, but tending less to pink flesh as in albinism; pale yellowish or flesh coloured to brown legs; iris more pinkish, in dark ino no visible effect
Horned/ Slavonian Grebe	Blackish green head plumage and dark grey brown hind-neck and upper parts of body plumage eumelanin-based; yellow to chestnut yellow in horns and chestnut in fore neck and flanks phaeomelanin-based; belly silky white; red eye-colour not (entirely) melanin-based; dark bill (eumelanin) with pale tip; feet olive green to blackish brown / **Non-breeding:** more dark grey rather than black above (eumelanin); white lower face, front neck, upper breast and flanks / **Juvenile:** similar to non-breeding; back slightly more brownish or sooty without pale feather margins; fore neck less pure white; bill pinkish / except for eyes, no other pigments identified				
	Albinism: Entirely white plumage; pale flesh pink beak; yellowish to flesh pink feet; red eyes more serous	**Leucism:** feathers affected all white; bill and feet either as in albinism if total, or asin albinism or normally pigmen-ted if partial; red eyes more serous	**Dilution:** Eumelanin-based plumage pale grey; phaeomelanin-based plumage nearly white (horns) or washed-out orange to pale rufous (neck and flanks); no phaeomelanin in non-breeding plumage; bill and feet often pinkish grey; eyes unaffected	**Brown:** Eumelanin-based plumage pale brown to beige; phaeomelanin-based plumage hardly affected; bare-parts barely affected; eyes not visibly affected	**Ino:** Eumelanin-based plumage pale brown to beige; phaeomelanin-based plumage whitish (horns) or with a pale rusty hue (neck and flanks); flesh coloured bill; feet lighter, more yellow; iris more pink; in non-breeding plumage no phaeo-melanin present

	Regular breeding/non-breeding /juvenile colouration and effects of genetic colour mutations				
Red-necked Grebe	Blackish upper head and hind neck, dark brown-black upperparts of body plumage and rusty grey in otherwise white cheeks eumelanin-based; chestnut in fore neck and upper breast phaeomelanin-based; flanks rather dark (eumelanin) mixed with some buff to chestnut feathers (phaeomelanin); belly silky white; dark chestnut to dark brown eye colour melanin-based; blackish bill (eumelanin) with yellow parts at base; feet olive green to dark grey / **Non-breeding:** generally paler, dark grey upper parts; cheeks and throat pale grey; fore neck whitish; flanks mottled grey / **Juvenile:** similar to non-breeding, slightly more brownish, with sometimes buff brown wash to grey sides of neck / except perhaps for yellow in bill, no other pigments identified				
	Albinism: Entirely white plumage; pale flesh pink to yellowish orange beak with no dark parts; yellowish orange to flesh pink feet; serous red eyes	**Leucism:** feathers affected all white; bill and feet either as in albinism if total, or normally pigmented or as in albinism if partial; dark brown eyes not affected	**Dilution:** Eumelanin-based plumage pale grey; phaeomelanin-based plumage with pale chestnut hues; bare parts possibly not affected; phaeomelanin not present in non-breeding plumage	**Brown:** Eumelanin-based plumage pale brown to beige; phaeo-melanin-based plumage unaffected; pale yellow bill; yellowish feet; dark eyes not visibly affected	**Ino:** Eumelanin-based plumage pale brown to beige; phaeomelanin-based plumage with light rusty yellowish tint (neck and flanks); feet and beak flesh coloured; iris serous pinkish, in dark ino less visible effect; in non-breeding plumage no phaeomelanin present
Black-necked/ Eared Grebe	Blackish upperparts and head plumage, black neck and upper breast entirely eumelanin-based; deep yellow to chestnut yellow ear tufts phaeomelanin-based; flanks mottled chestnut (phaeomelanin) and white; belly silky white; glowing red eyes possibly predominantly provoked by pterins; blackish bill eumelanin-based; legs and feet blackish to greenish grey / **Non-breeding:** dark grey rather than black above (eumelanin); white lower face, chin, fore neck, flanks and belly; sometimes dusky wash or smudges over fore neck / **Juvenile:** similar to non-breeding, but more brownish grey (eumelanin); buff tinge to sides of upper neck; dusky collar over breast; iris tan (possibly pterin)				
	Albinism: entirely white plumaged; bill and feet yellowish to pinkish grey; pale red, or rosy iris	**Leucism:** feathers affected all white; bill and feet either as in albinism if total, or normally pigmented or as in albinism if partial; red eyes unaffected	**Dilution:** eumelanin-based plumage pale grey to whitish; ear tufts pale whitish yellow and rusty hues in flanks (phaeomelanin-based); bill and feet possibly only affected in some forms; eye red; in non-breeding plumage no phaeomelanin	**Brown:** eumelanin-based plumage pale brown-beige; phaeomelanin-based plumage not visibly affected (ear-tufts and flanks); bill and feet hardly visibly affected; rather normal red eyes	**Ino:** eumelanin-based plumage pale brown-beige; whitish ear-tufts and pale rusty flanks (phaeomelanin-based); rosy or pinkish eyes reported for some juveniles and subadults; bill and feet yellowish; in dark ino effect on eyes and bare parts comparable to brown
Western Grebe	Crest, hind-neck and upperparts of body plumage black to dark grey entirely eumelanin-based; face, fore neck, upper breast and flanks white; glowing red eye perhaps due to pterins; green yellow bill with black ridge possibly a mix of eu- and phaeomelanin; feet dusky grey to green yellowish / **Non-breeding:** slightly paler overall / **Juvenile:** similar to non-breeding; facial pattern more diffuse				
	Albinism: pure white plumage; possibly pink eyes; yellow bill (may lead to confusion with Clark's Grebe) and feet	**Leucism:** pure white plumage; bill and feet either as in albinism if total, or normally pigmented or as in albinism if partial; red eyes unaffected	**Dilution:** pale grey to cream white plumage	**Brown:** pale brown-beige plumage; olive legs; bill unknown, possibly paler yellow and less dark at culmen	**Ino:** pale brown-beige plumage; perhaps a bit pale red eye; bill unknown

	Regular breeding/non-breeding /juvenile colouration and effects of genetic colour mutations				
Clark's Grebe	Crest, hind-neck and upperparts of body plumage black to grey entirely eumelanin-based; face, fore neck, upper breast and flanks white; glowing red eye; orange yellow bill (perhaps phaeomelanin); dark culmen provoked by eumelanin; feet dusky grey to green yellowish / **Non-breeding:** slightly paler overall / **Juvenile:** similar to non-breeding				
	Albinism: pure white plumage; possibly pink eyes; yellow feet and bill, bill lacking dark culmen	**Leucism:** pure white plumage; bill and feet either as in albinism if total, or normally pigmented or as in albinism if partial; red eyes unaffected	**Dilution:** pale grey to cream white plumage	**Brown:** pale brown-beige plumage; olive legs; bill yellow, less dark at culmen	**Ino:** pale brown-beige plumage; perhaps a bit pale red eyes; orange yellow bill

For other grebe species like Western and Clark's Grebes, only few records could directly provide an undisputed proof of the quasi-exclusive presence of melanin. The common evolutionary origin and the fact that the few examples provided were not in contradiction must therefore be sufficient basis for stating that the plumage colouration of these and probably all other grebe species is entirely melanin-based. Exceptions might be found for bare parts and for the eyes.

Drawing final conclusions concerning the pigmentation of bare parts was quite difficult for most species. For many individuals, regardless of species, these were not described. On photo records, the legs remained mostly hidden below the water surface. The examples with complete description favoured eumelanin dominance and absence of other pigments in these parts for most species. To what extent dilution could affect bare parts remained unclear. It seemed that, as with partial leucism, only some forms might change their colouration.

The eye colour of aberrant grebes represented another challenge. In dark- or chestnut-eyed species, albinistic and ino individuals provided sufficient proof of an entirely melanin-based pigmentation of the eyes. Many species display glowing red or yellow irises which may rely entirely, or to a small extent, or not at all on melanin. In this respect, the only species that contributed sufficient material to this study was *Podiceps nigricollis*. In some albino or pale brownish individuals, the iris appeared to display a less intense red colour than usual, implying that melanin may not be entirely absent from the eye. Low quantities could perhaps contribute to the brightness of the eye. The initial assumptions with respect to the reaction of eye colour to mutations need correction for those species in which melanins may play only a subordinate role in the colouration of the iris. Pterins could plausibly be responsible for the eye colour in these species. Pterins are known to produce yellow and red colours. They are also capable of changing colours with age. This feature would explain the differences in eye colour between juveniles and adults.

There is sufficient evidence to state that all black, grey, brown, chestnut and rufous tones in the integument of grebes, and the golden yellow colours of their ear tufts or horns, are melanin-based. This may not be the case for other colours in the plumage of some species. If present, they are often limited to small areas, such as the pale yellow in the ear tufts (Silvery Grebe) or the orange in the crest (Hooded Grebe). More vivid colours may also be found in unfeathered parts, for instance the orange yellow in the bill of Clark's Grebes, the yellow eye wattles in Hooded Grebes, or the bright yellow, orange or red on skinny eye rings, loral bare lines or beak gapes of several species. It remained unknown whether melanin alone could be responsible for their pigmentation.

Several studies in birds have assumed that yellow integumentary features are carotenoid-based and that some rust-coloured plumage colours contain a high concentration of carotenoid pigments. A study of yellow and red brown feathers in five avian species failed however to detect carotenoid pigments. Chestnut colours were provoked by melanins (McGraw et al. 2004). Hill (2006) stated that rust colouration may be melanin-based with a high proportion of phaeomelanin present. This is in complete agreement with the findings of this study for grebes and previous evidence provided by Frank (1939) and Toral et al. (2008). The situation might be less clear for yellow colours.

For instance, in the feathers of the King Penguin *Aptenodytes patagonicus*, the colour resulted from a yellow pigment, so far not described, that could be classified neither as melanin nor as carotenoid (McGraw et al. 2004). In general, yellow colours can be produced by at least five different mechanisms: these are melanin, carotenoid, pterin, iron-oxide staining and structural colour based (McGraw 2006c).

Carotenoids, which are the second most common pigments in birds, do not seem to contribute to the ordinary appearances of grebes. They are primarily contained in plants which are not in general part of the grebes' diets. They might occasionally show up accidentally in albinistic or leucistic individuals. For carotenoids to be present in grebes, they have to be ingested with the food. This means that they must be delivered by either fish or invertebrates that obtained them in their own diets. There is so far little knowledge about carotenoids in insects (McGraw 2006a). In some aquatic animals, carotenoids as astaxanthin and canthaxantin are dominant and may provide colouration to their predators. Uncharacteristically high concentrations of dietary carotenoids may then lead to unusual hues in especially white plumage (McGraw 2006a). This is, however, generally not the case in Podicipedidae. It is established that the rusty tinges in Great Crested Grebes, in so far as they do not stem from staining, are provoked by melanins, and not carotenoids (Toral et al. 2008). Also, *nigricollis* grebes, that during staging or wintering feed to some extent on the same invertebrate prey as flamingos Phoenicopteridae, were not observed to have produced pink or orange tinges in the white parts of their winter plumage.

4.2. The issue of unusual fore neck and upper breast colouration

Some examples in the register and my own field observations showed that unusual colouration in the fore neck or/and upper breast is not uncommon in different grebe species. To what extent could these phenomena be related to the genetic mutations under review? Basically, we may differentiate between three conditions:

- the red colouration in the ordinarily black upper breast and fore neck in the breeding plumage of Black-necked and Eared Grebes, and possibly other species that are normally rather black in these parts;
- the rusty chestnut to rusty orange yellow hues in the upper breast and/or fore neck of normally all white plumaged grebes in these areas;
- the occurrence of individuals with largely white feathered upper breasts, fore necks and/or chins during the breeding season in predominantly Black-necked and Eared Grebes, but also in other species with coloured fore necks.

Perhaps the most interesting case concerns Black-necked and Eared Grebes that display a red upper breast and fore neck during the breeding season. The saturation of the colouration and also the extent to which reddish feathers cover breast and neck were quite variable in the examples in the register. From a distance, the neck of an affected individual may have looked either entirely chestnut red or still black. In Europe, detecting a Black-necked Grebe with a red fore neck is considered a sensation. Nevertheless, such individuals could be more widespread than reported. One reason is that the presence of reddish colouration may not always be easily visible. Therefore, such individuals may pass unnoticed, especially in bigger aggregations of the species. Another reason may have something to do with the location of the main breeding grounds of the species, in more eastern parts of Europe, from where generally few observations of aberrant grebes are reported. In contrast, seven out of eight cases of erythromelanism in the register are from more western or central parts of Europe, where the species is less numerous. From North America, not a single observation of an Eared Grebe with a red fore neck was reported. The few examples in the register are either my own observations or cases supported by photos found by chance on the internet, and where the photographers appeared to have shown no surprise at the presence of the chestnut red feathers. Maybe the mutation is simply overlooked in North America. Alternatively, it could be rather common and not worth reporting (Konter 2013).

To what extent other grebes with black necks, such as White-tufted Grebes, are affected by a similar or identical mutation is unknown. The literature is silent in this respect. As the examples

of Eared Grebes with chestnut feathers in their upper breast show, this does not necessarily mean that such individuals do not exist.

Rokitansky (1952), referring to Naumann, proposed an age-related change in plumage colouration from black to chestnut red that could be limited to older males and females. There is no evidence for this suggestion. The switch could also result from a genetic mutation. Van Grouw (2006) believed initially that one melanin form does not replace the other. In the meantime he has revised his opinion and accepted that one melanin can be replaced by another. Pigment cells can produce both pigments, depending on what they "are told to do". Although in eumelanism in particular, the extra eumelanin is often overlaying the phaeomelanin, there are several mutations in which (parts of the) plumage which is normally provided with eumelanin gets provided with phaeomelanin only (and vice versa) (van Grouw 2012, pers. comm.). It is therefore possible that instead of black eumelanin, chestnut red phaeomelanin is delivered to the neck and upper breast feathers. Van Grouw (pers. comm.) supported the idea that the chestnut red colour in the normally black fore neck of *nigricollis* grebes could stem from a change in the proportions in which both pigments are deposited, making the phaeomelanin visible. When introducing the term erythromelanism, Harrison (1965) saw a close link between eumelanin and "erythromelanin". He noted that the chestnut-red pigmentation replaced the other melanin pigment. It is today accepted that there are only two types of melanin and that erythromelanin does not represent a third type. The term could therefore be applied to a switch from eu- to phaeomelanin production. Looking at the colours in erythromelanistic grebes, there is no obvious difference between the pigmentation in the flanks and in the fore neck. The pigment responsible for the colouration of the flanks appears to have invaded other plumage parts. We can therefore conclude that the chestnut colour in the fore neck and upper breast is phaeomelanin based. In House Sparrows *Passer domesticus*, a similar phenomenon is observed: the normally black bib of males may be brownish in some individuals. This results from a minimal delivery of phaeomelanin to the feathers. The deposit of phaeomelanin in parts of the plumage that normally contain only eumelanin is quite common in the House Sparrow, and is very likely hereditary (van Grouw 2012).

It is more difficult to assess the rusty chestnut hues in parts of the plumage that are usually white. In theory, various explanations are plausible. Besides the intake of colorants with food and forms of staining stemming from the habitat or from the nesting substrate, a genetic mutation and age-related causes could be at their origin.

The intake of colorants with food has not been reported to play a role in the regular feather colouration of grebes. This may be due to the lack of research in this area so far. Examples in albinistic and leucistic Great Crested and Eared Grebes suggest that other colorants may be ingested with prey and accidentally delivered to unpigmented feathers. Any hues provoked in the examples at hand were minor. In all cases, they were of a pale yellow and not of a rusty chestnut or orange.

Carotenoids must be ingested and can only be taken up by the feather cells during feather growth. Birds are able to store an excess of carotenoids in their liver, making the carotenoids available for the colouration of feathers whenever required (van Grouw 2012). Consequently, the physical preconditions for carotenoid pigmentation exist. However, in predominantly fish-eating species like the grebes, we would not expect their diets to contain the carotenoids needed for the hues in their plumage to arise in that way. Other possibilities appear more likely.

Staining may originate from the natural or accidental chemical properties of the water frequented by the grebes. J. Fjeldså (pers. comm.) believes that this is for instance the case in Hooded and Silvery Grebes in the Andes. Because of the extreme chemical composition of some lakes on the Patagonian basaltic plateaus and on some high Andean bodies of water, staining of white breast feathers by iron oxides becomes likely. Fjeldså often saw Silvery Grebes with a more or less intense orange colouration on the breast, especially at lakes located in districts of the Andes with mining activity. In Andean grebes, the colouration generally faded quickly further up, already in the lower fore neck. The colour pigments could be accumulated likewise during swimming and during incubation. Berthold (1965) investigated the occurrence of rust-coloured plumage in the Bearded Vulture *Gypaetus barbatus* and concluded that the colour only adhered externally to the feathers. The chemical analysis proved that the dye was mostly composed of amorphous iron oxides

and traces of α-quartz. Berthold assumed that the dye was obtained from surfaces with pronounced ferruginous content when humid. According to Berthold (1966), wear and tear eases the adherence of the dye to the feathers. However, whereas the plumage of the Bearded Vulture is only externally affected, in Anatids the iron oxides, if fine enough, may be stored inside feather cavities.

Staining by iron oxides may serve as an explanation for Western and Clark's Grebes displaying unusual hues in the pre-breeding season too. These may have wintered or staged at places where their plumage got exposed. Another explanation is that on contaminated bodies of water, the colorant concentration is greater in some areas than in others. Differences in the individual usage of lake sections would trigger differences in the intensity of the hues. As in Andean grebes, the hue in pre-breeding Western and Clark's Grebes was mostly limited to the region of the breast and faded quickly in the upper neck.

If related to the nesting substrate and considering that grebe partners share the duties of incubation, we would expect both mates to be affected to a similar degree. In addition, the upper neck should be less affected, or not at all, whereas the belly should be at least partially affected. The hues should be absent from the plumage early in the breeding season, when it is fresh. If caused by the nesting substrate, the continuous moult of breast and neck feathers would turn the plumage white again, at the latest in winter. The register provided examples of individual Western, Clark's, Great Crested and Hooded Grebes with chestnut red colouration in their breasts and upper necks prior to the start of nesting. Also, the hues were present in juvenile Great Crested Grebes that had hardly any contact with their floating nest after hatching. In incubating grebes, the examples showed that one mate could be strongly affected, the other not at all. Moreover, the distribution of the hues in the plumage did not necessarily correspond to expectations related to staining from the nesting substrate. It seemed unlikely that the nesting material contained a colorant that completely changed the appearance of the upper neck, but was hardly visible further down on plumage parts in direct contact with it.

Another explanation would consist in an age-related occurrence of the unusual hues. In this case, the rusty colouration would show up either only in juveniles or only in older birds. In more experienced grebes, we could then expect with increasing age either an extension of the area covered or a greater saturation in the colour. Great Crested Grebes provided examples, though, in which such hues were strongly present in identical manner in juveniles and adults. An age-related appearance therefore seemed unlikely.

In the Great Crested Grebe, the hue and the saturation of the chestnut feathers in the breast and the neck mostly corresponded exactly to those seen in flank feathers. The presence of rusty colours in otherwise white plumage may often be genetically controlled and may correspond to a kind of melanism or to acromelanism, in which pigments are delivered to feathers normally uncoloured. Acromelanism was defined by Lubnow (1963) as the deposit of melanin in the feathers depending on body and environmental temperature. The mutation is allelic (involving the same gene) with albino. In acromelanism, only the colder body extremities are provided with some pigment. The mutation cannot cause chestnut hues on the breast. However, a scenario related to a form of melanism remains plausible in Great Crested Grebes. In some individuals, the chestnut-red tinges were present in the normally white face. Toral et al. (2008) proved that chestnut feathers in the front neck or upper breast of Great Crested Grebes contained phaeomelanin. It is therefore unlikely that the effect is generally due to tinting from nesting material or other external causes.

Hoary-headed Grebes too can display rusty orange tones in their upper breast and front neck. The intensity of the cinnamon buff hue is quite variable (Fjeldså 2004). The coloration may reach up to the chin. It does not seem plausible then that it is caused by a kind of staining. Its presence could be genetically controlled. Contrary to the situation in Great Crested Grebes, the pigmentation is of more regular occurrence in Hoary-headed Grebes. It does not constitute an aberration, but must be considered as being part of the phenotypic variability of the species. The pigmentation is generally absent in wintering birds and present prior to the start of breeding, suggesting that its presence may depend on the hormonal state of individual grebes.

If an invasion by chestnut pigments of feathers which ordinarily look white can be easily imagined for species which already display the tinge in neighbouring parts of their plumage, the presence

of the hues in species that ordinarily do not rely on phaeomelanin is more difficult to explain. Arguments for a genetic origin may then appear rather weak. The white feathers on fore neck, breast and belly do contain melanin, however, mainly at the base of the feather (down layer). The fact that these 'white' feathers contain melanin makes it more understandable that the melanin deposit can be changed and hence the tips get coloured (van Grouw, pers. comm.). An origin related to ferruginous staining, as suggested by Berthold (1965, 1966), appears likely in some cases and may be excluded in others. On some lakes, the hue was strongly present in juveniles, but not – or only faintly – in adult Great Crested Grebes: there is no apparent reason why iron oxides should affect predominantly first-year birds and spare their parents.

In conclusion, the issue is far from being settled and, in practice, different explanations may apply to different situations. It is worth analysing biochemically the origin of the rusty chestnut colouration in the different species and, if relying on phaeomelanin, its genetic relatedness to other forms of melanism. Generally, birds seem to have a preference for red hues in contexts where visual communication is important, such as mate choice and agonistic encounters (Hill 2006, Toral et al. 2008). The chestnut feathers in the ordinarily white fore necks and upper breasts of grebes could give their bearers fitness advantages and, if hereditary, the condition could spread, as was perhaps the case in Hoary-headed Grebes.

The third aberration consists in the largely white upper breasts and fore necks that individual Black-necked and Eared Grebes display during the breeding season. In some *nigricollis* grebes, even the flanks were partially white. In contrast, most individuals had fully developed ornamental ear tufts and elongate crest feathers. They resembled grebes that had either not yet completed their moult into breeding plumage or could display partial leucism limited to these areas. Some individuals observed over longer periods did not change their appearance: their leucistic traits remained unchanged. A completion of their moult could not be expected. According to Storer and Jehl (1985), these individuals are subadults. Many of them only undergo a partial moult into breeding plumage. They may be recognized by their duller overall plumage, which is often mottled with brown or rufous in the wing coverts. Their flanks may be more brownish than chestnut. Their ear tufts are of a pale straw yellow colour. Their iris should be more orange or orange red, not glowing red as in adults. However, in reality, by no means all Black-necked or Eared Grebes with white feathers in the upper breast and fore neck were subadults. Some individuals were adult grebes with bright crimson or glowing red eyes. Their white feathers, present early in the breeding season, were not rapidly overgrown by black feathers. This suggested that the condition was due to partial leucism rather than to an incomplete moult in subadults. Another possibility suggested by Storer and Jehl (1985) was fading and wear in the plumage parts most exposed to the water. This would result from long stays on alkaline lakes, given that melanins are alkali-soluble. However, with body moult not starting until February at the earliest (Storer & Jehl 1985), it is unlikely that habitat plays a major role in the appearance of abnormal white feathers early in the breeding season.

Moreover, some Red-necked Grebes, Horned and Slavonian Grebes display partially white upper breasts or fore necks throughout the breeding season. The issue merits further investigation in all grebe species with pigmented fore necks when breeding.

4.3. Consequences of aberrations on health and survival

For traits to spread, the bearers of the corresponding genes must reproduce. A first condition therefore is to survive in good condition. For grebes in which the aberration does not express and that simply inherit the capacity for its transmission, survival chances do not differ from normally pigmented conspecifics that do not carry the gene. This study yielded no direct evidence in this respect. Even for individuals that were affected, the data in the register provided little information about the consequences of genetic aberrations on survival and health. Only for albinistic individuals did the records prove generally short lifetimes not exceeding a few months. For other mutations, the consequences appeared to be less deleterious. Long survival over more than three years was documented for six grebes in the register. An age in the range of ten years was

attained by a brown Little Grebe (seen 1987-1995), a brown Great Crested Grebe (1984-1994) and a diluted Red-necked Grebe (2000-2010). With ino, the maximum survival time may have been four years (Eared Grebe seen 1939-1943). Judging by the individual's appearances, observers were convinced they had seen the same bird in each year. This may however not always have been the case. Mates breeding successfully in one season tend to reunite in the same place for the next season. If the same partners mate in successive seasons, they plausibly produce similarly looking aberrant offspring each time. The offspring tend to return to the region of hatching. It is therefore possible that some long-term records involved more than one individual. Conversely, there have been many observations of Eared and Black-necked Grebes that looked alike and that were nearly all considered to have concerned different individuals. This was not necessarily the case: the same grebe may have been recorded in different years, or at different places in the same year during its migration. Moreover, if an individual was not recorded in the same area in the next year, it might nevertheless have survived.

Except for albinism, the study provides no examples of direct consequences on health of genetic colour mutations. Theoretically, any change in a co-adapted gene sequence is likely to produce a different protein that will result in the production of an inferior phenotype, leading to a decline in fitness. The effects of mutations on the phenotypic expression are mainly deleterious, because mutations disrupt the expression of genes that function relatively well under current environmental conditions (Møller & Mousseau 2001). This is also true for the genes responsible for plumage pigmentation. The negative effects will be mutation dependent. They will differ plausibly with grebe species and with habitat. In addition, some consequences will be direct, others indirect.

Aberrantly coloured offspring may be at a disadvantage from the start: parents may discriminate against unfamiliar pulli. According to Kilner (2006), colouration must have evolved as a result of sibling competition for parental care, and colour patches can convey information to parents that might influence their provisioning decisions. In many grebe species, colour signalling by their pulli is mainly based on haemoglobin that provisions bare parts. If upset, these change for an intense red colouration. Genetic mutations affecting melanin may therefore have less negative effects in grebes in this respect. Completely white or light plumaged pulli may even be at an advantage: the haemoglobin signalling may become more visible. In species that do not rely on flashing bare parts, disadvantages in sibling competition and in the preferences of parents may result. They could express in lower rates of food delivery and parental care in general.

The normal plumage of all grebe species is counter shaded in the sense that it exhibits darker upperparts and lighter underparts. The pigmentation of the upper surface plays an essential role in thermoregulation and in protection against UV radiation. Dark colours absorb more radiant energy and prevent radiation from passing through to the skin. Light coloured plumage allows more radiant energy to pass through the feathers, where it may warm the animal (Bortolotti 2006). White chicks are more vulnerable to overheating than are dark chicks. While black plumage may heat up more quickly in the sun, the peripheral temperature changes have relatively little effect on the core body temperature. The key variable is the depth to which solar radiation can penetrate (Kilner 2006). Forms of melanism may have little effect on thermoregulation and UV protection in grebes, as it will mostly affect plumage parts not much exposed to the sun. In contrast, all mutations provoking lighter feathers on the upperparts risk leading, to varying degrees, to overheating and increased damage through UV radiation. The effects on thermoregulation may be at least partially counterbalanced by feather erection, exposure to wind, longer stays in shaded areas and bathing.

Melanin pigmentation increases the hardness of feathers, whereas other pigments such as carotenoids offer no protection (Bortolotti 2006). As melanins serve the stability and the protection of feathers from UV radiation, reduced pigmentation in quantity or in quality will increase their vulnerability to sunlight and to pollutants contained in the environment. It will weaken the feather structure, causing accelerated abrasion and wear, particularly of flight feathers, and this may reduce mobility (Bonser 1995, Campbell & Lack 1985, Schreiber et al. 2006). The plumage might be more easily invaded by lice and other parasites or subject to bacterial degradation.

Loss of pigmentation that affects the retina of the eye can lead to impaired sight in bright light (Campbell & Lack 1985). While in albinos, the consequences are far reaching and may lead quickly to blindness (Löhrl 1971), they are less important in ino and brown individuals, which retain much better eyesight. In comparison to conspecifics with normal eyes, they will be at a disadvantage with respect to predator and prey detection. If feeding on slow moving food, the nutritional drawbacks might be limited, but pursuit predators may suffer from lower capturing rates, leading to malnutrition.

Possibly the most fatal indirect consequences of colour mutations are related to crypsis and protection from predators. We might generally expect normally plumaged individuals to be well concealed inside the habitats they usually occupy. Any change in colouration will therefore increase their detectability. Grebes affected by mutations leading to paler plumages, especially albinism or total leucism, will become highly visible to aerial and terrestrial predators. With ino, dilution and brown, the detectability of the bearers will increase to varying degrees, depending in part on the degree of affection, but also on the degree of sun bleaching of the plumage. The situation might be different with predators living inside the water, such as large fish. To them, melanistic grebes might be more visible than others as their dark bellies would disrupt to a greater extent the background provided by the sky. However, this disadvantage might only be temporary and limited to the chick stage. Fully grown grebes seem to be at hardly any risk in this respect. According to Jehl (2007), there is a general expectation that highly conspicuous individuals should be rapidly eliminated from the population. He expected white grebes to be more conspicuous, including under water, and this would increase their detectability and their risk of predation by predatory fish. As the upper surface of the plumage remains normally hidden to underwater predators, I believe that, except for forms of melanism which darken the plumage of the belly, genetic colour mutations are of little or no disadvantage in this respect.

In the wild, aberrant individuals are generally at a disadvantage, and most mutations will reduce the life expectancy to a lesser or greater extent. The disadvantages related to their poor eyesight mean that albinos are short-lived. Löhrl (1971) stated that besides problems with thermoregulation and possibly acceptance by parents, their poor eyesight and their greater conspicuousness together constitute insurmountable obstacles to long survival. All cases in the register where albinism was clearly established as causal mutation concerned chicks and juveniles. Totally leucistic individuals are a bit better off: their normal vision should improve their preying success and their reaction time to predator attacks. Other issues might remain the same as for albinism. Theoretically, partial leucism starts with just one unpigmented feather that is ordinarily pigmented and ends with just one pigmented feather left. With very few feathers affected, leucistic individuals may have a normal life, whereas with an almost entirely white plumage, the consequences can similar to those suffered by totally leucistic grebes. Detailed studies about associated drawbacks are lacking, at least in grebes.

In a study on Hooded Crow *Corvus cornix* populations in Norway, Slagsvold et al. (1988) showed that with increasing age category, the percentage of individuals with leucistic markings diminished. About 5% of the fledglings displayed white feathers in their plumage. In yearling birds, it was only 2%, and a further decrease to about 1% occurred among birds which had acquired their adult plumage. The authors noted that the crows affected were typically small-sized, both in bone-structure and feather size, which may have contributed to their rapid disappearance from the population. The study suggested that leucism could be coupled with other deficiencies. Although the authors of the study seemingly dealt with the mutation leucism, van Grouw (pers. comm.) believes that in reality the white feathers resulted from food deficiencies. He presented convincing arguments: (i) food deficiency is very common in Carrion *Corvus corone* and Hooded Crows, (ii) in the nest, juveniles are often fed with 'junk food', and this has consequences on feather growth and pigmentation, (iii) a greater percentage of juveniles with white feathers results from the feeding habits of the parents, and (iv) food deficiency also leads to smaller and less well developed adults.

The disadvantages associated with dilution largely depend on its degree. At low percentages, the consequences on plumage colour are hardly visible. Hence, they could be minimal on health and on survival too. Higher degrees of dilution

trigger higher cost. The mutations ino and brown are more deleterious as, in addition, they reduce eyesight. The consequences for affected individuals again depend on the degree of affection. In mild forms, protection against feather abrasion and UV radiation may still function.

Almost all forms of deficient melanisation have more or less negative consequences on the well-being of grebes. This could be less the case with hereditary forms of melanism. At most, they could be mildly deleterious without really endangering the health or reducing the survival chances of affected grebes. Forms in which normally unpigmented areas are not invaded by melanin, those in which normally dark markings are bolder or overrun typical boundaries, or those triggering a slightly changed pigment distribution are not expected to have direct consequences on physical condition. This might also be the case if the entire plumage of the grebe were darkened, provided the parents accept their offspring. For young birds, the risk of predation from below the water surface might be slightly increased. With chestnut and erythromelanism, I do not expect any far reaching disadvantages, neither in Black-necked and Eared Grebes nor in Great Crested and other grebes. The only argument against long survival of melanistic individuals is that the register has no supporting example. Non-hereditary forms of melanism, which can indicate malnutrition or some other pathology, may negatively affect survival (Davis 2007). If their causes are removed, normal feathers will appear during the next moult (van Grouw 2006).

The few cases in the register that dealt with mating and reproduction efforts of aberrant individuals mostly indicated negative consequences for the fitness of their bearers. In many cases, conspecifics avoided their company and they had problems in pairing. In only a few examples did an aberrant grebe successfully reproduce over more than one season. We may conclude that, even if some mutations do not exclude long survival, most of them will reduce fitness. Ultimately, the mutations survive due to transmission by individuals in which they do not express. Decreased survivorship of aberrant individuals and selection against them during pairing generally prevent the character trait from spreading.

4.4. Occurrence rates of mutations in the field

According to van Grouw (2006, 2010, 2013), progressive greying is the most common aberration, and leucism and brown are the most common mutations observed in birds. However, not every mutation occurs with the same frequency in every species (van Grouw 2010). In grebes, 73 out of 469 individuals were affected by progressive greying. The cause for the aberration could not be defined in 136 cases: a majority of them may have concerned progressive greying. Age-related plumage deficiency was plausibly the most common aberration in grebes. In 222 cases, a genetic mutation was identified. Dilution appeared to occur much more often than any other mutation: it represented 37% of all genetic mutations observed in this study. Dilution was followed by brown (18%) and total leucism (10%). As there are many different forms of dilution, all involving different genes, it might be misleading to compare their combined occurrence to that of mutations always involving one and the same gene.

Of 74 *nigricollis* grebes affected by a genetic mutation, 38 were subject to dilution. Also in *P. grisegena* (8 out of 21 individuals) and *P. auritus* (7 out 14 individuals) dilution was the most frequent colour mutation. In contrast, Great Crested Grebes were more often subject to brown (26 out of 87 cases) than to dilution (17 cases) or to total leucism (13 cases). In Little Grebes, total leucism and dilution were equally frequent (5 out of 22 cases). Melanism (4 cases) was slightly less frequent.

The results must generally be considered with care. The risk of confusion between different mutations and with progressive greying is highly dependent on the accuracy of the material available. With field observations, the analysis relies on the observer. Especially if limited to descriptions, the assessment might have reached a different result if all details were correctly listed. Van Grouw (2012) found that progressive greying was in fact by far the most common colour aberration in House sparrows *Passer domesticus*, but it was in the past always assigned to partial albino, without its real nature being understood.

Also, 101 grebes were classified as whitelings, or the mutation initially indicated proved impossible to verify. Their correct assessment could

have changed the overall picture. In addition, records entered in the register were generally representative of field observations and reports in ornithological journals and on the internet. These may not necessarily have corresponded to the real situation on the ground. For instance, albinos might be underrepresented in the results for one major reason. Many grebes breed either in remote areas or in habitat with difficult access. As albinism has direct consequences on the health and entails competitive disadvantages for affected chicks vis-à-vis siblings, albinos are more likely to die early (before detection) than chicks affected by other mutations that are less directly deleterious and do not hamper migration to a comparable extent. Fledged offspring become more mobile. This increases their chances of being sighted and reported. Albino grebes may be more liable to die prior to detection by humans than offspring subject to other mutations. Sage (1963) noted that nearly all migratory species show a very low incidence of albinism. Although his definition included all sorts of leucism, it suggested that migration is a major hurdle to albinistic birds. The low incidence of albinism would apply to fully grown individuals, whereas at hatching, albinism could be just as frequent as other colour mutations. This is in line with van Grouw (2006), who stated that albino births are more frequent than one might expect, given the rarity of observations. Most of them simply die rather quickly.

For other genetic mutations, bias may stem from predation rates of highly visible individuals prior to their detection by ornithologists, or from double counting of grebes showing up during migration or in successive years at different locations. The risk of double counting in this study was particularly high with Eared and Black-necked Grebes.

The investigations by Weller (1959), King (1973, 1975), Dittberner and Dittberner (1979), Jehl (1985) and Thiede (2005) all found that melanism is of relatively rare occurrence in grebes. This is in line with the results of this study, so long as we do not aggregate cases of melanism in the traditional sense with cases of erythromelanism and chestnut melanism. Traditionally, melanistic grebes represented 15 cases or 7% of all genetic mutations. However, including cases of erythromelanism (also 15 cases) already changed the picture. Depending on how we consider melanism, it could in reality be less rare in grebes than in other bird families. In addition, with grebes, the mutation is not always easily detectable in the field. In breeding plumage, the mutation may be quite prominent in species with a white fore neck (see the example of a Great Crested Grebe), but it is largely hidden in others (see examples of Horned, Eared and Least Grebes) as it could predominantly express on the belly. It might be questionable whether chestnut melanism (9 cases in Great Crested Grebes) falls within the same category as the other melanistic individuals.

When comparing observers' initial indications of mutations to this study's results, it appeared that less than 20% of them were correct. Generally, much confusion between albinism, leucism and dilution was observed. The mutations brown and ino were completely unknown, while the term "dilution" seemed to be familiar only to a very small minority of the birdwatchers. Van Grouw's (2013) general statement proved valid for grebes too: "most commonly misapplied is the name albino or partial albino used for all sorts of different aberrations, but only in a tiny proportion of cases, it is used correctly". Similarly misused in this study were the terms leucism and partial leucism.

There is no doubt that a major effort to raise awareness among bird watchers is needed. Van Grouw (2006) clarified that the melanin formation process is determined genetically, and changes in plumage are all based on only a few basic principles. However, the appearance of mutations may differ radically between species. Keeping the original colouration of a species in mind, we can distinguish between the different aberrations more easily by noting the actual changes in the pigmentation and being aware of the basic principles. To judge by van Grouw's results (2006, 2012), we have to remain aware that, generally, progressive greying is the most common aberration. Also in this study 73 grebes were subject to a loss of colouration with old age. Expressed as a percentage of the world population of grebes, this gives an infinitesimally low figure that cannot be representative of the real situation.

4.5. The past and future contribution of mutations to genetic variability and speciation

Aberrations are rarely observed in many natural populations, where aberrant plumage is selected against. Colouration is an important visual signal in birds and can provide information related to an individual's age, sex, sexual status, attractiveness, genetic compatibility, kinship, and potential quality as a mate or rival (Dale 2006, Kimball 2006). Unusually coloured individuals might therefore be at a disadvantage when it comes to pair bonding. They might either not be recognized as belonging to the same species; they might be judged of inferior quality by potential mates; or they might be easily chased off by rivals. Partial leucism may be confused with progressive greying, and paler plumage may be judged by potential partners to be invaded by parasites. Sexual selection would dissuade females from choosing these males. Recent research suggests that social status is signalled primarily by melanin. Hormones such as testosterone and luteinizing-hormone are both related to melanin deposit in the feathers and to aggressive behaviour and dominance. This perhaps explains why melanin seems to be such a good signal of dominance and aggressiveness (Senar 2006). Reduced melanisation, either in quantity or in quality, would then signal inferiority to potential mates and rivals. In contrast to normally coloured conspecifics, such individuals would have to fight more often over resources and thereby risk energy depletion, injury or death (Rohwer 1975, 1982 in Senar 2006). For all these reasons, we would expect that most mutations under review here contributed little in the past to improved genetic variability and hence to speciation. One exception might be where an increased melanin deposit could generate competitive advantages.

Mutation is a major factor contributing to the maintenance of genetic variation (Lynch et al. 1999 in Møller & Mousseau 2001). Genetically controlled aberrant plumage patterns in birds, besides providing human observers with identification challenges, present novel plumage phenotypes which are important for evolution (Hosner & Lebbin 2006). Plumage pigment aberrations often result in highly visible plumage differences that could be selected for in some species or populations. Buckley (1982 in Slagsvold et al. 1998) suggested that leucism may be responsible for white morphs seen in polymorphic species. It may also be responsible for the origin of totally white monomorphic species such as egrets *Casmerodius* and *Egretta sp.* Leucism may have led to variable amounts of white in the plumage of several groups thought to have low dispersal rates and isolated small populations. Similarly, variable amounts of melanism occur in isolated populations of some species. Also, melanism and erythromelanism contribute to polymorphism among several genera which have light and dark (melanistic) morphs, as well as reddish morphs. In spite of the obvious disadvantages associated with an altered quality or quantity of melanin in the plumage, it remains conceivable such mutations might occasionally have led to the appearance of a new species. Was this also the case in grebes?

If melanin really is a good signal of dominance (Senar 2006), individuals affected by melanism should be particularly successful in acquiring mates and in intimidating rivals. J. Fjeldså (pers. comm.) drew my attention to the fact that a melanistic Great Crested Grebe is reminiscent of *Podicephorus major navasi,* where some males are extremely dark. This trait could be favoured by females. The basal mutation would not be eliminated from the population. On the contrary, it could spread. Sexually selected traits such as plumage colour are expected to evolve rapidly for several reasons, including the strength of sexual selection, the possible arbitrary nature by which signals are devised, and the possible interaction between sexual selection and speciation (Oland & Hofmann 2006).

The now probably extinct Colombian Grebe *Podiceps andinus* may have been an example of such evolution. Its appearance was that of an erythromelanistic Eared Grebe. It is conceivable that in ancient times a small population of Eared Grebes, in which the gene for erythromelanism was widespread, became isolated in the Bogota highlands. Considering that this form of melanism could have been a Mendelian dominant and the possible signalling advantages of affected individuals, erythromelanistic grebes had a good chance of completely invading the subpopulation rather rapidly. Even with recessive alleles, this could have been achieved. In small isolated populations, inbreeding is more likely to take

place, and this increases the chances of recessive alleles turning up in double copies in individuals (homozygotes) and hence being expressed. Low population sizes strongly contribute to loss of genetic variation. On average, this increases the level of homozygosity (Bensch et al. 2000). Through sexual selection, the genes for the expression of the trait and the genes for mating preferences for the trait may then become genetically correlated (Dale 2006). Assortative mating may thus have produced a subpopulation of Eared Grebes with a different appearance from the parental stock. DNA investigations might reveal genetic differences to *Podiceps nigricollis californicus* that only warrant subspecies status. A comparable development is theoretically conceivable between Pied-billed Grebes and Atitlan Grebes. The latter were in principle oversized Pied-billed Grebes with a much darker plumage. The differences in plumage colouration may have evolved during isolation due to the rapid spread of a melanistic trait.

Thus, melanistic individuals could be at an advantage when it comes to female assessment of potential males or vice versa. In general, cases of melanism are nowadays rare in grebes. One reason could be that most forms are recessive. A possible preference for pairing with melanistic conspecifics would then, in large populations with a continuous distribution, not necessarily translate into a slowly increasing percentage. Another reason could reside in the survival chances of affected offspring. The aberrant looking chicks might not be accepted by their parents. Their different appearance might induce predators to select them more easily as a prey.

A more plausible example of speciation in grebes based on melanism could be with the closely related Western and Clark's Grebes. They were considered colour morphs of the same species until the American Ornithologists Union agreed to a split in 1985 (American Ornithologists' Union 1985). The two species closely resemble each other. We might see Western Grebes as a kind of melanistic Clark's Grebe in which enhanced eumelanin production caused the pigment to overrun previous plumage borders. An increased or altered presence of eumelanin in the bill could also explain the switch from an orange yellow bill with a black culmen to a more uniformly green yellow colouration. A segregation of the initial population followed by lasting isolation, as suggested by Storer and Nuechterlein (1985), may then have favoured one colour morph in one subpopulation and the second colour morph in the other.

The register contains quite a few examples of melanistic (including erythromelanism and chestnut melanism) grebes of different species paired to normal conspecifics. The pair bonds often existed early in the breeding season, indicating that their partners were not in a situation of limited mate choice. In most cases there was successful breeding with ordinary plumaged conspecifics, occasionally repeated, by these abnormally coloured individuals (see cases of melanistic Eared, Horned and Great Crested Grebes, of erythromelanistic Black-necked/Eared Grebes and of chestnut melanistic Great Crested Grebes). In addition, there were no examples that indicated avoidance of melanistic individuals. Although overall the examples were too few, they suggested that melanistic individuals may have no disadvantages when it comes to pairing. In all cases, the melanistic grebes were paired to regular conspecifics. No case of possible assortative mating between melanistic individuals was observed. This was probably a simple consequence of their very low numbers.

Fjeldså (pers. comm.) noted a general tendency among closely related grebes for shifts between lightly and heavily pigmented plumages. Such a shift may have occurred when the sister species *P. occipitalis* and *P. nigricollis* split. They may generally be widespread in birds, as suggested by many molecular phylogenetic studies. Under normal circumstances, we would expect a slow development within the limits of phenotypic variability that shifts average values within an evolutionary time frame. The common ancestor of *occipitalis* and *nigricollis* grebes may have been either rather heavily or lightly pigmented. In the first case, it is conceivable that a light form of dilution led in the end to the appearance of a greyish subform that later became the Silvery Grebe. In the second, a form of melanism may have caused a gradual darkening of the plumage, leading to the Eared/Black-necked Grebe. More speculative is a scenario in which a small more northern population of ancient Silvery Grebes, within which the gene for melanism was well established, became isolated. It may have basically followed a similar development to that described above for the Andean Grebe, except that the new

species was far more successful in reproducing and settling new territories.

Many of the mutations discussed here cause abrupt and quite drastic changes in the appearance of the grebes in which they express. Adaptive change is, however, generally more discreet and slower. So it would be exceptional for these mutations to contribute to a change for a different appearance, provided they were not deleterious. This would be most likely to happen in isolated populations. The genetic mutations leading to total leucism, brown, ino and dilution give their bearers a considerable number of obvious disadvantages in respect of survival, eyesight, feather stability, protection from UV radiation, visibility to predators, species recognition, display signalling, but no obvious advantages. It is therefore not surprising that the register contains only few examples of successful breeding by such individuals, all with regular partners. From none of these pairings were aberrant offspring positively and indisputably reported. Either the genetic rules inhibited the production of abnormal chicks or they died quickly after hatching. The genes responsible for the mutation may nevertheless have been transmitted to the regular chicks.

As with other genetic mutations, the genes likely to induce changes in plumage colouration will not invade a species all of a sudden. Mild forms of colour mutations may pass hardly noticed by the human eye. Where they are at most mildly deleterious under present conditions, they may survive in a population and contribute to genotypic variability. If conditions change, individuals in which the mutations express may be at an advantage. This could then accelerate the transmission rate. The benefits of mate choice to the parents are indirect, having a positive effect on the quality of their offspring. Similarly, if a mutation has no negative consequences (e.g. cases of very light dilution, limited partial leucism, melanism, erythromelanism and chestnut melanism), the aberration may become more widespread over time. This can then lead to a situation in which the aberrant forms represent a fairly large proportion of the whole population: they are then considered as colour morphs within the species (van Grouw 2013). This was perhaps the case with *Aechmophorus* grebes. A next step could then consist in the development of assortative mating, leading to speciation, a process in which geographic isolation could be a prerequisite.

4.6. Future work and tasks of observers

This study has revealed many examples of either misnaming or misidentification of genetic mutations and confusion with non-hereditary causes. Even though identification of colour mutations in the field can be extremely difficult and is by no means always possible (van Grouw 2013), better education of birdwatchers is of urgent importance. This study followed a rather simplistic grouping of aberrations that would make for easier identification and classification in the field. It should be promoted further in the present form. In addition, observers should be convinced of the need for detailed descriptions of affected birds, including their bare parts and eyes, even if these display the ordinary condition. The existence of a detailed description enhances the chances of correct verification of an observation at a later stage.

Bird watchers must be aware of how genetic mutations can be confused with progressive greying. In this context, it might be worth analysing to what extent summering Eared Grebes at Mono Lake, California, are really affected by leucism or dilution. Could it not simply be that they are old grebes finding it increasingly difficult to migrate? Their whiteness could stem from progressive greying, and it would be easier for them to feed on the slow moving food available at Mono Lake. In young birds, I would expect the urge for reproduction and associated migration to the breeding grounds to prevail over the increased chances of escaping predation at Mono Lake.

Besides the correct identification of colour mutations, the observation and analysis of their consequences for birds' lifetime histories requires greater efforts, especially when dealing with aberrations that have less directly lethal consequences. The study showed that observations seldom go beyond the naming of the mutation and perhaps a scant description of the grebe's appearance. Details with respect to survival, social relationship with conspecifics, pairing, breeding and breeding success are often simply not collected. It is always relevant to report the repeated hatching of aberrant offspring from the same pair of normal parents or within a given geographical area, as this would give us information about mate fidelity, survival of offspring

and possible spreading of an aberration. With better information, we can gain greater insights into the life history of aberrant grebes.

Pointer and Walsh (2010) postulated that we still have very little knowledge about the molecular genetic basis of the extraordinary diversity of plumage colouration in birds. Work in this field and on the identification of genes responsible for mutations or the control of quantitative variation in amounts and distribution of melanin should be continued. The involvement of the melanocortin-1 receptor (MC1R) gene, one of the major regulators of eumelanin and phaeomelanin content in feathers (Mundy et al. 2003), in evolutionary colour changes and polymorphism needs further clarification. It would also be useful to determine whether the MC1R gene has played a general role in the evolution of avian plumage (Theron et al. 2001). Biochemical analyses of feathers could help solve the issue of erythromelanism in the fore neck plumage of black-necked grebe species and of chestnut melanism in Great Crested Grebes and other white-necked species. Of interest is also the composition of the pigmentation that gives some grebe species their glowing red or bright yellow eyes.

The results of this study suggest that by no means all *nigricollis* grebes maintaining a partially white upper breast and fore neck during the breeding season are subadults, as stated by Storer and Jehl (1985). The phenomenon warrants further research, not only in Eared and Black-necked Grebes, but also in other species that have colourful necks.

Badyaev (2006) noted that internal factors cause variation, whereas independent external factors sort, delete or retain these variants. In this respect, study of the crucial importance of cultural inheritance and sexual imprinting and of adaptation to habitat should not be neglected. The triggering causes for mutations may not all be internal to the organism. For instance, in a study of albinism in Barn Swallows *Hirundo rustica* from Chernobyl, Møller and Mousseau (2001) suggested that radioactive contamination was associated with a significant increase in mutation rates leading to partial leucism. The question of how habitat contamination, related food poisoning or more generally changing environmental conditions can impact the occurrence rates of mutations is a subject of great interest. Fjeldså (pers. comm.) noted that there is apparently a strong tendency to albinism and leucism in grebe species that often stay in hypersaline lakes or other habitats with extreme mineral composition, which could reflect some mutagenic effects in these habitats.

Although there has been much progress over the last decades in many of the subjects set out above, a lot remains to be done.

5. Acknowledgement

I am very grateful to H. van Grouw, curator of birds at the Natural History Museum in Tring, UK, and Professor Jon Fjeldså from the University of Copenhagen and curator of birds at the Natural History Museum of Copenhagen, Denmark, for advice and support received in the identification of mutations. Their knowledge and experience always provided helpful indications with difficult individuals. A. J. Hernández Navarro kindly supported my efforts to obtain additional information about Spanish records of aberrant grebes. I thank J. J. Vlug for commenting on parts of an early draft and for contributing multiple individuals to the register. I am also indebted to Irina Vlug for translating texts from Russian, to Patrik Sorko for translating Polish papers and to Jari Toivonen for the translation of Finnish internet communications.

The following people readily provided photos or additional descriptive details about individual grebes upon request: J. Aalto, O. Adrian, B. Ahern, V. Ananian, F. Atiénzar, P. Axelsson, H.-M. Berg, R. Berndt, Z. Boev, A. Böhme, B. Bousman, P. Boussès, W. Bouton, J. A. Branca, P. Brockman, H. Buchholz, D. Cimiotti, G. Chaniot, C. Conard, R. Diebitz, A. Doll, P. Eckhoff, P. Erlemann, I.V. Fadeev, A. Fernández-Caro Gómez, J. Fisher, D. Ford, A. Fuhrmann, G. Gilson, A. García Ríos, H. Grimm, D. Guthrie, R. Harrington, J. Hering, A. J. Hernández Navarro, S. Heyl, C. Hervé, M. Hildén, S. Houpert, F. Huckenbeck, H. Jacoby, P. Kameník, K. Karlson, J. Kloskowski, H. Klein, P. Kolshorn, J. Lacalle, G. Lenglet, J. Lontkowski, F. Malher, P. Mansfeld, D. Marquart, F. Mayenburg, J. McIntyre, E. Melchior, Y. Meng, L. Miller, J. Mlíkovský, M. Moody, R. Muñoz, H. Niesen, B. Nirmala, N. Paklina, B. Posse, S. Quigley, G. Reis, F. Rust, P. Sackl, J. R. Saucier, F. Scheuer, B. Schiess, L. Schröpfer, A. Silcocks, S. Shadick, G. Shugart, C. Sloan, C. Slawson, A. Smith, S. Somershoe, J.

Stevens, D. Streiffert, S. Stübing, C. & R. Titus, T. Töpfer, P. van der Wielen, C. van Orden, C. van Rijswijk, R. Vasudev, P. Velte, I. Vlug, J. Wahl, C. Weseloh, R. Winkler, F. Woog, D. Young, M. Zutt. Their support was greatly appreciated.

Many thanks go to David Crowther for his final review and welcome English language corrections and to the Ferrantia editorial team. They both did a great job.

6. References

Adriaensen J., Carbonelle S., Deflorenne P., Dewitte T., Ellis F., Lambert M., Laudelout A., Roberfroid O. & Pierret S. 2010. - La chronique Septembre – Novembre 2010. La Grièche 22:2-24.

Allaby M. 1999. - Oxford dictionary of zoology. Oxford University Press, Oxford, New York.

Allen A. S. 1940. - An albino Eared Grebe. The Condor 42:127.

Altum B. 1867. - Aberrationen. Journal für Ornithologie 15:85-89.

American Ornithologists' Union 1985. - Thirty-fifth Supplement to the American Ornithologists Union check-list of North American Birds. Auk 102:680-686.

Badyaev A. V. 2006. - Colourful phenotypes of colorless genotypes: toward a new evolutionary synthesis of color displays *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 2, Function and evolution. Harvard University Press, Cambridge & London (p. 349-379).

Bandorf H. 1970. - Der Zwergtaucher. Neue Brehm-Bücherei, A. Ziemsen-Verlag, Wittenberg Lutherstadt.

Bauer K. M. & von Blotzheim U. N. G. 1987. - Handbuch der Vögel Mitteleuropas, Band 1. AULA Verlag, Wiesbaden.

Beckmann K. O. 1964. - Die Vogelwelt Schleswig-Holsteins, 2. Auflage. Wachholtz, Neumünster.

Belfiori D., Cavaliere V., Cianchi F., Culmone G., Liuzzi C., Maggio C., Marinelli M., Merola N., Politi P. M., Sigismondi G., Viarengo F., Mariotti B. & Canu A. 2011. - Notiziario 3/2011 – Luglio/Settembre. Notizie dalle Oasi 3/2011:4.

Bensch S., Hansson B., Hasselquist D. & Nielsen B. 2000. - Partial albinism in a semi-isolated population of Great Reed Warblers. Hereditas 133:167-170.

Benson C.W. 1971. - Quelques specimens anciens de *Podiceps ruficollis* (Pallas) provenant de Madagascar et des Comores. L'Oiseau et R.F.O. 41:89-93.

Benson C. W., Colebrook-Robjent J. F. R. & Williams A. 1976. - Contribution à l'Ornithologie de Madagascar. L'Oiseau et R.F.O. 46:103-134.

Berndt R. & Drenckhahn D. 1974. - Vogelwelt Schleswig-Holsteins. Ornithologische Arbeitsgemeinschaft für Schleswig-Holstein und Hamburg e.V.

Bernecker A. 1976. - Ein albinotischer Zwergtaucher *Podiceps ruficollis* am Ammersee. Anz. Orn. Ges. Bayern 15:225-226

Berthold P. 1965. - Über nicht durch Pigment bedingte Rostfärbung bei Vögeln. Naturwissenschaften 52:400.

Berthold P. 1966. - Über An- und Einlagerung von Eisenoxid als Federfarbstoff. Naturwissenschaften 53:338.

Bharos A. M. K. 1996. - Albino Little Grebe *Tachybaptus ruficollis*. Journal of the Bombay Natural History Society 93:293.

BirdLife International 2004. - Threatened birds of the world 2004. CD-Rom, BirdLife International, Cambridge, UK.

Blumin L. 2007. - Featured photo: Leucistic Grebe at Mono Lake - An Identification challenge. Western Birds 38:64–68.

Bonfio A. 1963. - Cattura interessante. Riv. ital. Orn. 33:48.

Bonser R. H. C. 1995. - Melanin and the abrasion resistance of feathers. Condor 97:590-591.

Booth E. T. 1876. - Catalogue of the cases of birds in the Dyke Road Museum, Brighton. G. Beal, Brighton.

Bortolotti G. R. 2006. - Natural selection and coloration: Protection, concealment, advertisement or deception? *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 2, Function and evolution. Harvard University Press, Cambridge & London (p. 3-35).

Bosselmann J. 2005. - Weißer Haubentaucher *Podiceps cristatus* am Laacher See und am Mittelrhein, Rheinland-Pfalz. Ornithologische Mitteilungen 57:161.

Bräuning C. 2002. - Der Bindentaucher, *Podilymbus podiceps*, eine neue Art für Deutschland. Limicola16:257-265.

Brichetti P., de Franceschi P. & Baccetti N. 1992. - Aves. I. Gaviidae - Phasianidae. Edizioni Calderini, Bologna.

Buller W. L. 1875. - On the ornithology of New Zealand. Transactions and Proceedings of the Royal Society of New Zealand 8.

Buller W. L. 1888. - A history of the birds of New Zealand. London.

Bunes V. & Solbakken K. A. 2004. - Sjeldne fugler i Norge i 2002 (Rapport fra Norsk sjeldenhet-skomité for fugl (NSKF)) [Rare birds in Norway in 2002 – Report from the Norwegian Rarities committee for birds (NSKF)]. Ornis Norvegica 27:4-47.

Busching W.-D. 1997. - Handbuch der Gefiederkunde europäischer Vögel, Band 1. AULA Verlag, Wiesbaden.

Campell B. & Lack E. 1985. - A dictionary of birds. T & A D Poyser, London.

Carter F. 1942. - Minutes of Cooper Club meetings – Northern Division. Condor 44:44.

Chernel de Chernelháza S. 1907. - On variations in the colouring of *Colymbus cristatus*, *C. griseigena* and *C. nigricollis* observed at the Lake of Velencze, Hungary. Proceed. IV. Intern. Ornith. Congr. London 1905. p. 524-527.

Cherriere B. 2007. - Leucistic birds in Ontario. Ontario Birds 25:115-123.

Coburn F. 1910. - On some of the rarer birds of Staffordshire and their migration across the county. With notes from adjoining counties - Annual Report and Transactions of the North Staffordshire Field Club 1909-1910, volume XLIV, Stafford (p. 84-128).

Collar N. J. & Stuart S. N. 1985. - Threatened Birds of Africa and Related Islands. ICBP, Cambridge, UK, and IUCN, Gland, Switzerland.

Conard C. 2008. - Seasonal observations – October 1 to October 31 – Rare and unusual bird reports. The Observer 60:7-8.

Coues E. 1868. - Instances of albinism among our birds. American Naturalist 2:161-162.

Cramp S. & Simmons K. E. L. 1977. - The birds of the Western Palearctic I (Handbook of the birds of Europe, the Middle East and North Africa). Oxford University Press, Oxford – New York.

Cullen S. A., Jehl Jr. J. R. & Nuechterlein G. L. 1999. - Eared Grebe. The birds of North America 433.

Dale J. 2006. - Intraspecific variation in coloration *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 2, Function and evolution. Harvard University Press, Cambidge & London (p. 36-86).

Davis J. N. 2007. - Color abnormalities in birds - A proposed nomenclature for birds. Birding 39:36-46.

Deane R. 1876. - Albinism and melanism among North American birds. Bulletin of the Nuttall Ornithological Club 1:20-24.

Deane R. 1879. - Additional cases of albinism in North American birds. Bulletin of the Nuttall Ornithological Club 4:27-30.

Deane R. 1880. - Additional cases of albinism in North American birds. Bulletin of the Nuttall Ornithological Club 5:25-30.

Dennis R. H. 1973. - Possible interbreeding of Slavonian Grebe and Black-necked Grebe in Scotland. Scottish Birds 7: 307-308.

Dettmann W. 1937. - Albino Pied-billed Grebe in Wisconsin. Auk 54:98-99.

Dietrich F. 1928. - Hamburgs Vogelwelt. Verlag Otto Meißner, Hamburg.

Dittberner H. & Dittberner W. 1979. - Bemerkungen zum Vorkommen albinotischer Haubentaucher. Beiträge Vogelkunde 25:124-126.

Dittberner H. & Dittberner W. 1984. - Zu Ökologie, Brutbiologie und morphologischen Merkmalen des Schwarzhalstauchers (*Podiceps nigricollis*). Mitt. Zool. Museum Berlin 60, Suppl.: Ann. Orn. 8:57-88.

Dittberner W. 1996. - Die Vogelwelt der Uckermark mit Schorfheide und unterem Odertal. Verlag Erich Hoyer, Galenbeck.

Drechsler H. 1951. - Die Kraniche vom Weißen Lug. Neumann-Verlag, Radebeul.

Dvorak M., Ranner A. & Berg H.-M. 1993. - Atlas der Brutvögel Österreichs. Umweltbundesamt, Wien.

Eddy N. A. 1885. - Some Michigan notes, with an addition to its fauna. The Ornithologist and Oologist 10:8-9.

Eichhorst B. A. & Parkin B. D. 1991. - Clark's Grebes and suspected Western x Clark's Grebe hybrids in Manitoba. Blue Jay 49:196-200.

Elloway R. 2000. - Birds of Paxton Pits. Bird & Wildlife Club, St. Neots.

Feenstra J. 2005. - Field trip reports: Piute Ponds. The Wrentit 53:7-9.

Feerer J. L. & Garrett R. L. 1977. - Potential Western Grebe extinction on California lakes. Cal-Neva Wildlife Transactions 1977:80-89.

Finkbein R. 1931. - Albinismus beim Haubentaucher. Mitt. Vogelwelt 30:23.

Finkbein R. 1932. - Der albinotische Haubentaucher. Mitt. Vogelwelt 31:90.

Fjeldså J. 1981. - *Podiceps taczanowskii* (Aves, Podicipedidae), the endemic grebe of Lake Junín, Peru. A review. Steenstrupia 7:237-259.

Fjeldså J. 2004. - The Grebes. Oxford University Press, Oxford & New York.

Fjeldså J. & Krabbe N. 1990. - Birds of the High Andes. Zoological Museum, University of Copenhagen, Copenhagen.

Forsten A. 2004. - Photonews. Alula 4:182.

Frank F. 1939. - Die Färbung der Vogelfeder durch Pigment und Struktur. Journal für Ornithologie 87:426-523.

Fray R., Davis R., Gamble D., Harrop A. & Lister S. 2009. - The birds of Leicestershire and Rutland. Christopher Helm, London.

Frede M., Gaedicke L., Gießling B., Hubatsch M., Möller E., Schnitzer P. & Weindorf H. 2008. - Bemerkenswerte Vögel in Nordrhein-Westfalen im Jahr 2007. Charadrius 44:67-115.

French R. 1992. - Country reports - January through March 1992 - Bucks County. Pennsylvania Birds 6:30.

Fridell R. & Summers S. 2004. - Great Basin. North American Birds 57:522-524.

Fuentes D. & González-Acuña D. 2011. - Aberraciones cromáticas del plumaje en aves: nuevos reportes en Chile. Boletin Chileno de Ornitología 17: 113-121.

Gerber R. 1944. - Schwarzhalstaucher, *Podiceps n. nigricollis*, mit weißem Kehlfleck. Ber. Ver. Schles. Orn. 29:57.

Géroudet P. 1949: Calendrier ornithologique – La saison d'hiver 1948-1949. Nos Oiseaux 20:70-78

Gloger 1866. - Der grosse gehäubte Steissfuss, (*Colymbus cristatus*.) in Weiss ausgeartet. Journal für Ornithologie 14:285-286.

Grinnell J. 1898. - Birds of the Pacific slope of Los Angeles: A list with brief notes. Pasadena Academy of Sciences, USA.

Grochmalicki J. 1925. - Bielactwo u perkoza dwuczubnego (*Podiceps cristatus* L.) (L'albinisme chez Grêbe huppé). Kosmos, Lemberg 50:892-894 (Polish with French summary).

Gross A. O. 1965a. - The incidence of albinism in North American birds. Bird-Banding 36: 67-71.

Gross A. O. 1965b. - Melanism in North American birds. Bird-Banding 36:240-242.

Guardiola A. (ed.) 2006. - Anuario ornitológico de la región de Murcia. Informe 1/2005. http://usarios.lycos.esaorm/docs/1-2005.pdf

Gurney J. H. 1879. - Ornithological Notes from St. Leonards. Zoologist 3 (3rd series):376-378.

Gurney J. H. 1887. - Ornithological Notes from North Norfolk. Zoologist 11 (3rd series):140-142.

Gurney J. H. 1908. - Ornithological report for Norfolk. Zoologist 12 (4th series):135.

Hailman J. P. 1984. - On describing color abnormalities in birds. Florida Field Naturalist 12:36-38.

Hanebrink E. L. 1968. - A survey of albino birds in Arkansas. Proc. Arkansas Acad. Sci. 22:17-28.

Hanebrink E. L. 1985. - Reports of albino birds in Arkansas since 1968. Proc. Arkansas Acad. Sci. 39: 124-128.

Hanson H. C. 1949. - Notes on white spotting and other plumage variations in geese. Auk 66:164-171.

Harengerd M. 1971. - Sammelbericht für die Zeit von November 1968 bis März 1971 (Teil 1). Anthus 8:17-21.

Harrison C. J. O. 1963. - Grey and fawn variant plumages. Bird Study 10:219-233.

Harrison C. J. O. 1965. - The chestnut-red melanin in schizochroic plumages. Ibis 107:106-108.

Hawkins F., Andriamasimanana R., Seing S. T. & Rabeony Z. 2000. - The sad story of Alaotra Little Grebe *Tachybaptus rufolavatus*. Bulletin of the African Bird Club 7:115-117.

Heidt C., Konter A., Lorgé P. & Weiss J. 2002. - Tätigkeitsbericht 1985-1997 der Arbeitsgemeinschaft Feldornithologie. Regulus WB 19:1-86.

Hennicke C. R. (ed.) 1903. - Naumann, Naturgeschichte der Vögel Mitteleuropas. Lithographie, Druck und Verlag von Fr. Eugen Köhler, Gera-Untermhaus.

Hering J. 2009. - Beitrag zur Vogelwelt Libyens. Vogelwarte 47:5-22.

Hering J. 2010. - Leukistischer Schwarzhalstaucher *Podiceps nigricollis* auf einem Gewässer in der Zentralsahara. Ornithologische Mitteilungen 62:25.

Hernández Navarro A. J. 2005. - Zampullines descoloridos. Quercus 236:36.

Hertenstein H. 1952. - Aus meinem ornithologischen Tagebuch. Vögel der Heimat 22:101-116.

Hess A. 1915. - Ein albinotischer Haubentaucher. Der ornithologische Beobachter 12:164.

Hill G. E. 2006. - Environmental regulation of ornamental coloration *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambridge & London (p. 507-560).

Hill G. E. & McGraw K. J. 2006. - Bird coloration, Vol. 1. Mechanisms and measurements. Harvard University Press, Cambridge & London.

Hofer J. 1962. - Haubentaucheralbino auf dem Sempachersee. Orn. Beob. 59:56.

Hoffmann G. 1934. - Vogelleben auf dem Karraschsee. A. d. Heimat 47:257-277.

Hosner P. A. & Lebbin D. J. 2006. - Observation of plumage pigment aberrations of birds in Ecuador, including Ramphastidae. Boletín SAO 16:30-43.

Hunter L. A. 1988. - Status of the endemic Atitlan Grebe of Guatemala: is it extinct? Condor 90:906-912.

Jacoby H. 1964. - Die See- und Lappentaucher des Bodensees. Examensarbeit, Manuskript.

Janssen R. B. 1986. - Minnesota records of Clark's Grebe. The Loon 58:109-111.

Jehl Jr. J. R. 1985. - Leucism in Eared Grebes in Western North America. Condor 87:439-441.

Jehl Jr. J. R. 2007. - Additional notes on leucistic Eared Grebes at Mono Lake. Western Birds 38:289-292.

Jehl Jr. J. R. & C. Johansson 2002. - Autumnal migration of Eared Grebes (*Podiceps nigricollis*) through southwestern Wyoming: a key to assessing the size of the North American population. Western North American Naturalist 62:335-340.

Kilner R. M. 2006. - Function and evolution of color in young birds *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 2, Function and evolution. Harvard University Press, Cambidge & London (p. 201-232).

Johnsgard P. A. 1987. - Diving birds of North America. University of Nebraska Press.

Kimball R. T. 2006. - Hormonal control of coloration *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 431-468).

King B. 1973. - The incidence of albinism and melanism in grebes. Bristol Ornithology 6:25-28.

King B. 1975. - Additional records of albinism and melanism in grebes. Bristol Ornithology 8:108-109.

King B. 1985. - Aberrant Slavonian Grebe. British Birds 78:142.

Kirwan G. 1995. - Partially albinistic Black-necked Grebe *Podiceps nigricollis* in eastern Turkey. Bulletin of the Ornithological Society of the Middle East 35: 31.

Knopfli W. 1956. - Die Vögel der Schweiz. Departement des Inneren, Inspektion für Forstwesen, Jagd und Fischerei, Bern.

Knysh N. P. 2004. - Albino oft he Great Crested Grebe in collection of an amateur. Berkut 13:30.

Koblik E. A. & Tsvetkov A. V. 1998. - Nablyudenie gibridnoi poganki v Podmoskovie (Observation of a hybrid grebe in Moscow region]. Ornitologiya.28:242-243 (in Russian).

Köcher W. & Kopsch H. 1979. - Die Vogelwelt der Kreise Grimma, Oschatz und Wurzen. Sonderheft Aquila.

Konter A. 2009. - Occurrence of Clark's Grebes (*Aechmophorus clarkii*) and of their hybrids with Western Grebes (*A. occidentalis*) in southern central Canada. Blue Jay 67:26-33.

Konter A. 2011b. - Interbreeding in *Aechmophorus* grebes. Wilson Journal of Ornithology 123:132-136.

Konter A. 2012a. - Ein melanistischer Haubentaucher *Podiceps cristatus* im Müritz-Nationalpark. Ornithologische Mitteilungen 64:87-88.

Konter A. 2012b. - Visual assessment of interbreeding by *Aechmophorus* grebes. Wilson Journal of Ornithology 124:711-718.

Konter A. 2013. - Are Eared Grebes with a chestnut red fore neck absent from North American population? Blue Jay 71:118-123.

Koop B. 1995. - Rothalsige Schwarzhalstaucher *Podiceps nigricollis* in Schleswig-Holstein. Limicola 9:223-226.

Koop B. 2003. - *Podiceps nigricollis* Black-necked Grebe *in* Parkin D.: BWP Update Vol. 5, N°3. Oxford University Press :185-202.

LaBastille A. 1974. - Ecology and Management of the Atitlán Grebe, Lake Atitlán, Guatemala. Wildlife Monographs 37:1-64.

Lapous E. 2002. - Séjour prolongé d'un Grèbe à bec bigarré dans la Sarthe. Ornithos 9:60-64.

Lee F. & Keeler C. E. 1951. - Pigment variations and their correlates in birds. Auk 68:80-85.

Leuzinger H. 1996. - Winterortstreue eines leucistischen Zwergtauchers *Tachybaptus ruficollis*. Ornithol. Beob. 93:179-180.

Leverkühn P. 1887. - Über Farbenvarietäten bei Vögeln. Journal für Ornithologie 35:79-86.

Leverkühn P. 1890. - Über Farbenvarietäten bei Vögeln. Journal für Ornithologie 38:168-232.

Li D., Li J. & Wu Y. 2011. - A leucistic Little Grebe *Tachybaptus ruficollis* in Hebei Province and a review of albinistic and leucistic species in China. BirdingASIA 16:75-77.

Lindvall M. L. & Low J. B. 1982. - Nesting ecology and production of Western Grebes at Bear River Migratory Bird Refuge, Utah. Condor 1984:66-70.

Löhrl H. 1971. - Wie lange sind Totalalbinos lebensfähig? Anz. Orn. Ges. Bayern 10:1-6.

Lubnow E. 1963. - Melanine bei Vögeln und Säugetieren. J. für Ornithologie 104:69-81.

MacDonald J. D. 1992. - Birds of Australia. Reed, Chatswood.

Marchant S. & Higgins P. J. (co-ordinators) 1990. - Handbook of Australian, New Zealand and Antarctic Birds, Vol 1. Oxford University Press, Melbourne.

McCarthy E. M. 2006. - Handbook of avian hybrids of the world. Oxford University Press.

McGraw K. J. 2006a. - Mechanics of carotenoid-based coloration *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 177-242).

McGraw K. J. 2006b. - Mechanics of melanin-based coloration *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 243-294).

McGraw K. J. 2006c. - Mechanics of uncommon colors: pterins, porphyrins and psittacofulvins *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 354-398).

McGraw K. J., Wakamatsu K., Ito S., Nolan P. M., Jouventin P., Dobson F. S., Austic R. E., Safran R. J., Siefferman L. M., Hill G. E. & Parker R. S. 2004. - You can't judge a pigment by its color: Carotenoid and melanin content of yellow and brown feathers in swallows, bluebirds, penguins, and domestic chickens. Condor 106:390-395.

McGregor R. C. 1900. - A list of unrecorded albinos. Condor 2:86-88.

McKenzie J. & Ford D. 2011. - Leucistic Australasian Grebe. Melbirdian 78:1.

Melde M. 1973. - Der Haubentaucher. Die Neue Brehm Bücherei, A.Ziemsen Verlag, Wittenberg-Lutherstadt.

Melde M. 1986. - Die Taucherarten der Gattung *Podiceps* in der Oberlausitz. Abh. Ber. Naturkundemus. Görlitz 60:1-8.

Micheli A. & Busetto M. 1989. - Resoconto ornitologico bresciano 1989. httP://www.grupporicercheavifauna.it/pdf/resoconto_1989.pdf

Mlíkowský J. 2010. - A preliminary review of the grebes, Podicipedidae. Systematic Notes on Asian Birds 74, Brit. Orn. Club. Occas. Publs 5:125-131.

Møller A.P. & Mousseau T. A. 2001. - Albinism and phenotype of Barn Swallows (*Hirundo rustica*) from Chernobyl. Evolution 55:2097-2104.

Montgomerie R. 2006. - Cosmetic and adventitious colors *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 399-430).

Muller M. J. & Storer R. W. 1999. - Pied-billed Grebe. The Birds of North America 410.

Mundy N. I. 2006. - Genetic basis of color variation in wild birds *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 469-506).

Mundy N. I., Kelly J., Theron E. & Hawkins K. 2003. - Evolutionary genetics of the melanocortin-1 receptor in vertebrates. Annals of the New York Academy of sciences 994:307-312.

NABU Schorndorf 2008. - Das kurze Leben eines Zwergtaucher-Albinos. Schorndorfer Nachrichten 28.10.2008.

Niethammer J. 1964. - Die Pigmentierung und das Farbmuster junger Haubentaucher (*Podiceps cristatus*). Journal für Ornithologie 105:389-426.

Nuechterlein G. L. 1981a. - Courtship behavior and reproductive isolation between Western Grebe color morphs. Auk 98:335-349.

Nuechterlein G. L. 1981b. - Variation and multiple functions of the advertising display of Western Grebes. Behaviour 76:289-317.

Nuechterlein G. L. & Buitron D. P. 1998. - Interspecific mate choice by late-courting male Western Grebes. Behavioral Ecology 9:313-321.

O'Donnel C. & Fjeldså J. 1997. - Grebes – Status survey and conservation action plan. IUCN, Gland & Cambridge.

Ogilvie M. 2001. - Albinism, partial albinism and all the other -isms! http://www.birdsofbritain.co.uk/features/mao-jun-01.asp

Omland K. E. & Hofmann C. M. 2006. - Adding color to the past: Ancestral state reconstruction of coloration *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 2, Function and evolution. Harvard University Press, Cambridge & London (p. 415-454).

Paillisson J.-M. 1999. - Observation rare d'un Grèbe castagneux *Tachybaptus ruficollis* albinos. Alauda 67:231.

Palmer R. S. 1962. - Handbook of North American Birds, Volume 1. Yale University Press, New Haven & London.

Paolillo G. 1988. - Casi di albinismo in Tuffetto, *Tachybaptus ruficollis*, e Svasso piccolo, *Podiceps nigricollis*. Riv. it. Orn. 58:84.

Parkin D. T. & Knox A. G. 2010. - The status of birds in Britain and Ireland. Christopher Helm, London.

Patankar P. G. 2004. - A white Little Grebe at Muval. Flamingo 2:12.

Petit L. 1909. - Cas d'albinisme et variétés de coloration chez des écureuils et différents oiseaux. Bull. Zool. Soc. France 34:32-35.

Pettingill O. S. Jr. 1956. - A laboratory and field manual of ornithology. Burgess Publications, Minneapolis.

Phillips A. R. 1954. - The cause of partial albinism in a Great-tailed Grackle. Wilson Bulletin 66:66.

Piersma T. 1984. - Growth bars in the wing of a Great Crested Grebe *Podiceps cristatus*? Limosa 57:112-113.

Pointer M. & Walsh N. 2010. - Genetic basis of the evolution of plumage coloration. www.zoo.cam.ac.uk

Poncy R. 1953. - Albinisme chez le grèbe castagneux. Nos oiseaux 22:47.

Prinzinger R. 1979. - Der Schwarzhalstaucher. Neue Brehm-Bücherei, A. Ziemsen-Verlag, Wittenberg-Lutherstadt.

Prum R. O. 2006. - Anatomy, physics and evolution of structural colours *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 1, Mechanisms and measurements. Harvard University Press, Cambidge & London (p. 295-353).

Ratti J. T. 1979. - Reproductive separation and isolating mechanisms between sympatric dark- and light-phase Western Grebes. Auk 96:573-586.

Ratti J. T. 1981. - Identification and Distribution of Clark's Grebe. Western Birds 12:41-46.

Rensch B. 1925. - Die Farbaberrationen der Vögel. Journal für Ornithologie 73:514-539.

Roberson D., Bailey S. F. & Singer D. S. 1998. - Middle Pacific coast region. National Audubon Society Field Notes 52:498-502.

Rockwell R. B. 1910. - Nesting notes on the American Eared Grebe and Pied-billed Grebe. Condor 12:188-193.

Rogers M. J. & the Rarities Committee (with comments by Ellis P. M. & Stoddart A. M.) 1995. - Report on rare birds in Great Britain in 1994. British Birds 88: 493-558.

Rogers M. J. & the Rarities Committee (with comments by Shaw K. D. & Ellis P. M.) 1996. - Report on rare birds in Great Britain in 1995. British Birds 89: 481-531.

Rokitansky G. 1952. - Ein seltenes Kleid des Schwarzhalstauchers. Vogelkundl. Nachr. Österreich 1:5.

Ross C. C. 1963. - Albinism among North American Birds. Cassinia 47:2-21.

Rothschild L. 1928. - Exhibition of an albino Red-necked Grebe (*Podiceps griseigena griseigena*) from Lincolnshire. Bull. Brit. Ornith. Club 48:73-74.

Sage B. L. 1956. - An albino Red-necked Grebe. Bulletin of the British Ornithologists' Club 76:109.

Sage B. L. 1962. - Albinism and melanism in birds. British Birds 55:201-225.

Sage B. L. 1963. - The incidence of albinism and melanism in British Birds. British Birds 56:409-416.

Sager H. 1933. - Weißer Haubentaucher. Heimat (Kiel) 43:56.

Salvadori T. 1865. - Katalog der Vögel Sardiniens mit Noten und Beobachtungen von Tommaso Salvadori - Aus dem italienischen übertragen von Dr. Carl Bolle. Journal für Ornithologie 13:415-432.

Schalow H. 1876. - Materialien zu einer Ornis der Mark Brandenburg. In Verbindung mit Alexander Bau bearbeitet. Journal für Ornithologie 24:1-35.

Schelcher R. 1914. - Ornithologische Ausflüge in die Umgebung von Freiburg (i. Br.) und die Südvogesen. Verhandlungen der Ornithologischen Gesellschaft in Bayern 12:53-86.

Scheygrond A. 1985. - Albino fuut op Reeuwijkse Plassen. Vogeljaar 33:179.

Schipke R. 1980. - Albinotischer Haubentaucher *Podiceps cristatus* in der Lausitz. Beiträge Vogelkunde 26:299-301.

Schreiber R. W., Schreiber E. A., Peele A. M. & Burtt E. H. Jr. 2006. - Pattern of damage to albino Great Frigatebird flight feathers supports hypothesis of abrasion by airborne. Condor 108:735-741.

Schreur J. L. 1987. - An albino Eared Grebe at Russell Lakes State Wildlife Area, southcentral Colorado. Colorado Field Ornithologists Journal 21:76-79.

Schultze N.-G. 1983. - Haubentaucher-Albino auf der Spree. Ornithologische Berichte für Berlin (West) 8:53.

Schüz E. 1931a. - Achtet auf Albino von Haubentaucher *Podiceps cristatus* L.. Der Vogelzug 2:40-41.

Schüz E. 1931b. - Vom Zug des Haubentauchers, *Podiceps cristatus* (L.). Der Vogelzug 2:67-68.

Sellin D. 2009. - Beobachtung eines farbaberranten Haubentauchers *Podiceps cristatus*. Orn. Mitteilungen 61:210-212.

Senar J. C. 2006, - Colour displays as intrasexual signals of aggression and dominance *in* Hill E. G. & McGraw K. J.: Bird coloration, Vol. 2, Function and evolution. Harvard University Press, Cambridge & London (p. 87-136).

Simmons K. E. L. 1974. - Another albino Great Crested Grebe. Bristol Ornithology 7:72.

Slagsvold T., Rofstad G. & Sandvik J. 1988. - Partial albinism and natural selection in the Hooded Crow *Corvus corone cornix*. Journal of Zoology 214:157-166.

Söderquist A. 2004. - Albinofågeln hittad död. http://mobil.hd.se/svalov/

Stedman S. J. 2000. - Horned Grebe. The Birds of North America 505.

Storer R. W. 1965. - The color phases of the Western grebe. Living Bird 4:59-63.

Storer R. W. 1982. - A Hybrid between the Hooded and Silver Grebe (*Podiceps gallardoi* and *P. occipitalis*). Auk 99:168-169.

Storer R. W. 1992: Least Grebe. The Birds of North America 24.

Storer R. W. & Jehl Jr. J. R. 1985. - Moult patterns and moult migration in the Black-necked Grebe *Podiceps nigricollis*. Ornis Scandinavica 16:253-260.

Storer R. W. & Nuechterlein G. L. 1992: Western Grebe, Clark's Grebe. The Birds of North America 26.

Stott K. Jr. 1948. - An Albino Eared Grebe at Mono Lake. Condor 50:46.

Stout B. E. & Nüchterlein G. L. 1999. - Red-necked Grebe. The Birds of North America 465: 1-32.

Stresemann E. & Stresemann V. 1966. - Die Mauser der Vögel: Podicipedes. Journal für Ornithologie 107:287-290.

Switek B. 2010. - Written in stone: evolution, the fossil record and our place in nature. Bellevue Literary Press.

Taylor J. 2014. - Archived 2014 discussion: Silvery Grebe (*Podiceps occipitalis*) is being split: list *P. juninensis* as Near Threatened or Vulnerable? http://www.birdlife.org/globally-threatened-bird-forums/2014

Theron E., Hawkins K., Birmingham E., Ricklefs R. E. & Mundy N. I. 2001. - The molecular basis of an avian plumage polymorphism in the wild: a melanocortin-1 receptor point mutation is perfectly associated with the melanistic plumage morph of the Bananaquit *Coereba flaveola*. Current Biology 11:550-557.

Thiede W. 2005. - Bemerkungen zu Farbabweichungen bei Lappentauchern. Ornithologische Mitteilungen 570:162-164.

Tischler F. 1941. - Die Vögel Ostpreußens und seiner Nachbargebiete. Ost-Europa-Verlag, Königsberg & Berlin.

Toon S. J. 2007. - Slavonian Grebe breeding with Great Crested Grebe. Bristish Birds 100: 381.

Toral G. M., Figuerola J. & Negro J. J. 2008. - Multiple ways to become red: Pigment identification in red feathers using spectrometry. Comparative Biochemistry and Physiology, Part B 150: 147-152.

Torres M. & Franke I. 2008. - Reporte de albinismo en *Podiceps major*, *Pelecanus thagus* y *Cinclodes fuscus* y revisión de aves silvestres albinas del Perú. Rev. peru. Biol. 15:105-108.

Utah Division of Wildlife Resources 2002. - Utah's dandy diving birds: loons and grebes. Growing Wild Spring/Summer 2002:1-10.

Van Dijk A.J., Hustings F. & Offereins R. 1994. - Broedgevallen van de Roodhalsfuut *Podiceps grisegena* in Nederland in 1980-92. Limosa 67:76-78.

Van Grouw H. 2006. - Not every white bird is an albino: sense and nonsense about colour abberations in birds. Dutch Birding 28:79-89.

Van Grouw H. 2010. - How to recognise colour aberrations in birds (in museum collections). J. Afrotropical Zoology, special issue: 53-59.

Van Grouw H. 2012. - What colour is that sparrow? A case study: colour aberrations in the House Sparrow *Passer domesticus*. International Studies on Sparrows 36:30-55.

Van Grouw H. 2013. - What colour is that bird? The causes and recognition of common colour aberrations in birds. British Birds 106:17-29.

Van Grouw H. 2014. - Some black-and-white facts about the Faeroese white-speckled Common Raven *Corvus corax varius*. Bulletin of the British Ornithologists' Club 134:4-13.

Van Oort E. D. 1908/09. - Contribution to our knowledge of the Avifauna of the Netherlands, being a list of all the species of birds hitherto observed, with special references to specimens in the Leyden Museum. Notes from the Leyden Museum 30:129-224.

Verroken L. & Verroken D. 1987. - Black-necked grebe with chestnut-red neck and breast. Dutch Birding 9:15-16.

Von Besserer Frh. 1905. - Merkwürdige Färbung eines kleinen Lappentauchers. Ornithologische Monatsschrift 30:388-389.

Von Pelzeln A. 1865. - Über Farbenänderungen bei Vögeln. Verh. Zool. Bot. Gesellsch. Wien 15:916-946.

Von Tschusi V. 1867. - Notizen über Farbenvarietäten bei Vögeln. Verh. der k. k. Zool.-Bot. Ges. in Wien 17:687-692.

Voous K.H. & Payne H.A.W. 1965. - The Grebes of Madagascar. Ardea 53:9-31.

Walkmeister A. 1956. - Albinotischer Rothalstaucher im Prättigau (GR). Ornithologischer Beobachter 53:47-48.

Weller M. W. 1959. - Albinism in *Podiceps grisegena* and other grebes. Auk 76:520-521.

Whiterby H. F. 1928. - Albino Red-necked Grebe in Lincolnshire and other albinistic birds. British Birds 21:264.

Wilmé L. 1994. - Status, distribution and conservation of two Madagascar bird species endemic to Lake Alaotra: Delacour's Grebe *Tachybaptus rufolavatus* and Madagascar Pochard *Aythya innotata*. Biological Conservation 69:15-21.

Wobus U. 1964. - Der Rothalstaucher *Podiceps griseigena.* A. Ziemsen Verlag, Wittenberg-Lutherstadt.

Woets D. 1984. - Albino fuut in Oostelijk Flevoland. Her Vogeljaar 32:259-260.

Wruss W. 1988. - Vogelkundliche Beobachtungen aus Kärnten 1987. Carinthia II 178:601-612.

Wyman L. E. 1918. - Minutes of Cooper Club meetings – Southern Division. Condor 20:195-196.

Yarrell W. 1885. - A history of British birds, 4th edition (revised by H. Saunders). John van Voorst, London.

Yeatman H. C. 1959. - An albino Grackle and a discussion of albinism. The Migrant 30:5-8.

Yee D. G., Bailey S. F. & Singer D. S. 1995. - Middle Pacific coast region. Field Notes 49:975-979.

Zhao H. P., Chai L. Q. & Hu J. Z. 2010. - A record of albinistic Little Grebe (*Tachybaptus ruficollis*) in Jinan, Shandong. Sichuan Journal of Zoology 29:150 (in Chinese).

Zwiesels H. 1920/21. - Ornithologischer Bericht aus Württemberg und dem badischen Bodenseegebiet. Der ornithologische Beobachter 15:9-27.

Appendix: Summary tables of records of aberrant grebes per species

This appendix contains 15 tables with aberrant grebes, one table for each grebe species for which aberrant individuals were recorded, and one table for hybrids. The subspecies follow each other in the different tables. The order of the tables follows the order of the species in the main text. The columns in the tables are to be interpreted as follows:

Numbering: All aberrant grebes were numbered according to a unique system leading to the structure SSSssYYYYnnLWP. The structure allows reading from the numbering the grebe species (SSS), the subspecies(ss), the year of observation (YYYY), the number of the record for the respective year (nn) and publication details (LWP). The components of the numbering have to be read as follows:

- SSS is an abbreviation for the species in capital letters. The first letter is the initial letter of the genus and the next two represent the first two letters of the species. The Pied-billed Grebe (PPD) and the Hoary-headed Grebe (PPL) do not entirely conform to this rule as for both, the application of this principle would have produced identical results;
- ss are the two first letters of the subspecies in miniscule letters;
- YYYY corresponds to the year of observation; if the exact year of an observation was not known, x replaced parts unknown in the year indication;
- nn is the running number given to a particular observation in a specific year. It starts with 01 and increases with each record. This numbering does not follow a timely sequence in the year of observation, but rather the sequence in which the records were entered into the register. Records eliminated later did not lead to a renumbering;
- L reports whether the record was published in the ornithological literature: possible values are 0 for unpublished, 1 for published with a rather detailed description of the grebe's appearance, 2 for mentioned in a publication without detailed description, and 3 for an own observation that was not published;
- W reports whether an observation was published in the worldwide web or received via e-mail: possible values are 0 for not found, 1 for an internet publication with detailed description, 2 for an internet publication without detailed description, 3 for a record received via e-mail;
- P indicates whether a photo of the aberrant grebe was available for its assessment: possible values are 0 for no photo, 1 for a photo published in the literature, 2 for a photo in the internet or received via e-mail, 3 for an own photo, and 4 for a photo that is representative for the conditions of a group of grebes and not only of the bird discussed (case of the publication by Jehl in 1985).

For example, a Little Grebe of the nominate form

- that was observed during the 1970s without that the exact year was recorded,
- that was the first record for the corresponding year indication,
- that was published in the literature without a detailed description of the individual,
- but with a photo

would be numbered TRUru197x01201.

If the species was initially misidentified and was later corrected, the record is found in the table of both species. The numbering in the wrong species is crossed out and the wrong initial identification is reflected in a remark.

Mutation/aberration: This column was filled after complete assessment of all observations. If the assessment led to an indisputable cause for the grebe's appearance, the cause is indicated in bold. A highly plausible cause is indicated in normal style. If no assessment was possible, the initial indication of the mutation/aberration is only adapted with respect to the nomenclature as applied in this study and is then included in *italics*. If the initial indication is unlikely to be correct, without that another mutation can be proposed, the term "whiteling" as used by Thiede (2005) is applied. If more causes for an aberration were plausible, they are indicated in regular style and they are linked with "or" in between. If one mutation seemed more plausible than the others, it is indicated first and in bold.

Reference: For a record published in the literature, references are listed (author followed by year of publication). For records published in the web, the website is indicated. Other records are listed as unpublished. In parentheses, the names of the observers of the different grebes are indicated, if known.

Description: This column contains date and place of observation followed by the description of the grebe either as reported in the publication or as resulting from a photo. Additional remarks may concern the grebe's pairing or breeding status, its fate and other useful indications.

Table 1: Aberrant Eurasian Little Grebes.

Numbering	Mutation/ aberration	Reference	Description
TRUru18xx01100	**Melanism**	Salvadori 1865, Hennicke 1903, Witherby 1958, Bandorf 1970	Date and place of collection unknown; skin conserved at Museum of Cagliari, Sardinia, Italy ; skin in breeding plumage appeared old and had a completely dark black instead of chestnut red neck
TRUru18xx02200	**Melanism**	Salvadori 1865, Hennicke 1903, Witherby 1958, Bandorf 1970	Date and place of collection unknown; skin conserved at Museum of Cagliari, Sardinia, Italy; skin in winter plumage appeared old and had a blackish brown throat; underparts heavily mottled in black and brown
TRUru18xx03100	**Melanism**	Von Tschusi 1867	Prior to 1867, south Austria, precise date and place unknown; grebe with entire back dark red brown with reddish hue; throat and breast pale rose-red with a silky shine; no other details given; skin at the collection of the Zoological and Botanical Society, Vienna
TRUru184201200	Whiteling	Von Tschusi 1867 (R. von Khevenhüller-Metsch)	1842, Lower Austria; possibly a white or whitish individual classified as abnormal by the author and listed in a chapter dealing with albinism and whitish plumage; no details given; shot
TRUru188701200	*Whiteling*	Schelcher 1914, Bandorf 1970	December 1887, Vogelsgrün, Baden, Germany; except for the indication "perfect albino", no details given; skin initially conserved at the Zoological Institute of Freiburg, but lost in a bombing in 1944
TRUru189401200	Whiteling	Knopfli 1956, Bandorf 1970 (E. Zollikofer)	Mid-September 1894, pond near St. Galle, Switzerland; about completely white individual; no detailed description; in company of TRUru189402200
TRUru189402200	Whiteling	Knopfli 1956, Bandorf 1970 (E. Zollikofer)	Mid-September 1894, pond near St. Galle, Switzerland; about completely white individual; no detailed description; in company of TRUru189401200
TRUru190401100	**Melanism**	Von Besserer 1905, Bandorf 1970	17 November 1904, Batzenhofen/Schmutter, Bavaria, Germany; adult male entirely chestnut red; upper head, nape, hind neck and upper parts of body somewhat darker chestnut red with silky shine; golden shine in the region of the ear; cheeks, chin and front neck rusty yellow; underparts of body similar; darker chestnut red pinions and leg feathers; wing coverts rusty brown; primaries rusty grey; inner vanes of secondaries white, outer vanes rusty yellow; feet light olive green and differing greatly from normal condition; red line on inner leg; lobes and beak very light.; collected for Natural Science Club of Schwaben and Neuburg
TRUru190701100	Total leucism	Gurney 1908, King 1973, Sage 1963	23 October 1907, shot at Blakeney Channel, Norfolk, UK; pure white plumage; bright lemon legs; pale brown iris
TRUru191801032	**Ino**	Unpublished	22 August 1918, Pachutken, near Riesenkirch, region of Gdansk, West Prussia, Poland; photo of skin received from Dr. Töpfer, Museum König; about entirely white plumage on back with just a suspicion of rusty fawn hue remaining; stronger hue on head, chin, upper breast and lower flanks; feet and beak yellowish; eye colour unknown; collection of Zoologisches Forschungsmuseum Alexander König, Bonn, Germany
TRUru192801200	*Albinism*	Knopfli 1956, Bandorf 1970 (H. Noll)	5 February 1928, Lower Lake of Lake Constance, Germany/ Switzerland; albino; no description provided

Numbering	Mutation/ aberration	Reference	Description
TRUru194301100	**Brown**	Poncy 1953, Knopfli 1956, Bandorf 1970	23 March 1943. Harbour of Geneva, Switzerland; partial albino; one of four juveniles present had its plumage generally light brown; back of head, fore neck, hind neck, rump and flanks brilliant white
TRUru194801200	*Albinism*	Knopfli 1956, Bandorf 1970 (Effertz)	29-30 October 1948, Lower Lake of Lake Constance, Germany/Switzerland; albino; no description provided
TRUru194802200	Whiteling	Hertenstein 1952, Knopfli 1956, Bandorf 1970	Winters 1948/49, 1949/50 and 1950/51, lower Rhine near Constance, Germany; albino; no description provided; may have been three different grebes
TRUru195x01030	Whiteling	Unpublished (H. Jacoby)	Date unknown, Lake Constance, Germany/Switzerland; pale, slightly yellowish plumage; dark wings, back slightly lined; skin at collection Ribi, Ermatingen, Switzerland (most birds in this collection are from the period 1958-1964)
TRUru195201100	Total leucism	King 1973 (B. R. Spence)	September 1952, Hollowell Reservoir, Northampton, UK; albino with bright orange bill and legs; eye colour not described
TRUru195601200	Total leucism	King 1973 (A. & N. Gonzalez)	Spring 1956 to winter 1956/57, Woodall Park, Hertfordshire, UK; an all-white bird that hatched at the lake; no complete description provided
TRUru195801130	Total leucism or light ino	Unpublished (H. Jacoby)	19 October and 1 November 1958, basin of Ermatingen, Lake Constance, Switzerland; entirely white plumage; yellowish beak; possibly grebe in first calendar year; no other details available
TRUru196x01200	*Albinism*	Bandorf 1970 (Szij)	No date given, Lake Constance, Germany/Switzerland; albino; no description provided
TRUru196x02200		Bandorf 1970	Bandorf referring to Jacoby mentioned 2-3 albinos for which H. Jacoby provided further details, see TRUru195x01030
TRUru196x03200		Bandorf 1970	Bandorf referring to Jacoby mentioned 2-3 albinos for which H. Jacoby provided further details, see TRUru195801130
TRUru196x04200	*Albinism*	Sudhaus 1968 (MS possibly unpublished), Bandorf 1970 (F. Dau)	Date unknown, Lake Warder, Germany; complete or total albino, no description provided
TRUru196001200	*Albinism*	Foschi 1986, Brichetti et al. 1992	1960, Emilia Romagna, Italy; complete or total albino; no description provided
TRUru196002230	*Albinism*	Unpublished (H. Jacoby)	29 October 1960, basin of Ermatingen, Lake Constance, Switzerland; albino not described, however, could have been same bird as observed there in 1958 and, thus, should have looked similar
TRUru196201100	Total leucism	King 1975 (R. A. Frost)	17 September 1962, Westhouses, Derbyshire, UK; all white plumage; reddish legs and orange red bill
TRUru196202200	No mutation	Bandorf 1970	25 June 1962, Frankfurt Zoo, Germany; in complete non-breeding plumage, except for a broad eye stripe; no other details given
TRUru196501100	Partial leucism or progressive greying	Bandorf 1970	27 November 1965, near Stein on the Rhine, Switzerland; partial albino with upper breast and lower front neck white

Numbering	Mutation/ aberration	Reference	Description
TRUru197501100	**Brown**	Bernecker 1976, Dittberner & Dittberner 1979 (H. Hörl, H. Schmid, A. Bernecker)	6 December 1975, Fischen Bay at entry of Ammer, Lake Ammer, Bavaria, Germany; plumage overall light beige, nearly cream coloured, except for upper head and part between both ends of closed wing that were middle to dark brown
TRUru198301200	*Albinism*	Paolillo 1988, Brichetti et al. 1992	24-25 September 1983, River Angitola, at outflow from Lake Angitola, Calabria, Italy; except for the indication „perfect albinism", no description given
TRUru198701100	**Brown**	Leuzinger 1996	Winter presence from 18 October 1987 to December 1994 near Stein on the Rhine, Switzerland; in non-breeding plumage light coloured all over, especially on head; upper back only slightly brownish; during winter moult (September) red-brown dotting on head; nape and hind-neck rusty chestnut; by mid-March, head and back brown with fine white lines
TRUru198901200	Whiteling	Brichetti et al. 1992 (de Faveri)	1989, Veneto, Italy; except for the indication „leucism", no description given
TRUru199801100	**Ino**	Paillisson 1999	17 July 1998, Grand Lieu Lake, Loire-Atlantique, France; about complete absence of pigmentation; whitish plumage on head breast, flanks and back; light beige tinge on scapulars and wing coverts; pink beak; two young grebes nearby seemed to belong to the same family
TRUru200801100	**Albinism**	NABU Schorndorf 2008 (D. Schnabel)	End of March to August 2008, Plüdershausen, Baden-Wurttemberg, Germany; one completely white chick with red eyes in a brood of 5; fully grown, it appeared to react more sensitively to warning calls, remaining hidden much longer than other birds; with 4 months of age, apparently unable to fly; disappeared with 19 weeks of age; probably predated
TRUru201101222	**Total leucism**	Belfiori et al. 2011 (V. Cavaliere)	July to September 2011, Persano, Italy; reported as albino; no description given; photo showed entirely white bird with fleshy pink beak; iris appeared dark brown
TRUir200601022	**Ino**	www.armenia birding (J. Aalto)	20 July 2006, Armash fish ponds, Armenia; no description given; photo showed completely white plumage; bill and legs pinkish; eye colour difficult to see, but iris seemed pale
TRUca187x01100	**Dilution**	Mlíkovský 2010	No date given, but prior to 1877, lake in Native Sikkim, India; blackish forehead and anterior sides of head, including the orbits and chin; nape and upper neck entirely chestnut, unlike that of any known species; lower hind neck brownish; remainder of plumage white, except for primaries which were brown; feathers of the back, scapulars, and secondaries with dark brown shaft-stripes; bill and feet regularly coloured; obtained by Mr. Mandelli
TRUca199401200	*Albinism*	Bharos 1996	10 November 1994, Khodri village, Bilaspur district, Madhya Pradesh, India; classified as albino; no description given
TRUca200401200	Whiteling	Patankar 2004	15 to 26 January 2004, Muval Village, Gujarat, India; a white Little Grebe recorded during the Asian Waterfowl Census; no other details given
TRUpo200801101	**Dilution**	Zhao et al. 2010; Li et al. 2012	2008, possibly end of November, Jinan, Shandong province, China; almost entirely white plumage; yellow iris; black at upper mandible; bill partially flesh coloured with white tip; photo showed a few dark feathers in the wing and remains of light chestnut in face and front neck; normally yellow at onset of beak; in company of regular conspecific (mostly in winter plumage)

Numbering	Mutation/ aberration	Reference	Description
TRUpo201001101	**Dilution**	Li et al. 2012	17 December 2010, north-west of Shijiazhuang, Hebei Province, China; most of the feathers white, with the exception of its brown primaries; yellowish bill with white tip; yellow iris; immature female unable to fly, captured by hand; photo showed overall greyish white plumage with some darker brownish grey stripes in the upper head and face; iris pale greenish yellow, unaffected; bill bright orange yellow; yellow at gape; skin in Museum of Hebei Normal University
TRUpo201101022	**Dilution**	http:/ww.flickr.com/photos/aberlin2009/… (anonymous)	Probably 16 July 2011, no place or country mentioned, possibly China; photo showed white plumage, except for head, where behind eye up to nape and crest light rusty brown feathers were present; pale green yellow iris, unaffected; bill pale fleshy orange; bare gape bright yellow
TRUja200901022	**Dilution**	www.flickr.com/photos/tony_enamel/... (S. Tracy) http://ibc.lynxeds.com/... (J. Sargatal)	9 August 2009 and 12 February 2010, Inokashira Park Zoo, Mitakashi, Tokyo, Japan; photo showed face, fore neck, upper breast and flanks mostly white; back white with a light tinge; upper head very light grey with perhaps a slight tinge of brown; division to white face clear cut; same colour appeared to run down on hind neck; iris light olive yellow; beak normal; naked skin at gape very pale yellowish; mandibles blackish; tip light; on 12 February 2010, most probably same individual photographed at Inokashira by J. Sargatal; bare skin at gape and eyes more deep yellow; in company of conspecific in breeding plumage

Table 2: Aberrant Australasian Little Grebes.

Numbering	Mutation/ aberration	Reference	Description
TNOno201001101	**Dilution**	McKenzie & Ford 2011	2010, South Morang, Victoria, Australia; very pale though not white; head rather normally pigmented; photo showed rather normal colouring in head, especially where phaeomelanin-based, that abruptly stopped in upper neck for a mix of whitish and greyish feathers; flanks and upper breast rather white; darkest in middle back, but still much lighter there than usual; eyes, bill and bare parts at onset of beak normally pigmented; hatched chicks in 2010 and 2011; chicks of 2011 normally coloured
TNOno201101101	**Dilution**	McKenzie & Ford 2011	June 2011, South Morang, Victoria, Australia; picture showed pale brownish chestnut upper head; eyes yellowish; beak mostly flesh coloured and paler than usual; otherwise apparently completely whitish or cream coloured; bred successfully; was photographed in company of TNOno201102001; by the observer believed to be a chick of TNOno201001101 from 2010; probably female
TNOno201102001	**Progressive greying**	McKenzie & Ford 2011	June 2011, South Morang, Victoria, Australia; the authors did not consider this individual as aberrant; photo showed mostly normal breeding plumage, but white feathers in front neck and upper breast
TNOno201103032	**Dilution**	Unpublished (D. Ford)	December 2011, South Morang, Victoria, Australia; photo showed pale rusty remains on upper head; eyes yellowish; beak more pale flesh coloured, otherwise mostly whitish plumage with some pale greyish shadows of small area in sides of neck and on back; believed to have been a chick from the preceding season of TNOno201101101

Table 3: Aberrant Least Grebes.

Numbering	Mutation/ aberration	Reference	Description
TDObr196401202	**Melanism**	King 1975; (R. Browning)	19 March 1964, La Laguna, Darien, Panama; female with very dark underparts; no other details given; skin now at US National Museum; photos of the skin showed normal pigmentation in the upper plumage of head, neck and back; belly darker than in other birds, but neither blackish nor dark cinnamon; belly with mostly pale brown slightly greyish feathers and light mottling with white feathers
TDObr200901012		(M. Such)	23 February 2009; Estero Llano Grande Sate Park, Texas, USA; see Table 16 for possible hybrids

Table 4: Aberrant Pied-billed Grebes.

Numbering	Mutation/ aberration	Reference	Description
PPDpo19xx01200	*Total leucism*	Ross 1963	No date and no place indicated; sight record; no description given; considered to be different from PPDpo190701100 and from PPDpo193601100
PPDpo190701200	**Total leucism**	Rockwell 1910, Weller 1959, Ross 1963, King 1973, Muller & Storer 1999	6 July 1907, Barr Lakes near Denver, Colorado, USA; entirely snow white plumage; no other details given; catching attempts failed as the grebe was "very wild"
PPDpo193601100	Dilution	Dettmann 1937, Ross 1963	Throughout summer 1936, Lake Keesus, Wisconsin, USA; plumage entirely pure white, no dark markings; feet and legs apricot yellow; eyelids and gape buff yellow; iris neutral grey; bill greyish lavender; skin deposited with the Milwaukee Public Museum
PPDpo198801032	Brown	Unpublished (C. Titus)	19 November 1988, Floyd Lamb Park, Tule Springs, Las Vegas, Nevada; photo showed grebe in winter plumage; rather light brownish buff upper plumage; overall much paler than conspecifics around; pale beak lacking black markings; iris appeared pale; feet appeared pale yellowish
PPDpo199601202	**Ino**	Muller & Storer 1999	8 August 1996, Brooklyn, Pacific County, Washington, USA; chick, 80% grown, with markings in pale cinnamon and with a pale orange tinge; tarsi and toes brown-orange; bill pale orange, darker on upper mandible; photos received from Museum showed light cinnamon on lower neck and breast; cinnamon to brown colour fading on back and wings, where mottling with whitish feathers occurred; pink eye reported; chin and throat white; flanks pale; skin now at Slater Museum, University of Puget Sound, Olympia, Washington, USA
PPDpo199801010	Progressive greying	http://lists.ufl.edu/cgi-bin/... (B. Ahern)	Regular winter resident, at least 1998-2001/02, Terra Verde ponds, Florida, USA; white feathers scattered on the cheeks, neck and top of head, also in parts of the back and the folded wings
PPDpo200501010	**Total leucism**	http://martes.livejournal.com/... (Martes)	22 June 2005, Sepulveda Basin, California, USA; all white grebe with pink bill, but dark eyes and regularly coloured legs (species identification not entirely clear)
PPDpo201301020	*Partial leucism*	http://birding.aba.org	16 September 2013, place unknown; individual resembling a juvenile Red-necked Grebe with entirely white and not beige cheeks; perhaps simply young grebe, in which the cheeks are white when the striping disappears

Table 5: Aberrant Hoary-headed Grebes.

Numbering	Mutation/ aberration	Reference	Description
PPLpo19xx01303	**Chestnut melanism**	unpublished	Date and place unknown, collected between 1897 and 1987 probably in Victoria; skin at Victoria Museum, Melbourne, Australia; mix of more rusty chestnut and silvery white hair like feathers on sides of head and in crest
PPLpo201101020	Whiteling	http://www.eremaea.com/... (anonymous)	30 December 2011, Western Treatment Plant coastal ponds, Werribee, Victoria, Australia; albino grebe; no description given; supposed to be a Hoary-headed Grebe because they are temporarily abundant there
PPLpo201301012	**Chestnut melanism**	http://www.eremaea. com/… (R. & M. Alcorn)	18 July 2013, River Gum Creek Reserve, Hampton Park, Melbourne, Victoria, Australia; grebe in breeding plumage with a darkly stained chest; photo showed bright chestnut red upper breast and lower fore neck, the colour faded quickly in the upper fore neck and towards the flanks

Table 6: Aberrant New Zealand Grebes.

Numbering	Mutation/ aberration	Reference	Description
PRUru18xx01100	**Melanism**	Buller 1888, King 1975	No date and place given; entire underparts dark buff, deepening into dull chestnut-brown on the breast and fore neck; crown of head and nape black with steel-blue reflexions and with abundant white hair like plumes on the vertex and occipital region; collection of Canterbury Museum, Christchurch, New Zealand
PRUru187x01100	Dilution	Buller 1888 King 1975, Marchant & Higgins 1990	1870s, Glenmark, New Zealand; plumage generally pure white, sides of head and throat shaded with brown; crown, nape and hind neck streaked and spotted with black; fore neck and breast varied with pale rufous; shoulders, back, and scapulars with numerous scattered black feathers giving the upper surface a pied appearance; wings dusky black mottled with white; bill and feet of normal colour; presented to Canterbury Museum by T. Waters; skin now at American Museum of Natural History
PRUru19xx01200	*Albinism*	King 1975	Many years prior to 1975, Canterbury, New Zealand; according to letter by R. Falla to B. King, details of record mislaid

Table 7: Aberrant Great Grebes.

Numbering	Mutation/ aberration	Reference	Description
PMAma200701101	**Ino**	Torres & Franke 2008	10 February 2007, Laguna Napique, Sechura province, Peru; body plumage mostly white with extremes of both wings and lower back brownish; beak and legs uncoloured; iris dark; in company of conspecifics; photo confirmed overall description, however coloured parts not blackish, but brownish to partially yellow brown; eyes looked pale

Table 8: Aberrant Great Crested Grebes.

Numbering	Mutation/ aberration	Reference	Description
PCRcr18xx01200	**Brown** or ino	Gurney 1887, King 1973	19th century, place unknown, skin obtained in Leaden Hall Market, London, UK; except for sandy-coloured, no details given; collection of Mr. Barclay, Leyton
PCRcr18xx02102	**Brown**	Von Pelzeln 1865 (H. Kotschy)	Prior to 1865, Syria, exact date and place unknown; juvenile with crest, rudimentary ruff and hind neck line brownish; rest of head and neck white; mantle piebald due to white edges and bases of feathers; some feathers brownish, others with rusty yellow parts; pale legs and bill; except for a whitish nape, photo of skin showed overall light brown upperparts, including hind neck and crest,; bill and feet pale; feet with much brown especially in the lobes; collection of Natural History Museum, Vienna
PCRcr18xx03100	**Brown**	Leverkühn 1887	No date given, Lake Ratzeburg, Germany; a white grebe with normal colour shining through in isolated places on head and back; collection of a Hamburg Museum
PCRcr182301100	Chestnut melanism	Von Pelzeln 1865	1823, region of Banat, today located for parts in Romania, Serbia and Hungary; female with throat, lower neck, breast and centre of belly lined in rusty yellow, this effect being produced by rusty yellow ends to the feathers; collection of Natural History Museum, Vienna
PCRcr185301100	**Brown**	Gloger 1866, Schalow 1876, Leverkühn 1890, Hennicke 1903, Weller 1959, King 1973, Melde 1973, Dittberner & Dittberner 1979	6 November 1953, Potsdam, Germany; about complete albino with only tips of crest showing a light yellow-brown colour; behind ruff, on both sides, tips of feathers in black and yellow-brown form a pale blackish dot; remiges and their coverts and other pinions for part of their inner vanes greyish brown without tinges of chestnut or yellowish brown that are normally present; such tinges present in two pinions of the right wing which lack grey and form two rusty yellow dots; feet including lobes much lighter and paler than usual; bill pale yellowish red; iris of about normal colour
PCRcr186x02100	**Brown**	Altum 1867, Hennicke 1903, Melde 1973, Dittberner & Dittberner 1979	Prior to 1865, Munsterland, Germany; pale whitish aberration; normal colours remained detectable overall; at the time in Bolsmann collection
PCRcr186401100	**Progressive greying**	Leverkühn 1890, Hennicke 1903, van Oort 1908/09, Melde 1973, Dittberner & Dittberner 1979	18 November 1864, province North-Holland, The Netherlands; male with usual colour pattern, but all normally brown parts somewhat lighter; wing coverts interspersed with much white; many rami of primaries and secondaries white; grizzled feathers all over wings and mantle; feet and bill of normal colour; shot; initially in the collection van Wickevoort Crommelin, now Leiden Museum
PCRcr186601200	**Brown**	Van Oort 1908/09)	Probably 1866, Holland, The Netherlands; upper parts of plumage with light brown tinge; skin purchased in 1866 by Leiden Museum from the cabinet van Lidth de Jeude
PCRcr189201100	Brown	Chernel de Chernelháza 1907, Weller 1959, King 1973	29 March 1892, Lake Velencze, Hungary; grebe with partial albinism and erythrism; crown, forehead, crest and tufts chestnut with tips somewhat brownish-grey; feathers of back lighter than usual, especially to the side of the back and in lower neck, with more rusty and white; wings generally white, quills only dark brownish-grey; innermost secondaries partially brownish-grey, some of the middle wing coverts light rusty or brownish grey towards the end

Numbering	Mutation/ aberration	Reference	Description
PCRcr19xx01200	*Partial leucism*	Dietrich 1928, Berndt & Drenckhahn 1974, Sellin 2009	Prior to 1928, Lake Ratzeburg, Germany; inside the museum at Lake Ratzeburg, a partially albinistic individual; no other details given
PCRcr190501100	**Melanism** and partial leucism	Chernel de Chernelháza 1907, King 1973	14 April 1905, Lake Velencze, Hungary; grebe generally quite black overall; partially brownish black in head; back darkest; ruff slightly metallic green and glossy; silvery shine underneath dark general colour; almost all feathers on crest or tufts on each side of the nape white, except for a few black ones; bill, legs and feet horn-black; iris dark brown; shot
PCRcr190901200	Whiteling	Tischler 1941, Dittberner & Dittberner 1979, Sellin 2009	1909, Lake Kinkheim, northeast Poland; present for entire breeding season; except for dark ruff, whitish coloured; no other details given
PCRcr191101032	**Ino**	Unpublished	June 1911, Bergsee, Mecklenburg, Germany; photo of the mounted skin received from Dr. Töpfer, Museum König, showed an entirely whitish plumage with a light brownish or tan hue; ruff whitish; pale pink bill; collection of Zoologisches Forschungsmuseum Alexander König, Bonn, Germany
PCRcr191401032	**Brown**	Unpublished	Probably 1914, region of Kiev, Ukraine; in winter plumage with short crest and ruff; overall pale beige to cream upper plumage with a few pale rusty orange tinges in the region of the ear tufts and in the flanks; conserved bill looks quite pink and has darker culmen; Count A. Bobrinskoy donated skin to British Museum in Tring
PCRcr191501101	**Albinism**	Grochmalicki 1925, Weller 1959, King 1973	August 1915, Bytyn Lake, Szamotuly, Poland; young grebe, probably female; fully grown with entirely snow white plumage; no pigmentation visible on entire plumage; bill whitish yellow; feet yellowish with locally brownish tint
PCRcr191502100	**Albinism**	Hess 1915	1915, no precise date given, Lake Constance, Germany/ Switzerland; entirely white grebe with pale reddish eyes and light flesh-coloured feet; shot
PCRcr192001200	Whiteling	Zwiesels 1920/21	19 May 1920, Rohrsee near Wolfegg, Wurttemberg, Germany; albino; no details given; shot; observation date makes albinism unlikely
PCRcr192701100	**Ino**	Witherby 1928, Rothschild 1928, Sage 1963, King 1973, 1975	29 December 1927, Cleethorpes, Lincolnshire, UK; initially identified as *P. grisegena*; labelled *cristatus* by British Museum; H. van Grouw, bird curator at Tring, confirmed female *cristatus* (pers. comm.); pure white grebe with the exception of a slight yellowish or creamy wash at the base of the neck; down layer still slightly coloured; iris pale rose-colour; feet pale yellow; bill bright yellow at base and yellowish-horn at tip with dusky splashes on basal half; extreme silkiness of plumage, especially on breast
PCRcr193001200	Whiteling	Schüz 1931a, 1931b, Tischler 1941, Weller 1959, King 1973, Dittberner & Dittberner 1979, Sellin 2009; (Heinroth, Technau)	29 September 1930, Baltic Sea near Ulmenhorst/Rossitten (today Rybatschi), Curonian Spit, today Russia; completely white individual; no other details given; observation date makes albinism unlikely
PCRcr193003200	*Whiteling*	Schüz 931ab, Weller 1959, King 1973, Dittberner 1996	15 October to 5 November 1930, Lake Ucker near Prenzlau, Germany; completely white; no other details given; classified as albino by Dittberner; observation date makes albinism unlikely

Numbering	Mutation/ aberration	Reference	Description
PCRcr193004101	Brown	Finkbein 1931, 1932, Schüz 1931ab, Dittberner & Dittberner 1979, Dittberner (1996), Sellin 2009 (Finkbein, Lange)	Early August to perhaps early October 1930, Lake Templin, 20 October 1930 to January 1931, nearby Fährsee, both Uckermark, Germany; snow-white juvenile fed by regular adult; no other details given; photo from too far to see details
PCRcr193201100	Brown	Finkbein 1932	Summer 1932, Lake Templin, Uckermark, Germany; snow-white juvenile in company of regular adult and second juvenile with normal plumage; perhaps same parents as PCRcr193004101
PCRcr193202100	**Dilution**	Sager 1933, Berndt & Drenckhahn 1974, Sellin 2009	September 1932, Greater Lake Segeberg, Germany; at distance appeared entirely white; a closer look revealed that head and neck approached the normal pattern; back shining white
PCRcr193301200	Total leucism	Hoffmann 1934, Tischler 1941, Dittberner & Dittberner 1979, Sellin 2009	Summer 1933, Lake Karaś, Masurian Lake District, Poland; pure white individual; no other details given
PCRcr193801100	**Dilution**	Simmons 1974 (J. C. M. Nichols)	8 October 1938, Fleet Pond, Hampshire, UK; pure white grebe with the faintest tinge of blue-grey along the back; in breeding dress; considerable crest
PCRcr194401200	*Albinism*	Knopfli 1956	20 February 1944, Barrage of Klingnau, Switzerland; albino; no description provided
PCRcr195x01200	*Partial leucism*	Knopfli 1956	No place and date given, possibly Lake Sempach, Switzerland; two partial albinos in the collection of Vogelwarte Sempach; skin has disappeared today
PCRcr195x02200	*Partial leucism*	Knopfli 1956	No place and date given, possibly Lake Sempach, Switzerland; two partial albinos in the collection of Vogelwarte Sempach; skin has disappeared today
PCRcr195001100	**Albinism**	Knopfli 1956	July 1950, Lake Constance, Germany/Switzerland; albinistic grebe; pure white plumage with silvery shine; pale red eye; flesh-coloured feet
PCRcr195002100	**Dilution**	Knopfli 1956 (P. Géroudet)	9 November 1950, Lake Geneva, Switzerland; normally dark grey parts of the plumage were light grey
PCRcr195301020	*Albinism*	unpublished	18 October 1953, near Lednice, Breslau, Czech Republic; albinistic; no other details given (communicated by M. Sebela via L. Schröpfer); skin at National Museum of Moravia, Brno
PCRcr196001100	Brown	Berndt & Drenckhahn 1974, Sellin 2009 (Orbahn)	10 April 1960, Lake Warder, Segeberg, Germany; grebe speckled dirty white and a bit light brown; no other details given
PCRcr196002100	Dilution	Hofer 1962, Melde 1973, Dittberner & Dittberner 1979	13 August 1960, Lake Sempach, Switzerland; as pullus completely white with legs and beak black; first seen with normal parents when six weeks old
PCRcr196101101	**Brown**	Bonfio 1963, Brichetti et al. 1992	15 December 1961, Mille Campi Valley, Veneto, Italy; colour indication "isabellino" corresponding to cream coloured; upper part of head, neck and back of uniform cream colour; legs pale brown; photo showed a much lighter plumage than usual with cream coloured patches on back; collected

Numbering	Mutation/ aberration	Reference	Description
PCRcr196201100	**Albinism** or total leucism	Dittberner & Dittberner 1979	9 August 1962, Lake Selchow, Beeskow, Germany; chick with plumage snowy white; pale yellow beak and pale legs; eyes not described; in company of regular parents and a normal sibling
PCRcr197101100	Whiteling	King 1973	11 January 1971, Durleigh Reservoir, Somerset, UK; a grebe with truly albinistic features; completely white head, except for a small dark mark behind the eye; no other details given
PCRcr197301100	**Total leucism**	Schipke 1980, Melde 1986	8 July to 3 September 1973, Pond III of Koblenz/Wartha, Oberlausitz, Germany; white pullus on the back of adult; no other details given
PCRcr197302100	Total leucism	Köcher & Kopsch 1979 (Fehse, Köcher, Köhler)	3 to 12 October 1973, Großteich Fremdiswalde, Saxony, Germany; completely white plumage; yellowish legs and beak; no description of eyes
PCRcr197401101	**Total leucism**	Schipke 1980, Melde 1986	27 April to 13 July 1974 and 20 April to 28 September 1975, different ponds of Koblenz/Wartha, Oberlausitz, Germany; female with completely white plumage; iris dark red; feet and beak yellowish-grey; seen court shipping in 1974, but apparently did not breed; in 1975 nest with one egg; considered to have been pullus of 1973, but not verifiable
PCRcr197901101	**Diet**	Piersma 1974, Fjeldså 2004	21 December 1979, Lake IJssel, The Netherlands; grebe with pale light brown and diffusely barred wing-feathers, otherwise normal plumage; regularly spaced bars in the wing coverts; alula feathers and remiges were corresponding and seemed simultaneously grown; possibly growth bars; drowned in fishing net
PCRcr198x01101	**Brown**	Knysh 2004	Late 1980s, Sumy region, north-east Ukraine; aberrant plumage; white with light fawn tinge; grey brown chestnut crest; bill and legs yellowish; photo showed that some colouration present in crest, ruff and parts of wing; collected
PCRcr198201100	**Total leucism**	Schultze 1983	16 January to 13 February 1982, River Spree, close to Landwehrkanal, Berlin, Germany; grebe with entire plumage snow-white; bill and beak yellowish; said to be albino; eye colour not recorded
PCRcr198401101	**Brown**	Woets 1984, Scheygrond 1985, Sellin 2009 (O. Moedt, Woets)	5 October to 10 November Lake IJssel near Lelystad-Havn, The Netherlands; grebe with clay or cream-coloured plumage, brownish at nape; beak pinkish; eyes not visibly affected; winter subdivision of plumage still detectable
PCRcr198402200	**Brown**	Bullock 1985-1995, Thiede 2005	1984 to 1994, Boddington Reservoir, Northamptonshire, UK; leucistic grebe with light clay-coloured plumage and light central crown; bred 1987 to 1990, successful at least in 1987, 1989 and 1990
PCRcr198403101	**Brown**	Scheygrond 1985	Begin of July to 24 September 1984, Reeuwijk Lakes, The Netherlands; albino juvenile still dependent on parents when first observed; no description given; first photo in black and white from begin of July showed very pale plumage that had retained a hue of pigmentation and striping in head; second photo of 26 July showed a fully grown whitish bird with hardly any striping left in head; beak and eye colour not identifiable; feet seemed paler; grebe reported by Woets in 70 km distance 10 days later had darker upper plumage; differences in colouration a priori speak in favour of two different individuals

Numbering	Mutation/ aberration	Reference	Description
PCRcr198501200	Whiteling	Fray et al. 2009	30 August 1985, Rutland Water, East Midlands, UK; leucistic grebe, no other details given
PCRcr198601100	Brown	Sellin 1986	9 to 24 August 1986, Nature Reserve Peenemünder Haken, eastern part of Western Pomerania, Germany; completely light cream-coloured grebe; not really white; no crest or plumage structures identifiable, therefore, plausibly juvenile; bill monochrome light beige; eye colour unknown
PCRcr198602200	**Total leucism**	Wruss 1988	1986, May 1987, Lake Völkermarkt, Austria; albino chick again seen in May 1987; as adult completely white; sibling of similar condition; it is not sure that the chick of 1986 and the adult of May 1987 were identical
PCRcr198603200	**Total leucism**	Wruss 1988	1986, Lake Völkermarkt, Austria; albino chick; no other details given; sibling of similar condition
PCRcr198701200	**Total leucism**	Wruss 1988	1987, Lake Völkermarkt, Austria; one white chick in a brood of four; possibly same parents as in 1986
PCRcr198702200	**Brown**	Bullock 1987, Thiede 2005	1987, Boddington Reservoir, Northamptonshire, UK; chick reared by PCRcr198402200; even lighter plumage than parent
PCRcr199x01030	**Albinism**	http://www.groenehart-vertellingen.nl/Pagina/... (F. Mayenburg)	Late 1990s, Sloene Pond, Reeuwijk, province South Holland, The Netherlands; completely white plumage with red eyes; hatched at the pond; stayed there for a couple of months before being shot
PCRcr199101200	*Albinism*	Dittberner 1996, Sellin 2009	15 October 1991, Bauernsee, Angermünde, Germany; albinistic; no description provided
PCRcr199501200	Whiteling	Fray et al. 2009	9 to 23 September 1995, Eyebrook Reservoir, East Midlands, UK; leucistic grebe; no other details given
PCRcr199601200	**Dilution**	Heidt et al. 2003	27 April 1996, Nature Reserve Haff Réimech, Luxembourg; overall paler than usual; no other details given; later said to have been pale grey
PCRcr199801020	*Albinism*	http://ornithologie.free.fr/site/champagne/... (A. Chappuis)	23 February 1998, Lac du Der-Chantecoq, Champagne, France; albino; no description given
PCRcr199901020	*Albinism*	http://champagne-ardenne.lpo.fr/…	15 November 1999, Lac du Der-Chantecoq, Champagne, France; albino grebe; no further description; species not entirely clear
PCRcr199902200	Whiteling	Fray et al. 2009	22 December 1999, Rutland Water, East Midlands, UK; leucistic grebe; no other details given
PCRcr200x01012	**Dilution**	http://www.ivn.nl/detail_press.phtml… http://www.weidevogel-bescherming-weerselo.nl/…	Present for over two years, no precise date given, Province Limburg, perhaps near Werselo, The Netherlands; rather white, but no albino, as no red eyes; photo showed grebe in breeding plumage; very light grey upper plumage; subdivision between normally coloured and uncoloured parts still detectable; light chestnut shine in the ruff; pink bill, darker at culmen; regular eyes
PCRcr200001303	**Dilution**	Unpublished A. Konter	8 October 2000, Lac du Der-Chantecoq, Champagne, France; overall pale grey plumage with remains of chestnut in the ruff ; pinkish bill; normal eyes
PCRcr200002020	*Albinism*	http://www.karperwereld.Nl/board/... (R. Hackert)	2000, no precise date given, Lake IJssel, The Netherlands; albino; no description or photo provided

Numbering	Mutation/ aberration	Reference	Description
PCRcr200004303	Chestnut melanism	Unpublished (A. Konter)	30 May 2000, Lake IJssel, The Netherlands; normal breeding plumage; bright chestnut rusty feathers on entire fore neck and upper breast; much chestnut in forward flank, less more backward; whitish belly; bred in the season
PCRcr200005200	*Partial leucism*	Elloway 2000	Summer 2000, Sailing Lake, Little Paxton, Cambridgeshire, UK; leucistic juvenile raised on the lake; no other details given; the parents raised two broods in the season; only one of the pulli from the first brood was leucistic
PCRcr200201022	Ino	http://fotooizo.free.fr/... (S. Houpert)	14 July to 1 September August 2002, Michelbach south of Thann, Alsace, France; photo showed complete white bird with fully developed and entirely white crest and ruff; light flesh pink beak, legs and eye ring; iris appeared pale,; bird at least in second calendar year
PCRcr200202020	*Albinism*	http://dir.groups.yahoo.com/group/Amsterdams_VogelNet/... (VWGA excursion)	20 January 2002, Flevopolders, Lake IJssel, The Netherlands; albino; no description provided
PCRcr200203303	**Progressive greying**	Unpublished (A. Konter)	March to April 2002, Lake IJssel, Enkhuizen, The Netherlands; grebe in breeding plumage; white in upper nape except for a thin central dark line; ruff interspersed with much white feathers; nape largely whitish with only a thin dark central line; no development in these conditions over three weeks
PCRcr200204303	**Progressive greying**	Unpublished (A. Konter)	April 2002, Haff Réimech, Remerschen, Luxembourg; bird in breeding plumage; white in upper nape, except for a thin dark central line; ruff with much white mottling; whitish in flanks; no development in these conditions over at least one month
PCRcr200205032	**Dilution**	Unpublished (A. Faure)	29 December 2002, Lake of Bourget, Department of Savoy, France; grebe with overall pale grey plumage; rather dark at crest and hind neck; paler on back; regular bill and eye colour; in loose group
PCRcr200301200	**Total leucism**	Bosselmann 2005, Thiede 2005 (K. H. Euskirchen, R. Scheid, P. Brockman)	August 2003 to spring 2004, Lake Laach, Germany; albino or whiteling; seen as a completely white pullus in August 2003, in company of 3 regular siblings. From 30 November into December present 10 km further east on oxbows of the Rhine, then again on Lake Laach from 7 to 26 February 2004 from where it possibly moved for 18 km to reach Lake Kenn, Neuwied
PCRcr200302303	**Progressive greying**	Unpublished (A. Konter)	March to April 2003, Lake IJssel, Enkhuizen, The Netherlands; grebe in breeding plumage; white in upper nape, except for a thin central dark line; ruff with much white at onset; chestnut area reduced; no development in these conditions over three weeks
PCRcr200303303	**Hormonal disorder**	Unpublished (A. Konter)	March to April 2003, Lake IJssel, Enkhuizen, The Netherlands; grebe in breeding plumage; white in upper nape and in short crest and ruff; ruff pale, partially white, only with tinges of rufous; no development in these conditions over one month
PCRcr200305330	*Total leucism*	(P. Brockman)	August 2003, Lake Laach, Germany; albino; no other description given, except that the bird was very active; possibly simultaneously present with PCRcr200301305 (unless there was a third aberrant grebe present in August what seemed unlikely)

Numbering	Mutation/ aberration	Reference	Description
PCRcr200401012	**Albinism**	http://www.artportalen.se/birds/atlas/... http://mobil.hd.se/svalov/… (M. Olsen)	1st August to 7 September 2004, Lake Svalöv, Sweden; true albino with red eyes (investigated when dead by the nature inspector P. Ljungberg); photo showed completely white plumage with light pink beak and feet.; hatched on lake from normally coloured parents; 3 normally coloured siblings; found dead floating on lake surface on 7 September; investigation could not find injuries
PCRcr200402101	**Albinism**	Forsten 2004	20 August to 5 September 2004, Raahe, northern Gulf of Bothnia, Finland; one of two albino chicks; one left on 5 September; photo showed completely white bird with fleshy pink beak and light eyes
PCRcr200403100	**Albinism**	Forsten 2004	20 August to September 2004, Raahe, northern Gulf of Bothnia, Finland; one of two albino chicks (see PCRcr200402101)
PCRcr200404021	Ino	http://www.gettyimages.com/... (C. Schenk)	No date given, possibly 26 March 2004, no place given, only Europe; photo showed male in mostly shining white plumage; pale yellowish rusty hue in otherwise white crest and ear tufts; beak light pink, no dark parts; feet yellowish pink; eyes difficult to judge
PCRcr200501022	**Total leucism**	http://www.kof.nu/galleri/galleribilder... (O. Lindberg)	26 March 2005, Hittarp, Skåne, Sweden; photo from quite far showed entirely white adult with light pink beak; too far out for eye colour identification; survived over winter
PCRcr200502020	*Albinism*	www.algonet.se/~jonal/fagny/rapp05... (K. Svensson)	1st to 19 May 2005, Kinneviken, Sweden; albino, no other details given
PCRcr200503020	**Albinism**	http://www.artportalen.se/birds/atlas/... (K.-E. Karlsson)	23 June 2005, Lake Svalöv, Sweden; no description given; hatched on lake from normal parents; had 3 normal siblings in the year; it is likely that parents were the same that produced a true albino in 2004
PCRcr200505303	**Chestnut melanism**	Unpublished (A. Konter)	Early April to early May 2005, Lake IJssel, Enkhuizen, The Netherlands; grebe in full breeding plumage with rusty chestnut feathering in fore neck, upper and lower breast, and ending on belly; same colour as in flanks; bred
PCRcr200505303	**Chestnut melanism**	Unpublished (A. Konter)	20 August 2005, Baltic Sea at Haapsalu, Estonia; fully grown juvenile still fed by parent; typical facial marking; central part of fore neck shining rufous; upper breast mostly white with just a hardly noticeable hue of rufous; in company of sibling with a less pronounced chestnut hue in central fore neck
PCRcr200509303	**Chestnut melanism**	Unpublished (A. Konter)	March 2005, Lake IJssel, Enkhuizen, The Netherlands; in breeding plumage with rusty feathering covering entire upper front neck and fading on lower front neck and breast; white area of face much reduced, invaded by rusty orange feathers
~~PCRcr200510022~~		http://agami.nl/index.gallery....	August 2005, Rotterdam-IJsselmonde, The Netherlands; wrong year of observation indicated on this website (confirmed by C. van Rijswik, see PCRcr200602012)
PCRcr200601020	Whiteling	http://fr.groups.yahoo.com/groupobsnatu-fc/... (J.-L.. Patula)	31 December 2006, Champagney Barrage, Franche-Comté, France; seen from far; no description given, except for indication "totally white"

Numbering	Mutation/ aberration	Reference	Description
PCRcr200602012	**Brown**	http://www.buiten-beeld.nl/... http://home.tiscali.nl/elzerman/... (C. van Rijswik)	25 August 2006, Rotterdam-IJsselmonde, The Netherlands; photo showed juvenile with pale brownish striping, the colour fading on the back; in company of normally coloured sibling that was much darker
PCRcr200603012	**Total leucism**	http://www.fotocom munity.de/pc/pc/display/5026380 (T. Dyckers)	19 February 2006, no place or country given, but possibly Germany; photo showed pure white bird; pink to light flesh coloured bill and feet; light loral bare line; iris difficult to assess, but appeared dark
PCRcr200605303	**Chestnut melanism**	Unpublished (A. Konter)	11 April 2006, Lake IJssel, The Netherlands; grebe in complete and well developed breeding plumage; overall orange rusty on front neck and upper breast
PCRcr200701012	**Progressive greying**	www.flickr.com/photos/... www.gobirding.eu/Photos/... (D. Appleton)	14 October 2007, Swanton, Morley, Norfolk, UK; albinistic bird largely in winter plumage with rudimentary ruff and short crest; scattered white dots on back; otherwise normal colouring; based on bill size, female
PCRcr200702131	**Total leucism**	Frede et al. 2008 (F. Huckenbeck)	15 October 2007, Lake Neubrück, Cologne, Germany; grebe with totally white plumage and orange feet; photo showed entirely white bird with developed crest and ruff; light pink beak, naked lore line and skinny eye ring; bright yellow orange feet; eyes difficult to assess, but iris seemed chestnut brown
PCRcr200704020	Whiteling	http://www2.birdphotos.dk/actionsuk/...	July 2007, Lake Gentofte, Denmark ; leucistic young grebe, no other description given
PCRcr200705303	**Chestnut melanism**	Unpublished (A. Konter)	April 2007, Lake IJssel, The Netherlands; male grebe in breeding plumage with strong chestnut hue on fore neck and upper breast, ending rapidly on lower breast
PCRcr200801012	**Brown**	ww.birdpix.nl/album_page… http://www.digiscooppix.nl/album… (J. Hop, A. van Berg)	28 September 2009, Stellendam, The Netherlands; photo showed juvenile bird with pale colours, but normal plumage patterns still detectable; head striping in light orange brown; crest, hind neck and back paler, tan or cream coloured; orange tinges in flanks, crest, ruff and hind neck; beak pink; legs yellow; eyes not clearly visible, iris seemed brown
PCRcr200802012	**Progressive greying**	www.flickr.com/photos/... www.gobirding.eu/Photos/... (D. Appleton)	23 February to 13 July 2008, Swanton, Morley, Norfolk, UK; in winter plumage, with scattered white dots on back; author of photos from Swanton believed that bird seen on 23 February 2008 is same as the one seen in October 2007; based on bill size, both have different sex, this bird being a male with much less white dots on back
PCRcr200803032	**Progressive greying**	unpublished (N. Paklina and C. van Orden)	29 March 2008, Enkhuizen, Lake IJssel, The Netherlands; bird in full breeding plumage, except for white spotting or lining on mantle
PCRcr200901012	**Brown**	http://www.radioactiverobins.com/… (N. D. van Swelm)	16 October 2009, Stellendam, The Netherlands; photo showed not really white plumage, except for face, breast and fore neck; back, hind neck, crest and ear tufts cream-coloured; pink beak; eyes of normal colour; normal colour subdivision of plumage visible; short ruff and crest; could be same bird as seen at Stellendam in 2008

Numbering	Mutation/ aberration	Reference	Description
PCRcr200902022	**Dilution**	http://www.vogelmeldung.de/public/index.... (H. Klein)	27 October 2009, Krickenbeck Lakes, Nette valley, Germany; photo from far showed bird in pale grey where usually darker grey brown to grey black plumage is present
PCRcr200903020	*Albinism*	http://www.birdskorea.org/... (T. Edelsten)	20 January 2009, between Jukbyeonhang and Onyang-ri, Uljin, South Korea; albino; no description given; species not entirely clear as text says: "Black-necked and Great Crested Grebe (which included one albino)"
PCRcr201001101	**Dilution**	Adraensen et al. 2011 (J. Lambert)	9 November 2010, Barrage de l'Eau de l'Heure et Roly, Belgium; photo showed male in about completely white non-breeding plumage; beak pink flesh coloured; seemed to have retained a hue of light grey in upper head, perhaps also on back
PCRcr201002022	**Total leucism**	http://www.fotonatur.de (S. Morsch)	9 October 2010, river Schlei/Baltic Sea, Schleswig, Germany; photo showed entirely white bird with a short crest; no visible ruff; flesh pink bill and feet; normally coloured eyes
PCRcr201101022	**Dilution**	http://70085.forumromanum.com/member/... (Heinz)	31 March 2011, Lake Gaishorn, Steiermark, Austria; appeared completely white in the field; photo showed grebe changing into breeding plumage with head, fore neck and breast plumage rather normally coloured; crest grey rather than black; short ruff, perhaps slightly pale; back pale grey; flanks about completely white
PCRcr201102022	**Dilution**	http://www.vso-web. de/forum/… (Michael from Leipzig)	16 July 2012, Wermsdorf, Saxony, Germany; photo showed pale, nearly white, not fully grown juvenile with pale grey striping; very light back; still fed by parents; no siblings
PCRcr201103022	**Brown**	http://www.miradanatural.es/fotousuario... http://www.fotonatura.org/... www.enfoqueyluz.blog spot.com.es/ (A. Sanchez, M. Velázquez Herranz)	22 to 28 August 2011, Esparragalejo pond, Merida, Badajoz Province, Spain; photo showed rather cream-brown plumage; light rusty orange brown on back, hind neck and crest; ear tufts light cream, a bit brownish on the outer ends; bill pink without darker parts; eyes appeared dark; on belly a light rusty orange wash
PCRcr201104020	**Brown**	http://www.hgon.de/voegel/beobachten/... (E. & P. Erlemann)	11 September 2011, Gravel pits near Niederwald, Hesse, Germany; a juvenile with light brown plumage
PCRcr201105020	Whiteling	www.sofnet.org/1.0.1.0/773/... (M. Ullman)	24 September 2011, Lake Vaya, Poda, Bulgaria; leucistic; no other details given
PCRcr201106010	**Melanism**	http://www.oessm.org/... (L. Pannek, W. Karin)	November/December 2011 to March 2012, near west tower of Steinhuder Meer, Lower Saxony, Germany; body plumage entirely light cinnamon; only parts of the generally black head were somewhat darker
PCRcr201107032	**Brown**	(J. P. Pépin)	22 February 2011, Lake of Val Joly, community of Willies, Nord-Pas-de-Calais, France; grebe changing for breeding plumage; brownish crest; pale grey-brown back; hue of pale orange chestnut in the ruff and flanks, that otherwise were mostly whitish; dark eyes; shining, pink to flesh coloured bill; pale legs

Numbering	Mutation/ aberration	Reference	Description
PCRcr201201131	**Melanism**	Konter 2012 (M. Zutt)	29 June 2012, Lake Wolferitz, Müritz National Park, Germany; crest and ear tufts black; dark blackish-brown face; dark beak with a slight tinge of pink; fore neck and upper breast dusty dark grey with tinges of chestnut; mantle feathers slightly duskier than in ordinary birds; bred successfully with normally pigmented partner; produced regular chicks
PCRcr201202020	Whiteling	http://web113.webhotelli.fi/~eklyo977/… http://keskustelu.Suom i24.fi/… (Lauri P.)	10 June and 17 July 2012, Nurmijärvi, area of Kummiinselkä, Finland; white-backed (albino?); no other details given
PCRcr201203012	**Dilution**	http://weedworld.blogs pot.com/… (B. W.)	August 2012, watersports car-park at Ferry Meadows, CP, Peterborough, UK; as pullus and juvenile, much paler than its two siblings; paleness obvious, sepia-toned rather than black and white; photo showed that pullus was much paler than its two siblings; on back pale brownish grey stripes; darkest grey on head, though paler than normal; eyes appeared unaffected
PCRcr201204012	**Brown**	http://corseornitho.canalblog.com/... (T. Rossi)	3 November 2012, Tombolo Bianco, Corsica, France; plumage of "isabelle" or mostly light beige colour, nearly white; photo showed normal subdivision of winter plumage; bird otherwise rather light brown or beige; darker at crest; pale pinkish bill; probably regular eye colour
PCRcr201205022	**Brown**	http://www.ornitho.it/ index… (P. Faifer)	September 2012, Italy, no exact place given; photo showed bird still in breeding plumage; overall somewhat pale brownish colours with a pale pink-orange shine, especially on flanks; bill and eyes not visibly affected
PCRcr201206022	**Dilution**	http://www.f1online.de/... (H. Taavetti)	No date given, possibly 19 May 2012, north-west Finland; photo showed mostly shining white plumage with possibly a light greyish hue; light pink beak; eyes difficult to judge, but seemed regular; text mentioned that it might have been one of the siblings of 2004 having returned to the area; then the place could be Raahe and the date could have been earlier
PCRcr201207020	Whiteling	http://barnsleybirds.blogspot.com/... (A. Smith)	31 March 2012, Wintersett, Barnsley, Yorkshire, UK; leucistic; no description provided
PCRcr201208010	Dilution	http://keskustelu.suomi24.fi/… (Hartsa ?)	2012 or earlier, record published 10 June 2012, Finland ; albino grebe; neck and head colourful, but body white; shunned by conspecifics
PcrCR201209032	**Chestnut melanism**	Unpublished (D. Cimiotti)	28 August 12, Radenhäuser Lache near Amöneburg, Hesse, Germany; photo showed juvenile in regular plumage with bright chestnut fore neck and upper breast; facial striping and borders of dark hind neck line rusty orange
PCRcr201301020	Brown	http://briansbirding.blogspot.com/ http://jj-anderson.blogspot.com/ (J. Anderson)	5 January 2013, Sea near Dungeness, Kent, UK; almost completely white with some light brown plumage in it

Numbering	Mutation/ aberration	Reference	Description
PCRcr201302032	**Progressive greying**	Unpublished (P. van der Wielen)	17 March 2013, Leemansgemaal, Den Oever, Zuiderhaven, Lake IJssel, The Netherlands; photo showed bird in breeding plumage that in all parts exposed extensive white mottling (crest, ruff, neck, back, flanks); ear tufts looked streaked with white; big white blotches on back; pink beak; normal eyes
PCRcr201303022	**Brown**	https://twitter.com/earlswood birds (M. Griffiths)	8 to 10 July 2013, Engine Pool, West Midlands, UK; female grebe; didn't show any pure white patches; overall paler plumage in varying shades of brownish-rufous; back distinctly pale brownish-grey containing a few darker feathers; flanks and nape paler and lacking darker tones; crest and crown lighter than usual; bill much paler; legs seemed paler, but uncertain; photo confirmed description; inside non-breeding flock
PCRcr201304021	**Albinism**	Ornitho.de (J. Scheuer)	7 September 2013, Speicher Schiedungen/Hohenstein, Nordhausen, Thuringia, Germany; albino pullus in company of regular parents and two regular siblings; photo showed entirely white plumage; pink legs and bill; pale red eyes
PCRcr201305021	**Dilution**	http://www.hgon.de (D. Jürgens)	16-17 September 2013, VSG Lahnaue, Segelsee, south of river Lahn, Hesse, Germany; photo showed grebe with head and neck in regular breeding plumage; normal eyes and bill; pale back and flanks, largely whitish and light grey with few darker grey blotches
PCRcr201306022	**Ino**	http://geocaching.com (Captain Morgan)	Summer 2013, Finland, exact place unknown; photo showed adult, overall pale brownish in those parts generally grey; crest pale brown beige; hind neck with just a tinge of pale brown; ruff nearly white with just a light rusty hue; eye colour not visible; pink beak; pale brownish back; displayed with regular partner
PCRcr201307022	**Dilution**	http://www.vogelmeldung.de/ (F. Rust)	July 2013, present for 4 weeks in summer, Nature Reserve Vorster Busch, Mönchengladbach, Germany, probably previously observed at the nearby Krickenbeck Lakes; grebe with pale grey plumage in those parts that are normally dark grey brown to black; ruff very pale, hardly visible; pink bill; once observed in company of regular conspecific
PCRcr201308022	**Ino**	http://observations.be/ (G. Raison)	11 November 2013, Nature Reserve of Virelles, Chimay, Belgium; photo showed pale beige brown grebe; beak light pink; legs yellowish flesh coloured; eyes could not be assessed
PCRau200603303	**Chestnut melanism**	Unpublished (A. Konter)	3 January 2006, Lake Pearson, New Zealand; in regular breeding plumage; lower neck and upper breast (possibly even belly) bright rusty orange; neither female partner, nor both chicks displayed a similar pattern

Table 9: Aberrant Slavonian/Horned Grebes.

Numbering	Mutation/ aberration	Reference	Description
PAUau186901200	*Total leucism*	Booth 1876, Gurney 1887, Booth 1911, King 1973	April 1869 (Booth gives year 1869, King referring to Booth gives year 1859), Loch Slyn, Ross-shire, UK; a pure white bird in company of a normal male; grebe at least in second calendar year
PAUau190x01200	Dilution	Petit 1909, King 1973, Weller 1959	Place unknown, year uncertain; Petit obtained the skin in 1909 from a Swiss collector, but gives no year of collection; King indicates 1909; entire dorsal surface of plumage dull white; no other details given, suggesting that head and neck were not visibly affected
~~PAUau198101100~~		King 1985	Simmons (in King 1985) expressed the opinion that this was probably a hybrid, presumably with a Red-necked Grebe; see Table 17
PAUau194901032	**Albinism**	Unpublished e-mail by M. Hildén (donated by K. Tuori)	August 1949, Karkku, Finland; juvenile, collected, mounted at Natural History Museum, Luomus; there classified as albino; plumage completely white; bill and feet yellowish
PAUco188301200	Whiteling	Eddy 1885	October1883, Quannicassee Marshes, Michigan, USA; perfect albino that was shot and then exhibited in a store windows
~~PAUco193101110~~		Weller 1959, King 1973	Initially identified as Horned Grebe, later corrected to Eared Grebe (confirmed by J. Fjeldså, pers. comm.); see PNIca193101110
PAUco196501100	**Brown** or ino	King 1973 (B. Trimble)	February 1965 and February 1966, Jones Beach, Nassau County, Long Island, New York, USA; pure white plumage; streaked on back and sides with buff
PAUco199201200	Partial leucism or progressive greying	French 1992	31 March 1992, Nickamixon Special Reserve, Pennsylvania, USA; head and neck totally white; no further details given
PAUco199501200	Dilution	Yee et al. 1995 (S.C. Rottenborn, M.J. Mammoser)	22 July 1995, Mountain View, Santa Clara, California, USA; no description given, text simply states: "three summering alternate plumaged Horned Grebes included a schizochroistic bird"
PAUco199801200	Whiteling	Roberson et al. 1998	Spring to 26 June 1998, Shoreline L, Santa Clara, California, USA; partial albino; no description provided
PAUco200201020	*Albinism*	http://mailman1.u.washington.edu/pipermail/... (M. & D. Spencer)	14-17 September 2002, small pond on Barker Canyon Rd., Washington, USA; albino; no description given
PAUco200401010	**Dilution**	http://utahbirds.org/listarchives/birdnet/... (K. Purdy, J. McIntyre)	Late August 2004; Farmington Bay Waterfowl Management Area, Great Salt Lake, Utah, USA; mostly white feathers with small black blotchy marks on the back and sides; pale, washed-out orange instead of rufous neck; horns of the palest yellow; only really black in head plumage on lower tips of the "helmet" on either side of the neck; normal eye colour; reddish bare line from the eye to the beak; dark grey black beak and feet

Numbering	Mutation/ aberration	Reference	Description
PAUco200601012	**Progressive greying**	http://www.flickr.com/photos/jamuudsen/... (Jamuudsen)	17 April 2006, Etobicoke, Ontario, Canada; resembling bird in moult for the cheeks region, but exceptionally light coloured otherwise; photo showed entirely white upper breast; light orange, instead of chestnut fore neck, mottled with white; light grey back; mostly whitish flanks with pale grey shadows; white on cheeks and chin; horns pale yellowish with a slight orange tinge; middle brown below horns and behind cheek, similar on crest; mostly dark bill with light tip; red eyes
~~PAUco200603021~~		Blumin 2007, Jehl 2007	Mid-October 2006, Mono Lake viewing platform, County Park, California, USA; identified by Jehl as an Eared Grebe, see PNIca200603111
PAUco200701011	**Brown**	http://www.backyardbirdcam.com/gallery/... (P. Velte)	29 January – 31 March 2007, Lake Hefner, Oklahoma City, USA; photo showed grebe in winter plumage; usually sooty grey to blackish parts were beige grey with a tinge of pale brown; bill pink, grey at culmen; eyes red, perhaps a bit paler than usual; feet partially pink
PAUco200702121	**Dilution**	Cherriere 2007 (B. Cherriere, C. Edgecombe)	7-12 April 2007, Oakville, near Bronte Harbour, Ontario, Canada; normally chestnut or black areas much faded and orange yellow of horns completely gone; quite normally coloured bill, somewhat faded at base; photo showed normal subdivision of breeding plumage, with all parts much paler and ornamental feathers slightly short; no really dark parts left; horns cream white with a few pale yellow stripes; other parts of head mostly with only tinges of pale grey; neck and flanks mottled pale chestnut and white; upper breast largely white; back pale greyish with white edges to feathers; eyes of normal colour
PAUco200703022	**Dilution**	http://www.flickr.com/... (anonymous)	5 November 2007, Colfax, New Mexico, USA; photo unclear; showed upper side pale greyish; under parts white; beak possibly yellowish
PAUco200801022	**Ino**	http://groups.yahoo.com/group/RIBIRDS/... (M. St. Saveur)	10 February 2008, Salter's Grove, Gaspee section of Warwick, Rhode Island, USA; leucistic grebe; photo showed overall pale brownish to buff plumage; bill partially flesh coloured and paler than usual; iris pale pink; lower face and front neck cream beige
PAUco201001020	Dilution	https://groups.google.com/group/easternsierrabirds/ (B. & S. Steele)	16 October 2010, Grant Lake, Mono County, California, USA; very pale grebe, sun bleached rather than leucistic; no other details given
PAUco201101303	Hormonal disorder	Unpublished (A. Konter)	May 2011, Lake Ewauna, Oregon, USA; horns rather short and slightly whitish; dark ruff strongly mottled with white feathers; extensive white patches on cheeks and chin and reaching hind neck; upper head mostly dark; eyes red; dark beak with light tip; upper fore neck pale orange interspersed with white; upper breast mostly white; flanks mostly white with tinge of chestnut and few dark shadows; few white patches on back; according to J. Fjeldså, appearance corresponded to moult seen in August

Numbering	Mutation/ aberration	Reference	Description
PAUco201102022	Partial leucism	http://groups.yahoo.com/group/central_valley_birds/… (S. Hampton)	17 October 2011, Davis Wastewater Treatment Plant, California, USA; grebe declared as leucistic with interesting head pattern; photo showed bird looking as still in moult at this late date; white area extending above eye into upper crown; pale grey shadowing present in mostly white face; dark vertical patch behind ear leading to throat; fore neck dirty white with laterally chestnut tinge; flanks mottled with grey; light beak; perhaps slightly diluted red eyes
PAUco201201010	Partial leucism or progressive greying	http://www.surfbirds.com/birdingmail/... (T. Bronson, K. Payne)	13 April 2012, Monongahela River, West Virginia, USA; partially leucistic; back appeared dark, but rest of plumage whitish; no dark parts on head or neck at all; no other details given
PAUco201202010	**Dilution**	http://www.freelists.org/post/tn-bird/... (C. Sloane, S. Somershoe, S. Zipperer)	4 November 2012, Big Sandy Unit of Tennessee National Wildlife Refuge near Paris, Tennessee, USA; leucistic; very washed out plumage; normally black or dark areas very pale grey; light red brownish tint on neck (perhaps simply an artefact of distance or light)
PAUco201203022	**Melanism**	http://www.flickr.com/ (G. W. Beyersbergen)	13 July 2012, SW Edmonton, Alberta, Canada; photo showed grebe in breeding plumage with red-brown pigmentation in those parts usually blackish; head and back entirely brown; brown colour does not deviate much from chestnut neck; eye and bill colour regular; caring for a chick
PAUco201301022	**Progressive greying**	http://richbyoung.com/ (R. B. Young)	15 April 2013, Farmington Bay, Great Salt Lake, Utah, USA; no description given; photo showed bird in complete breeding ornament with upper breast and lower fore neck white; flanks mostly white with few darker blotches; some white feathers on back; eyes and bill regular; January photo of probably same bird showed comparable dispersal of white feathers
~~PAUco201302022~~		http://digest.sialia.com/?rm=message (J.A. Branca, C. Nycek, C. Titus)	8 April 2013, Pond 7, Henderson Bird Viewing Preserve east of Las Vegas, USA; initially identified as Horned Grebe, but was Eared Grebe; see PNIca201306022
PAUco201303022	Partial leucism	http://birding.aba.org/ (L. Wilson Neish)	14 October 2013, Penticton Marina of Okanagan Lake, British Columbia, Canada; photo showed adult grebe looking as still in moult; entire fore neck and upper breast about completely white; hind neck blackish; hind neck stripe about absent in lower nape; sides of neck with small pale rufous area; flanks mottled with white and grey feathers and very light chestnut tinge; back entirely dark grey; bill flesh coloured with dark culmen; red eyes; facial plumage white reaching into nape and to well above eyes; greyish dot at ear; blackish plumage in front and crown interspersed with few white feathers

Table 10: Aberrant Red-necked Grebes.

Numbering	Mutation/ aberration	Reference	Description
PGRgr184801032	**Brown**	Unpublished	January 1848, Yarmouth, Norfolk, UK; photos of skin received from H. van Grouw showed very pale plumage with cream brown tinges; ivory to pale yellow bill; yellowish feet
PGRgr187901200	Whiteling	Gurney 1879, Yarrell 1885, Hennicke 1903, Sage 1963, King 1973 (J. Marshall)	1879, Beachy Head, Sussex, UK; completely/perfectly white, almost an albino; shot; skin originally in the collection J. Marshall, Belmont, Taunton
PGRgr188701100	**Brown** or ino	Gurney 1887, Sage 1963, King 1973	April 1887, eastern counties of England, UK; all white, except for sandy tinge; shot; species perhaps not entirely clear as original text says "Red-necked Grebe, *Podiceps ruficollis*"
PGRgr188801100	Shock or partial leucism	Hennicke 1903 (von Niesky)	6 May 1888, place not indicated, probably Germany; female with a big unclearly delimited purely white spot on hind neck; collected for von Niesky's private collection
PGRgr189801100	Brown	Chernel de Chernelháza 1907, King 197 (B. de Meszleny)	19 August 1898, Lake Velencze, Hungary; whole plumage white; bill, legs and feet orange-coloured; iris lead-grey; shot
PGRgr193801030	Ino	Unpublished (Dementiev)	5 December 1938, near Dzhulek, region of Kyzylorda, district of Shieli, Kazakhstan; female with completely white plumage; bill and feet yellowish; skin with glass eye mimicking albino condition; collected by Dementiev; skin now at Darwin Museum, Moscow (information received by I. V. Fadeev, curator of birds)
PGRgr194801100	**Partial leucism**	Géroudet 1949, Knopfli 1956	25 December 1948 to 1 March 1949, port of Neuchatel, Switzerland; partial albino; a drawing by Fragnière showed pure white wing coverts; head, neck and flanks with regular colouration; bare parts and eyes regular
PGRgr195x01201	**Ino**	Drechsler 1951	Hatched early April, year unknown, possibly around 1950, Weißer Lug, Kreba-Neudorf, Saxony, Germany; second of four chicks hatched is said to be albino; completely white feathers; photo showed a pullus with middle grey stripes in face, fore neck and upper breast; crest, hind neck and back with very light yellowish rusty tint; feet and beak are flesh coloured; iris serous red
PGRgr195501101	Dilution	Walkmeister 1956, Sage 1956, 1962, King 1973	4 October 1955, Strahlegg, Fideris, Switzerland; juvenile of the year; photo showed rather normal colours on head and upper neck; mostly white in lower neck and back; back mottled with a few dark patches
~~PGRgr195601200~~		Sage 1956, 1962	In the text, Sage indicated that the Red-necked Grebe was among those species for which albinism was recorded in the UK; as example, he provided Walkmeister's (1956) record from Switzerland
PGRgr196601020	Whiteling	Mitteilungsblatt des OAK Mittelelbe-Börde 6 (4/66)	May-June 1966, Mittelelbe near Börde, Germany; abnormal; no further indications

Numbering	Mutation/ aberration	Reference	Description
PGRgr197001100	Progressive greying or partial leucism	Berndt & Drenckhahn 1974, Thiede 2005 (Kühl, Scholl)	1970, 1971, 1974, Kasseteiche, Schleswig-Holstein, Germany; partial albino with head appearing nearly white and a bit mottled; no other details given; bred at least twice successfully; pigmentation of chicks not mentioned
PGRgr198401100	Dilution	Dittberner 1996	Hatched on 18 June 1984 and seen until 12 August 1984, Maßpfuhl near Landin, Germany; white, except for its normal red neck and characteristic head pattern of juvenile plumage
PGRgr200001030	**Dilution**	Unpublished (P. Axelsson)	2000, 2002, 2003, 2005, 2008, 2009, 2010, Ållskog, Baldringe, south Sweden; almost no pigmentation; no rufous at all, only shading in tones of dark and light grey in those parts usually coloured; other parts white; beak with yellow spot; same bird was possibly present in all years
PGRgr200101030	*Partial leucism*	Unpublished (J. Aalto)	22 May, 2001, Särkisalmi, Parikkala, Finland; except for having been partially albino, no other details given
PGRgr200201022	**Brown**	http://www.vogelschutz-maerkische-schweiz.de/… (G. Berger, J. Hoffmann)	12 June 2002, Zichow, Uckermark, Brandenburg, Germany; about completely white chick in company of one regularly coloured sibling; film showed grebe out of some distance; it appeared to have a slight hue of some colour, possibly grey brown, in upper head, hind neck and back; beak appeared entirely yellow; eyes did not prove to be albinistic; behaved quite normally
PGRgr200301032	**Dilution**	Unpublished (J. Aalto)	30 May 2003, 29 July 2004, Siikalahti, Parikkala, Finland; photo showed normal colour pattern of breeding plumage, but overall paler, especially fore neck very light chestnut; back slightly paler; no other details given
PGRgr200401032	**Progressive greying**	Unpublished (J. Aalto)	3 May 2004, Kirkkoranta, Parikkala, Finland; photo showed dark crest, mottled with some white feathers; face and upper fore neck rather of normal colour; upper breast to middle of fore neck mostly white; flanks and back mostly white with a few darker patches; eye and beak colours normal; yellow eye ring suggested second calendar year
PGRgr200801022	**Progressive greying**	https://picasaweb.google.com/... (R. Svensson)	5 April 2008, Björkeröd, Sweden; photo showed grebe in breeding plumage; extensively white on crest, with a bit of dark shining through; on forehead, white patch above beak; rather heavy bill of normal colour (male?); normal chestnut neck; mostly normal dark brownish back with two tiny white patches on shoulder; may have bred successfully, as in 2012 a quite similar bird with white on back was observed at the same lake
PGRgr200901022	**Dilution**	http://www.naturparkmaribo.dk/index... (U. B. Nielsen)	23 March 2009, Søndersø, Nature Park Maribo Lakes, Denmark; photo showed very whitish bird with isolated dark grey blotches, for instance on sides of crest and wings; yellow at base of beak fading towards tip into a yellowish pale grey; yellow eye ring indicated second calendar year; inviting on nest in company of normal partner
PGRgr201001030	**Dilution**	unpublished (P. Axelsson)	2010, Ållskog, Baldringe, south Sweden; another pigment-free grebe; with folded wings almost white; no other details given; bred together with PGRgr200001030; they produced eggs, but nesting failed

Numbering	Mutation/ aberration	Reference	Description
PGRgr201101022	**Brown**	http://www.hgon.de/voegel/beobachten/... (T. Sacher) http://f3.webmart.de/... (C. Kleinert)	17 April 2011, Pfaffensee, Wetterau, Hesse, Germany; four pairs present; one slightly leucistic bird; no other details given - 7 April 2012, Pfaffensee, same lake; nine grebes present; one slightly leucistic bird; no other details given - May 2013: present for the third consecutive breeding season; in all years, attempts to find a partner failed, all pair bonding of short duration; according to behaviour, should be a male; photo of 2013 showed entirely brown (not blackish brown) back and crest plumage; normally coloured beak and eyes
PGRgr201202022	**Progressive greying**	http://www.artportalen.se/artportalen/... (L. Klinteroth)	27 April 2012, Björkerödsdammen, Kullaberg, Brunnby, Sweden; photo showed grebe in breeding plumage; extensively white on crest, with a bit of dark shining through; edges of crest darkest; white patch above beak on forehead; bill of normal colour in yellow and blackish; neck normally chestnut; back dark with several white patches
PGRho195401100	**Total leucism**	Weller 1959, Ross 1963, King 1973, Stout & Nuechterlein 1999 (M. W. Weller, M. C. Milonski)	July 1954, Delta Marsh, Manitoba, Canada; white-plumaged juvenile; plumage lacked any colouration; brown iris; yellow bill and feet; in company of one normally coloured adult and a leucistic sibling; collected; first in Museum at Delta Waterfowl Research Station, Manitoba, Canada; now at Manitoba Museum, Winnipeg
PGRho195402100	**Total leucism**	Weller 1959, Ross 1963, King 1973, Stout & Nuechterlein 1999 (M. W. Weller, M. C. Milonski)	July 1954, Delta Marsh, Manitoba, Canada; white-plumaged juvenile; plumage lacked any colouration; brown iris; yellow bill and feet; in company of one normally coloured adult and a leucistic sibling
PGRho195901100	**Progressive greying**	King 1975, Stout & Nuechterlein 1999 (R. W. Storer)	27 May 1959, Fort Qu'Appelle, Saskatchewan, Canada; female; normally plumaged except for scattering of white feathers at crown, nape and back; initially identified as incomplete albino; found dead
PGRho200501022	**Dilution**	http://www.furnfeather.net/... http://www.kevinkarlsonphotography.com/... (D. Young, K. T. Karlson)	3 July 2005, 30 June 2006, 28 June 2008, Tunkwa Lake southwest of Kamloops, British Columbia, Canada; appearance seemed unchanged in successive years; photos showed grebe with pale plumage, more greyish white above (mantle and especially crest); normal subdivision line of head plumage visible; cheeks lacked dirt appearance; mostly yellow bill with black culmen; dark eyes; no chestnut in front neck or upper breast; bred with normal partner in 2005 and produced two regular chicks; possibly same grebe present in 2006 and 2008; no breeding recorded in these years
PGRho200701022	Partial leucism or early moult or progressive greying	http://www.kevinkarlsonphotography.com/... (K. T. Karlson)	1 July 2007, British Columbia, Canada; grebe in regular breeding plumage, except for strong white mottling on upper breast, reaching into fore neck and flanks; on nest, four regular chicks on back

Numbering	Mutation/ aberration	Reference	Description
PGRho200801022	**Melanism**	http://www.flickr.com/ (B. Whitney)	18 November 2008, Port Townsend, Washington, USA; photo showed grebe in winter plumage with entirely blackish head, face, neck and back; face very dark except for chin region; neck entirely black; dark flanks and dark mottling on belly; yellow lower mandible; upper mandible partially black; yellow eye ring indicated first calendar year bird
PGRho201x01022	*Total leucism*	http://mailman1.u.washington.edu/… (J. Meche)	Prior to 2011, near the Alaska Ferry Terminal in south Bellingham, British Columbia, Canada; a totally snow-white grebe with regular eyes; partial albino; no other details given
PGRho201x02010	**Dilution**	http://s65.beta.photobucket.com/... (C. Evans)	No date given, possibly 2012 or slightly earlier, bay west of Minet's Point, Kempenfelt Bay, Barrie, Ontario, Canada; photo showed whitish grebe in winter plumage; light greyish in those parts normally darker
PGRho201201303	**Melanism**	Unpublished	Early July 2012, Wabamun Lake, Alberta, Canada; grebe in breeding plumage with very black face and much dark in otherwise chestnut front neck
PGRho201301022	**Brown**	Unpublished (S. Quigley, S. Shadick)	June 2013; Kenosee Lake, Saskatchewan, Canada; entirely white individual with pale yellowish beak; eyes looked dark, but impossible to validate from photo; nested with regularly coloured partner; nest destroyed by storm on 27 June

Table 11: Aberrant Black-necked/Eared Grebes.

Numbering	Mutation/ aberration	Reference	Description
PNIni188301102	**Erythromelanism**	Rokitansky 1952, Koop 1995, 2003	24 April 1883, Lake Velencze, Hungary; in breeding plumage with neck colouration similar to Slavonian Grebe; entire front neck completely chestnut red, only central part displayed a slight darkening; chin black; photo of skin showed back plumage interspersed with some rufous feathers; upper breast and lower neck chestnut; chestnut colouration continuing into flanks; gradual darkening in upper neck due to mottling of chestnut and blackish feathers; ear tufts golden yellow to rufous; collection of Natural History Museum, Vienna
PNIni189801032	**Brown**	Unpublished	July 1898, Koprnik, Czech Republic; skin at National History Museum in Prague; photo received from museum showed upper head, hind neck and mantle very pale brownish beige; lower face, fore neck and belly cream white; bill and feet yellowish; no visible crest or ear tufts suggested young bird
PNIni190201100	Progressive greying	Chernel de Chernelháza 1907, Weller 1959, King 1973	14 April 1902, Lake Velencze, Hungary; black parts of head and neck speckled with white feathers, especially at back of head, face and fore neck; upper surface almost quite white; other parts of normal colouring; shot
PNIni190801131	**Progressive greying**	Coburn 1910 (G. H. Clarke)	28 September 1908, Norton Pool, now known as Chasewater Reservoir, Staffordshire, UK; individual with curious marking on back stemming from stripes of white along the feathers of the mantle and scapulars; collected
PNIni191101100	Partial leucism or progressive greying	Gerber 1944, Dittberner & Dittberner 1984 (O. Grimm)	31 May 1911, Haselbach Ponds, Germany; male in breeding plumage except for a white spot on fore neck extending from chin towards breast and laterally to below cheeks, 27x25 mm; shot; in collection of Natural History Museum, Leipzig
PNIni191201100	Partial leucism or progressive greying	Gerber 1944	20 April 1912, Haselbach Ponds, Germany; male in normal breeding plumage except for a white chin-spot extending for 5x4 mm; in collection of Natural History Museum, Leipzig
PNIni191801200	Whiteling	Tischler 1941	23 August 1918, Pachutken, near Riesenburg, region of Gdansk, Poland; a purely white individual; in the collection of Vogelwarte Rossitten (today Russia)
PNIni191901100	Brown	Tischler 1941	Summer 1919, Rossitten (Rybatschi), Kaliningrad, Russia; white grebe with weak grey-brown upper side; collection of Vogelwarte Rossitten (today Russia)
PNIni192601030	Albinism or total leucism	Unpublished (Eropkin)	28 August 1926, near Horde (Urda), district of Bokeyordinsky, West Kazakhstan; entirely white plumaged individual; feet and bill yellowish; pale reddish iris on glass eye of skin; collected; skin at Darwin Museum, Moscow (information received by I. V. Fadeev, curator of birds)
PNIni192801200	Whiteling	Beckmann 1964, Bernd & Drenckhahn 1974	1928, no precise date given, Kührener Teich, Schleswig-Holstein, Germany; completely white male
~~PNIni195x01200~~		Koop 2003	Koop only referred to Rokitansky (1952) for this record, but gave no year; year is 1883, see PNIni188301100

Numbering	Mutation/ aberration	Reference	Description
PNIni196901200	**Erythromelanism**	Harengard 1971 (H. Petzold)	16 August 1969, Hattrop Ponds, Westphalia, Germany; except for red-throated, no details given
PNIni197x01100	Partial leucism or age related	Dittberner & Dittberner 1984	1913-1977, Lake Felchow, Angermünde, Germany; in normal breeding plumage, except for a white chin spot up to 10 mm wide; one out of five similar males caught during ringing between 1973 and 1977
PNIni197x02100	Partial leucism or age related	Dittberner & Dittberner 1984	1913-1977, Lake Felchow, Angermünde, Germany; in normal breeding plumage, except for a white chin spot up to 10 mm wide; one out of five similar males caught during ringing between 1973 and 1977
PNIni197x03100	Partial leucism or age related	Dittberner & Dittberner 1984	1913-1977, Lake Felchow, Angermünde, Germany; in normal breeding plumage, except for a white chin spot up to 10 mm wide; one out of five similar males caught during ringing between 1973 and 1977
PNIni197x04100	Partial leucism or age related	Dittberner & Dittberner 1984	1913-1977, Lake Felchow, Angermünde, Germany; in normal breeding plumage, except for a white chin spot up to 10 mm wide; one out of five similar males caught during ringing between 1973 and 1977
PNIni197x05100	Partial leucism or age related	Dittberner & Dittberner 1984	1913-1977, Lake Felchow, Angermünde, Germany; in normal breeding plumage, except for a white chin spot up to 10 mm wide; one out of five similar males caught during ringing between 1973 and 1977
PNIni197401100	**Erythromelanism**	Dittberner & Dittberner 1984, Dittberner 1996, Koop 1995	18 June 1974, Lake Felchow, Angermünde, Germany; female; neck strongly mottled with red-brown feathers; from a distance neck appeared entirely red-brown; reddish feathers below upper and lower wing coverts; all feathers of lower wing (normally blackish) showed reddish colour; flanks more shining red; caught for ringing
PNIni198401100	Total leucism or brown or ino	Paolillo 1988, Brichetti et al. 1992	19 May to 18 June 1984, River Angitola at outflow from Lake Angitola, Calabria, Italy; complete albinism; light beak; no other details given; seen courting with normally coloured conspecific (weed diving)
PNIni198402100	Dilution	Paolillo 1988	18 June 1984, River Angitola at outflow from Lake Angitola, Calabria, Italy; in breeding plumage, but clearly paler than others around; displayed typical ear tufts
PNIni198403100	**Erythromelanism**	Verroken & Verroken 1987, Kirwan 1995, Koop 2003	30 August to 8 September 1984, near Lochristi, East Flanders, Belgium; chestnut-red lower half of fore neck and breast; chin and throat whitish; upper neck greyish; flanks without any red, possibly as a consequence of moult; by 8 September, extent of red in neck and breast strongly reduced
PNIni198901200	Whiteling	Micheli & Busetto 1989, Brichetti et al. 1992 (A. Rossi)	9 to 19 October 1989, South Padenghe beach, Lake Garda, Lombardy, Italy; partial albinism; no other details given; in company of normally coloured conspecific
PNIni199301020	Whiteling	http://www.internatura.Org/... (JHP, MJP)	23 April 1993, El Hondo, Valencia, Spain; leucistic; no other details given
PNIni199302100	**Dilution**	Kirwan 1995 (M. Davies, G. Kirwan)	22 May 1993, Bendimahi Delta, Lake Van, Eastern Turkey; normal colour pattern of summer bird on head and neck (glossy black, golden-yellow ear-tufts); tail and tertials stained buff; rest of plumage almost entirely pure white; apparently unpaired; others around were paired

Numbering	Mutation/ aberration	Reference	Description
PNIni199401100	**Erythromelanism**	Koop 1995, 2003	May 1994 and 25 April 1995 (on 3 May 1995 on nearby Lake Dassow), Schellbruch, Lübeck, Schleswig-Holstein, Germany; chestnut-red in fore neck, upper breast and flanks, there similar to Slavonian Grebe; paired to normally plumaged partner; raised two chicks
PNIni199402100	**Erythromelanism**	Koop 1995, 2003	2 April to 13 May, Ponds of Lebrade, Schleswig-Holstein, Germany; pale chestnut-red fore neck; according to Koop, different from bird near Lübeck
PNIni200x01030	Whiteling	Foro_Andaluz, communicated by A.J. Hernández (J. Garzón)	Date unknown, year could be 2005, Laguna de Medina, Cadiz, Spain; leucistic; no other details given
PNIni200001303	**Brown**	Unpublished (A. Konter)	Easter 2000, near Cadiz, Spain; in breeding plumage; more brownish overall; brownish grey rather than black on crest, head and hind neck; tan brown in face and fore neck; some white on lower neck; golden ear tufts; pale beak
PNIni200203303	Subadult or hormonal disorder	Unpublished (A. Konter)	April 2002, Wagbachniederung, Baden-Wurttemberg, Germany; looked still like bird in complete winter plumage; rudimentary ear tufts; neck and upper breast white; much white in flanks; from chin to hind neck white; cheeks grey
PNIni200301232	**Dilution**	Hernández Navarro 2005 (L. Ventoso)	2003, Mallorca, Spain; no description given; photo from far showed grebe apparently in breeding plumage; upper head middle grey; chin and face whitish; ear tufts pale whitish yellow; front neck whitish; flanks mostly white with pale red brown hue; back pale grey mottled with white
PNIni200302032	Progressive greying or partial leucism	(T. Tancrez)	August 2003, Argilière de Ploegsteert, Belgium; juvenile with overall dark brown plumage and red brown iris; very dark, nearly black on crest except for isolated white feathers; whitish lower face; pale flesh coloured bill; fore neck more pale reddish brown; back heavily mottled with dark grey brown, white and few chestnut feathers; overall, back left a rather pale impression; flanks similarly mottled as back
PNIni200401020	*Albinism*	http://www.go-south.org /… (D. Jerez Abad, R. Ramirez Espinar)	1 February 2004, Mohamed V Dam south of Zaio, Oujda-Angad Province, Morocco; albino; no description given
PNIni200501022	**Progressive greying**	http://www.seo-alicante.org/... (F. Atienzar, A. J. Hernández Navarro)	29 August 2005, Santa Pola, Alicante, Spain; completely white; first photo from very far; photo provided by A. J. Hernández Navarro showed quite white bird with pale greyish upper head; white below face and in fore neck; light grey back; blackish edges in wing visible below mantle suggested that wing was entirely blackish; completely white flanks; beak light grey and partially flesh coloured; darker at tip; red eye
PNIni200502022	**Dilution**	http://www.avesibericas .es/podnig.htm (M. Rouco)	September 2005, Azud de Riolobos, Salamanca, Spain; whitish on face and front; middle grey crest; ear tufts mottled white and light yellow; chin and front neck white; flanks mostly white, with few pale grey feathers; back rather light grey, with very few white shadows; hardly traces of chestnut in plumage

Numbering	Mutation/ aberration	Reference	Description
PNIni200503232	**Progressive greying**	Hernández Navarro 2005, Guardiola 2006	12 March 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed grebe with winter subdivision of plumage; lower face, front neck, upper breast and flanks about completely shining white; upper parts and hind neck light grey; no rufous; small ear tufts in very light yellow or even beige; red eye; light beak; light grey legs
PNIni200504232	**Progressive greying**	Hernández Navarro 2005, Guardiola 2006	12 March 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed bird with upper head light grey; short pale yellow ear tufts; red eyes; pale grey bill; white face and fore neck; pale grey hind neck; white flanks; pale grey and partially white back
PNIni200505232	Dilution or progressive greying	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed about completely white plumage; a light shade of grey and yellow in crest; pale yellow hue in white feathers at ear tufts; pale grey to yellowish bill; red eyes
PNIni200506232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed overall light coloured plumage; upper head, face, neck and breast speckled to varying degrees white and light grey; darkest in nape; flanks whitish with a light greyish and yellowish hue; back feathers light grey fading to white towards rump; bill light coloured
PNIni200507232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed light beak; head mostly dark grey with white spotting; golden ear tufts; chin whitish; front neck and upper breast mostly white; flanks very light; light back with grey mottling
PNIni200508232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed mostly middle grey head with some white feathers; overall light yellow ear tufts; front neck and upper breast mostly white; flanks very light; light back with some grey patches; in pork-pie, beak and eyes not visible
PNIni200509232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; female; photo showed overall light coloured plumage; upper head, face, neck and breast speckled to varying degrees white and light grey; darkest in nape; flanks whitish with a pale greyish and yellowish buff hue; back feathers light grey, fading to white towards rump; light coloured bill
PNIni200510030	Progressive greying	Unpublished (A. García Ríos)	24 April 2005, Salinas de Ibiza, Spain; one of four leucistic grebes in a group of 33; one of them quasi albino; photo showed grebe in breeding plumage; pale grey to whitish crest and face; pale yellowish ear tufts; pale grey hind neck; pale grey to whitish fore neck; white upper breast; back partially middle grey with whitish parts; flanks about white; beak and eyes of regular colour or slightly paler

Numbering	Mutation/ aberration	Reference	Description
PNIni200511030	Progressive greying	Unpublished (A. García Ríos)	24 April 2005, Salinas de Ibiza, Spain; one of four leucistic grebes in a group of 33, one of them quasi albino; photo showed grebe in breeding plumage; pale grey to whitish crest and face; pale yellowish ear tufts; pale grey hind-neck; whitish fore neck and upper breast; back light grey with whitish parts; flanks white; beak and eyes of regular colour or slightly paler
PNIni200512032	**Progressive greying**	Unpublished (A. García Ríos)	24 April 2005, Salinas de Ibiza, Spain; one of four leucistic grebes in a group of 33, one of them quasi albino; photo showed light to middle grey upper head; whitish face and fore neck; middle grey hind neck; back heavily mottled with white and greyish; flanks pale or whitish; beak pale grey; eyes perhaps of regular colour
PNIni200513032	**Progressive greying**	Unpublished (A. García Ríos)	24 April 2005, Salinas de Ibiza, Spain; one of four leucistic grebes in a group of 33, one of them quasi albino; photo showed light to middle grey upper head; whitish face and fore neck; middle grey hind neck, light grey brown to the sides; back mottled with white and greyish, darker than in previous bird; pale, whitish flanks; beak and eyes perhaps of regular colour
PNIni200514020	Whiteling	http://www. donanabirdtours. com/… http://www.jaegertours. Net/spain-05.htm (S. Emmerson, J. Spick, A. Binns)	2/3 May and 15 May 2005, El Portil Lagoon, Huelva, Spain; a completely white grebe with two small blackish lines in the flanks; red eyes
PNIni200515020	Whiteling	http://www. donanabird tours. com/… http://www. jaegertours. Net/ spain-05.htm (S. Emmerson, J. Spick, A. Binns)	2/3 May and 23 May 2005, El Portil Lagoon, Huelva, Spain; partial albino; no other details given
PNIni200517232	**Dilution**	Hernández Navarro 2005 (E. Perez Romero)	9 July 2005, Cabezo Beaza (south of Mar Menor), Cartagena, Spain; photo showed about entirely white bird; slight pale greyish shadow on upper head and few little blotches of pale grey on body; pale grey beak with pale pinkish shine; red eye; kind of pale delimiting line between head and neck
PNIni200518030	Whiteling	Foro_Andaluz (communicated by A.J. Hernández) (J. Garzón)	September 2005, Odiel Marshes, Spain; leucistic grebe or albino; no other details given
PNIni200519034	**Dilution**	Unpublished (A.J. Hernández Navarro, A. Fernández-Caro Gómez)	13 October 2005, Cabezo Beaza (south of Mar Menor), Cartagena, Spain; photo showed about entirely white bird except for mostly dark wing coverts; pinions white; with folded wing, dark parts hardly visible; slight pale greyish shadow on upper head and few little blotches of pale grey on body; pale grey beak with pale pinkish shine; legs pale grey; red eye; perhaps same bird as reported in July, although it was even more white, but this may be attributable to further bleaching

Numbering	Mutation/ aberration	Reference	Description
PNIni200520232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; on photo similar to PNIni200507234; light beak; head mostly dark grey with white spotting; golden ear tufts, mottled with white; chin darker; front neck and upper breast mostly white; flanks very light with buff hue; light back with less grey mottling
PNIni200521232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; on photo light beak; whitish on face and forehead; dark grey in crest and nape; white in region of ear covered by yellow ear tufts; white to pale cream buff on front neck, breast and flanks; dark grey with some white on back
PNIni200522232	Partial leucism or age related	Hernández Navarro 2005, Guardiola 2006	16 April 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed female grebe mostly in breeding plumage with upper parts black and golden ear tufts; white chin, front neck and upper breast; some white in flanks
PNIni200523232	Whiteling	Hernández Navarro 2005, Guardiola 2006	8 June 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed grebe with winter subdivision of plumage; similar to PNIni200503234, but darker, more striped grey; longer beak; some buff cinnamon on side of neck; about completely white lower face, front neck, upper breast and flanks; light grey upper parts and hind neck, no rufous; red eye; very light beak, ivory to light grey
PNIni200524232	**Dilution**	Hernández Navarro 2005, Guardiola 2006	7 August 2005, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed bird with winter subdivision of plumage; about completely white lower face, front neck, upper breast and flanks; upper parts and hind neck grey, appearing darker than in PNIni200503234 and PNIni200523234; grey beak
PNIni200526022	**Progressive greying**	http:// territorionatural. Mundoforo.Com/... (J. Lacalle)	2005, Cartagena, Spain; photo showed largely white bird with some darker markings; judging from development of crest and ear tufts, photo taken during (pre)breeding season; white face; long white crest with blackish shadows; fully developed white ear tufts with pale yellow shine; white hind nape and neck, mottled with a bit of grey; darkest in upper front neck and chin, though front neck and upper breast largely white; flanks white; back mottled white and black; bill paler grey than usual; eye red; in company of PNIni200527022
PNIni200527022	**Progressive greying**	http:// territorionatural. Mundoforo.Com/... (J. Lacalle)	2005, Cartagena, Spain; photo showed largely white grebe mottled in blackish and white, with white dominating; short crest mottled white and black; similar in nape and back of neck, but more white; short ear tufts, mostly white with some dark shadows; about entirely white face, front neck and flanks; back very pale, white with blackish shadows; red eye; beak pale grey above, pale pinkish at lower mandible; in company of PNIni200526022

Numbering	Mutation/ aberration	Reference	Description
PNIni200528022	**Erythromelanism**	Unpublished (A. García Ríos)	24 April 2005, Salinas de Ibiza, Spain; in a group of 33; not mentioned by A. García Ríos, but present on his photos; grebe in breeding plumage with clearly bright chestnut red fore neck and upper breast, some white feathers there, too; otherwise regular plumage
PNIni200601032	**Dilution**	Unpublished (A. Fernández-Caro Gómez)	21 January 2006, Balsa de Regadío del Campo de Cartagena, Spain; photo showed grebe in non-breeding plumage; rather dark grey on upper crest and hind neck; pale grey to virtually white on back; completely white on lores, lower face, neck and flanks; pale yellowish beak; eyes in shadow
PNIni200602022	Progressive greying	http://aorm.blogspot.com/... (V. Hernandez Gil)	18 April 2006, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; photo showed grebe in white and light to medium grey plumage; crest darkest; lower face including region of ear tufts, front neck and flanks mostly white; sides of neck light grey; hind neck darker; mantle rather pale, mottled white and grey; eye of normal red colour; bill steel grey
PNIni200603032	**Dilution**	Unpublished (A.J.Hernández Navarro)	22 September 2006, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; one aberrant grebe in a total of 430; photo showed female with back heavily mottled white and grey; more grey towards neck and about white towards rump; flanks rather light
PNIni200604032	**Dilution**	Unpublished (A.J.Hernández Navarro)	11 October 2006, Salinas de San Pedro del Pinatar, Mar Menor, Murcia, Spain; one aberrant juvenile grebe in a total of 444; back slightly more whitish than in conspecifics; rest of plumage appeared normal; photo showed grebe in moult with some yellow in beak; especially back and flanks lighter than in surrounding birds
PNIni200701010	Dilution	http://www.birdtours.co.uk/... (K. Malling Olson)	21 May 2007, Aydinlar, Turkey; overall plumage pale greyish-brown; traces of normal summer head visible; no other details reported
PNIni200702201	**Progressive greying**	Hering 2009, 2010	29 December 2007, Crater Lakes of Wau, Libya; photo showed grebe with normal winter subdivision of plumage; white lower face, fore neck, upper breast and flanks; upper head, hind neck and back very pale, but not white, rather displaying a mix of grey and whitish feathers
PNIni200704303	Progressive greying	Unpublished (A. Konter)	21 April 2007, Wagbachniederung, Baden-Württemberg, Germany; grebe in breeding plumage with fully developed crest and golden yellow ear tufts; glowing red eyes; black bill; fore neck heavily mottled with white; upper breast nearly entirely white; many white feathers in the flanks that were very pale overall; nest building, but not observed to have bred
PNIni200801003	Shock	Unpublished (A. Konter)	3 June 2008, Wagbachniederung, Baden-Württemberg, Germany; male in regular breeding plumage, with long crest and golden yellow ear tufts; on centre of upper breast, blackish semi-circle, surrounded upward by rufous and a few white feathers delimiting it from the black neck

Numbering	Mutation/ aberration	Reference	Description
PNIni200805303	**Progressive greying**	Unpublished (A. Konter)	3 May 2008, Wagbachniederung, Baden-Württemberg, Germany; grebe in complete breeding plumage with a kind of white line in the black plumage leading from the lower fore neck over the breast into the flank; similar whitish area on folded wings
PNIni200901303	**Erythromelanism**	Unpublished (A. Konter)	25 April 2009, Wagbachniederung, Baden-Württemberg, Germany; female grebe in complete breeding plumage, with chestnut feathers in its upper breast leading into the lower fore neck; lower part of ear tufts with much chestnut; paired
PNIni201101020	Whiteling	http://www.azudriolobos.Com/... (F. Atiénzar)	March 2011, Santa Pola, region of Valencia, Spain; entirely white grebe; no other details given
PNIni201103020	Whiteling	http://www.vogelbescherming.nl/...	30 September 2011, Cape IJzeren, Texel, The Netherlands; one albino grebe; neither picture nor description provided
PNIni201104020	Whiteling	http://es.groups.yahoo.Com/group/faunaMurca/... (Eloy)	4 May 2011, EDAR del Cabezo Beaza, Spain; leucistic grebe; no other details given
PNIni201301022	**Dilution**	http://elnidoderafa.blogspot.com/... (A. Bazán Hiraldo, R. Torralba Zapatero)	22 April 2013, Laguna de Pétrola, Albacete, Spain; photo showed grebe with entirely whitish grey upper plumage; pale whitish yellow ear tufts; dark beak; normal red eyes; darkest in the head; about white in front neck and flanks; pale grey back
PNIgu20xx01022	**Dilution**	http://www.namibia-tour-guide.com/...	Date unknown, year probably close to 2010, Walvis Bay, Namibia; photo showed pale greyish bird; slightly darker on crest, nape and upper neck; nearly white on forehead, lower neck and back; pale yellowish to white at ear tufts; pale grey beak
PNIgu200402303	**Dilution**	Unpublished (A. Konter)	21 October 2004, Fickland Pan, Wakkerstroem, South Africa; female grebe in middle to light grey breeding plumage with a few light brown tinges; cream white on fore neck, upper breast and flanks; light chestnut brown hues to sides of neck; flanks without rufous chestnut, only grey and white; short yellow ear tufts; dark beak; regular red eye
PNIca188601200	*Albinism*	Grinnell 1898	30 September 1886, San Pedro, California, USA; immature bird in perfect albino plumage; shot; collection of W. H. Wakeley
PNIca19xx01200	Whiteling	King 1975 (letter by R. W. Storer)	Prior to 1974, exact date unknown, probably Bear River Wildlife Refuge, Utah, USA; completely white; no other details given; Storer saw the mounted skin at the offices of the refuge
PNIca191501202	**Progressive greying**	Weller 1959, Ross 1963, King 1973	2 July 1915, Marshall Lake, Coconino County, Arizona, USA; male in breeding plumage showing albinistic feathers; no other details given; shot; skin at US National Museum; possibly in list of Ross 1963; listed as female by museum; photos received by the museum proved that sex was female; rather dark head mottled in white and dark grey brown; slightly pale yellow ear tufts; bill and feet unaffected; neck rather pale; back and flanks virtually white; unbleached underlying feathers partially shining through; edges of wings dark brownish

Numbering	Mutation/ aberration	Reference	Description
PNIca191801200	*Albinism*	Wyman 1918 (Howard)	1918, Baldwin Lake, San Bernardino, California, USA; pure albino; no other details given
PNIca193101112	**Progressive greying**	Weller 1959, Ross 1963, King 1973	18 June 1931, Barr Lakes, Adams County, Colorado, USA; male with normal wings and with some dusky scapular feathers; otherwise rather white; skin now at Denver Museum of Natural History, there classified as *nigricollis* (initially identified as *auritus*); *nigricollis* confirmed by A. Doll from the museum and J. Fjeldså; photos showed a mostly white grebe; pale straw hue in upper head and region of ear tufts; few small pale grey patches in back plumage; brownish black edges to wings; whitish coverts; feet pale yellow; beak pale grey to pale yellowish
PNIca193901200	Ino	Allen 1940, Carter 1944, Weller 1959, King 1973	29 July 1939 to 10 February 1940, 1941, 1942, Dumbarton Bridge, California, USA; almost pure white bird; rosy coloured eyes; no other details given; seen in a group of three in 1939; in 1942 present for the 4th consecutive year (could have been different birds in each year)
PNIca194701200	Whiteling	Stott 1948, King 1973	24 August 1947, Mono Lake, California, USA; albino seen at close range; no detailed description given; in a group of normally coloured grebes
PNIca198001104	Whiteling	Jehl 1985	1980, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198002104	Whiteling	Jehl 1985	1980, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198003104	Progressive greying or dilution	Jehl 1985	1980, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198101104	Whiteling	Jehl 1985	1981, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198102104	Progressive greying or dilution	Jehl 1985	1981, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198103104	Progressive greying or dilution	Jehl 1985	1981, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198104104	**Brown** or ino	Jehl 1985	1981, Mono Lake, California, USA; predominantly white plumage with brown or tan smudges in the regions of head or neck or both; ear tufts white to very pale yellow; wings brown or tan to variable degrees
PNIca198105104	**Progressive greying**	Jehl 1985	1981, Mono Lake, California, USA; white body feathers with occasional grey feathers on back or rump; grey colouration not easily detectable, except at close range; wings dark,, except for normally white parts; black or grey markings on crown or nape, often extending around ear tufts or onto chin; ear tufts, if present, golden to pale yellow

Numbering	Mutation/ aberration	Reference	Description
PNIca198106104	**Progressive greying**	Jehl 1985	1981, Mono Lake, California, USA; white body feathers with occasional grey feathers on back or rump; grey colouration not easily detectable except at close range; wings dark, except for normally white parts, black or grey markings on crown or nape, often extending around ear tufts or onto chin; ear tufts, if present, golden to pale yellow
PNIca198107104	**Progressive greying**	Jehl 1985	1981, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198108104	**Progressive greying**	Jehl 1985	1981, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198109104	**Progressive greying**	Jehl 1985	1981, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198110104	**Brown** or ino	Jehl 1985	1981, Mono Lake, California, USA; brown or tan plumage evident on back; brown or tan area on neck more extensive and laterally present
PNIca198111104	**Brown** or ino	Jehl 1985	1981, Mono Lake, California, USA; brown or tan plumage evident on back; brown or tan area on neck more extensive and laterally present
PNIca198112104	**Brown** or ino	Jehl 1985	1981, Mono Lake, California, USA; brown or tan plumage evident on back; brown or tan area on neck more extensive and laterally present
PNIca198113104	**Brown** or ino	Jehl 1985	1981, Mono Lake, California, USA; tan or brown head, neck and chest; golden ear tufts, dark back, tan or brown wings; rest of body white
PNIca198201104	Whiteling	Jehl 1985	1982, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198202104	Progressive greying or dilution	Jehl 1985	1982, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198203104	Progressive greying or dilution	Jehl 1985	1982, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198204104	Progressive greying or dilution	Jehl 1985	1982, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198205104	Progressive greying or dilution	Jehl 1985	1982, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198206104	Progressive greying or dilution	Jehl 1985	1982, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented

Numbering	Mutation/ aberration	Reference	Description
PNIca198207104	**Progressive greying**	Jehl 1985	1982, Mono Lake, California, USA; white body feathers with occasional grey feathers on back or rump; grey colouration not easily detectable, except at close range; wings dark, except for normally white parts; black or grey markings on crown or nape, often extending around ear tufts or onto chin; ear tufts, if present, golden to pale yellow
PNIca198208104	**Brown** or ino	Jehl 1985	1982, Mono Lake, California, USA; predominantly white plumage with occasional brown or tan feathers on back or rump; wings dark, except for normally white areas; brown or tan markings on crown or nape, often extending around ear tufts and onto chin; ear tufts golden or pale yellow
PNIca198209104	**Brown** or ino	Jehl 1985	1982, Mono Lake, California, USA; predominantly white plumage with occasional brown or tan feathers on back or rump; wings dark, except for normally white areas; brown or tan markings on crown or nape, often extending around ear tufts and onto chin; ear tufts golden or pale yellow
PNIca198210104	Progressive greying	Jehl 1985	1982, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198211104	Progressive greying	Jehl 1985	1982, Mono Lake, California, USA; piebald plumage appearing uniformly grey at a distance; in reality, mixture of grey and white feathers in all upper parts; wing pattern variable
PNIca198301104	Whiteling	Jehl 1985	1983, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198302104	Whiteling	Jehl 1985	1983, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198303104	Whiteling	Jehl 1985	1983, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198304104	Whiteling	Jehl 1985	1983, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198305104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198306104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198307104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198308104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198309104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented

Numbering	Mutation/ aberration	Reference	Description
PNIca198310104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198311104	Progressive greying or dilution	Jehl 1985	1983, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198312104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; white body feathers with occasional grey feathers on back or rump; grey colouration not easily detectable, except at close range; wings dark, except for normally white parts; black or grey markings on crown or nape, often extending around ear tufts or onto chin; ear tufts, if present, golden to pale yellow
PNIca198313104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198314104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198315104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198316104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198317104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198318104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198319104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; black head, neck and chest; golden ear tufts; back and wings dark; rest of body, including face, chin and flanks, white
PNIca198320104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; black head, neck and chest; golden ear tufts; back and wings dark; rest of body, including face, chin and flanks, white
PNIca198321104	**Progressive greying**	Jehl 1985	1983, Mono Lake, California, USA; black head, neck and chest; golden ear tufts; back and wings dark; rest of body, including face, chin and flanks, white
PNIca198322104	Progressive greying	Jehl 1985	1983, Mono Lake, California, USA; piebald plumage appearing uniformly grey at a distance; in reality, mixture of grey and white feathers in all upper parts; wing pattern variable

Numbering	Mutation/ aberration	Reference	Description
PNIca198323104	Progressive greying	Jehl 1985	1983, Mono Lake, California, USA; piebald plumage appearing uniformly grey at a distance; in reality, mixture of grey and white feathers in all upper parts; wing pattern variable
PNIca198324104	Progressive greying	Jehl 1985	1983, Mono Lake, California, USA; piebald plumage appearing uniformly grey at a distance; in reality, mixture of grey and white feathers in all upper parts; wing pattern variable
PNIca198401104	Whiteling	Jehl 1985	1984, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198402104	Whiteling	Jehl 1985	1984, Mono Lake, California, USA; purely white plumaged grebe with the wings presumed to be white
PNIca198403104	Progressive greying or dilution	Jehl 1985	1984, Mono Lake, California, USA; white plumage with grey smudges on head or hind neck or both; ear tufts, if present, white or very pale yellow; wings variable; remiges or coverts could be pigmented
PNIca198404104	Progressive greying	Jehl 1985	1984, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198405104	Progressive greying	Jehl 1985	1984, Mono Lake, California, USA; grey pigmentation visible on back; black or dark area on neck more extensive and present laterally and to the front; wings dark
PNIca198501101	**Ino**	Schreur 1987	1 to 16 August 1985, Russell Lakes, south-central Colorado, USA; juvenile with white plumage, except for a dorsal dark area between wings; yellowish feet, due to carotene colouring (?);pink bill; eyes with pink iris and darker pupils
PNIca199x01201	Progressive greying	Jehl 2007	No place and date indicated, possibly Mono Lake, California, USA; entirely white plumage; dark bill with light tip; normal red eyes
PNIca199x02200	Whiteling	Jehl 2007	Prior to 2007, Oregon, USA, no exact date or place available; one leucistic grebe staging at Mono Lake, California, banded and seen nesting in Oregon; no other details given
PNIca199501101	Whiteling	Jehl 2007	September 1995, Mono Lake, California, USA; one of two birds captured for banding; on photo appeared entirely white; regular bill; eyes could not be assessed on black and white photo
PNIca199502101	Ino	Jehl 2007	September 1995, Mono Lake, California, USA; one of two birds captured for banding; on photo appeared entirely white; perhaps light tan hues in head; eyes could not be assessed on black and white photo
PNIca199503022	**Dilution**	http://www.utahbirds.org/RecCom/… (A. Smith)	18 November 1995, Great Salt Lake, causeway to Antelope Island, Utah, USA; grebe in winter plumage; still quite dark on head and hind neck; quite pale grey on back; yellowish fleshy beak; red eye
PNIca199801030	Whiteling	(H. Hawkins & Red Rock Audubon Society)	2 October 1998, Henderson Bird Viewing Preserve, east of Las Vegas, Nevada, USA; juvenile albino grebe; no other details given; possibly hatched at the Preserve; was with other juveniles of the same size

Numbering	Mutation/ aberration	Reference	Description
PNIca200201200	*Albinism*	Utah Division of Wildlife Resources 2002	April 2002, Great Salt Lake, causeway to Antelope Island, Utah, USA; completely white albino; no other details given
PNIca200301210	Dilution or progressive greying	Fridell & Summers 2004 (T. Lenz)	14 June 2003, Big Soda Lake, Churchill County, Nevada, USA; about completely white plumaged; ears with a bit of creamy-yellowish feathering; small black bill indicating female bird
PNIca200302012	Progressive greying	http://www.utahbirds.org/featarts/2008/... (N. Davis)	Mid-October 2003, Great Salt Lake, Antelope Island, Davis County, Utah, USA; photo showed completely white plumage in all parts; bill dark at culmen; lower mandible with some silver grey; normal red eyes
PNIca200303012	**Progressive greying**	http://www.utahbirds.org/listarchives/... (M. G. Moody)	5 October 2003, Great Salt Lake, Antelope Island, Davis County, Utah, USA; grebe in winter plumage; fore neck and flanks completely white; crown, hind neck and mantle middle grey, mottled with white; white above beak leading into crest; red eye; pale grey beak
PNIca200304012	**Ino**	http://utahbirds.org/birdsofutah/... (M. G. Moody)	5 October 2003, Great Salt Lake, Antelope Island, Davis County, Utah, USA; grebe with completely white plumage; photo showed pinkish eye that looked affected; light bill
PNIca200401020	Whiteling	http://utahbirds.org/listarchives/... (J. McIntyre)	16 October 2004, north of western bridge on Antelope Island Causeway, Utah, USA; leucistic grebe; no other details given
PNIca200501200	Whiteling	Feenstra 2005 (F. Gilliland)	6 August 2005, Lancaster Sewage Ponds, Antelope Valley, California, USA; completely white grebe, except for dark bill; said to have been nearly albino
PNIca200502020	**Brown** or ino	http://list.audubon.org/... (J. A. Branca)	October to November 2005, Henderson Bird Viewing Preserve east of Las Vegas, Nevada, USA; albino or leucistic grebe; blonde coloured plumage
PNIca200601012	Partial leucism or progressive greying	http://groups.yahoo.com/group/nwcalbird/... (P. Bitton)	22 January 2006, off Woodley Island Marina, NW California, USA; grebe with almost all-white head; dark cheek patches; dark streak on top of head; body and wings dark above; body mostly white below.
PNIca200602022	**Melanism**	http://calphotos.berkeley.edu/... (R. Vasudev)	28 January 2006, Huntington Beach, Orange County, California, USA; photo showed grebe with no prominent ear tufts; winter plumage; no really white parts in upper plumage, except for rather large white blotch on upper hind neck; dark black on upper head and mantle; lower part of face pale grey; neck blackish with yellowish rufous shine in central part; flanks white and blackish; beak steel grey, except for darker culmen; eyes of normal red colour; yellow eye ring
PNIca200603111	Progressive greying	Blumin 2007, Jehl 2007 (P.& L. Blumin, R. Wolf, J. Dunn, C. Burge)	7 to 18 October 2006, Mono Lake, California, USA; fully leucistic grebe; photo showed entirely white bird; light bill, dark flesh-coloured in the middle, dark grey above; red eyes in shadow appeared rather dark
PNIca200604303	**Erythromelanism**	Unpublished (A. Konter)	July 2006, Oak Hammock Marsh, Manitoba, Canada; grebe in complete breeding plumage with upper breast bright chestnut, some white in lower parts; chestnut tinges in neck; flanks bright chestnut

Numbering	Mutation/ aberration	Reference	Description
PNIca200702022	**Dilution**	http://www.flickr. com/photos/...	21 June 2007, Benton Lake National Wildlife Reserve, Montana, USA; photo showed grebe in breeding plumage; overall paler than usual; normal colour distribution guessable; dark crest, but not really black; ear tufts pale yellow; neck pale grey due to white mottling and bleaching; mostly white flanks; pale grey back, mottled with white; bill paler than usual; legs steel grey; eye red
PNIca200703010	Progressive greying	http://secureserver. securesites. net/ pipermail/… (B. Beneke)	18 September 2007, Antelope Island, east of the marina, Great Salt Lake, Utah, USA; very white grebe; body plumage mostly white with just a bit of grey mottling; head with some grey and black in it; most of the neck quite white
PNIca200704022	**Progressive greying**	http://vtm.smugmug. com/Other-California-Wildlife/... (V. Murayama)	6 May 2007, Salton Sea region, California, USA; photo showed grebe with lower cheeks, lower front and chin mostly white; less white feathers on otherwise blackish head, including in crest; ear tuft region with a few golden feathers; mix of white and black in neck, with white dominating fore and black dominating hind neck; upper breast and flanks completely white; back rather pale, due to intense presence of white feathers that mix with blackish feathers; eyes, bill and feet of normal colour
PNIca200705022	**Dilution**	http://www.flickr. com/ (M. Peck)	29 October 2007; Mexico, exact place unknown; grebe in winter plumage with pale grey upper head; virtually white back, except for hardly visible grey hue; red eye; yellowish at onset of bill
PNIca200802022	**Dilution**	http://www.azfo. org/... (C. Babbitt)	May to at least 23 August 2008, Gila Bend Power Plant Pond, Maricopa County, Arizona, USA; about completely white plumage, except for wings which showed pale grey parts; light steel grey beak; eyes of normal red colour
PNIca200803020	Whiteling	http://www.calbirds. com /index… (Robin)	23 October 2008, South end of Salton Sea, southwest of Obsidian Butte, California, USA; leucistic grebe, no other details given
PNIca200804022	**Dilution**	http://www.flickr. com/photos/ (M. Brown)	15 June 2008, Guadalupe Sewage, California, USA; photo from far showed quite pale grey grebe; parts normally dark in winter were pale grey; crest darker; bill steel grey; eyes possibly red
PNIca200805022	**Total leucism**	http://www. stevewalternature. com/birds/... Walter)	27 April 2008, Santa Barbara County, California, USA; photo showed entirely white grebe; intermediate-sized pale beak; red eyes; at least second calendar year
PNIca200810303	Age or partial leucism	Unpublished (A. Konter)	27 May 2008, Little Manitou Lake, Saskatchewan, Canada; adult grebe in full breeding plumage with well-developed crest and ear tufts; glowing red eyes; blackish bill; golden ear tufts; remainder of upper plumage black; about entirely white on lower fore neck and upper breast; flanks rather pale with many white feathers
PNIca200813022	**Dilution**	http://notesfromt hewildside. com/2009/… (Adrian)	June 2008, Antelope Island, causeway, Great Salt Lake, Utah, USA; almost entirely white grebe with the exception of back of head and around throat; long head plumes (crest); photo showed dark grey tints in crest and nape; back greyish white; swimming with normally coloured grebe

Numbering	Mutation/ aberration	Reference	Description
PNIca200814020	Whiteling	http://notesfromthe wildside.com/2009/... (Adrian)	27 April 2008, Santa Barbara County, California, USA; one of four leucistic grebes; no other details provided
PNIca200815020	Whiteling	http://notesfromthe wildside.com/2009/... (Adrian)	27 April 2008, Santa Barbara County, California, USA; one of four leucistic grebes; no other details provided
PNIca200816020	Whiteling	http://notesfromthe wildside.com/2009/... (Adrian)	27 April 2008, Santa Barbara County, California, USA; one of four leucistic grebes; no other details provided
PNIca200817220	Whiteling	Conard 2008 http://www. sacramentoaudubon. org/...	11 October 2008, Consumnes River Preserve, Sacramento, California, USA; albino grebe; no other details given
PNIca200818030	Whiteling	Unpublished (G. Chaniot)	5 November 2008, Borax Lake, California, USA; apparently totally albino grebe seen out of some distance; snow white plumage without any hue of pigmentation
PNIca200819030	Whiteling	Unpublished (L. Hug)	9 November 2008, Soda Bay resort, Clear Lake, California, USA; nearly completely albino grebe; no other details provided
PNIca200820022	**Ino**	http://www. flickr.com/ (anonymous)	12 September 2008, Eagle Lake, Lassen County, California, USA; photo showed virtually white plumage; red brown hue on upper head; same hue on back, but there much paler; yellowish bill; slightly pinkish eyes
PNIca200821022	**Vitiligo**	http://www.flickr. com/ (J. Ting)	18 April 2008; San Francisco Bay National Wildlife Refuge, Fremont, California, USA; photo showed grebe in breeding plumage; fully developed crest and ear tufts; black bill; red eyes; greyish white plumage surrounding base of bill and at chin; plumage underlying ear tufts white; whitish on upper breast and lower neck with pale grey dotting
PNIca200901020	Whiteling	http://www.towhee. net/... (H. Fuller)	24 May 2009, Moore Park, Lower Klamath Lake, Oregon, USA; one grebe with white feathers; with numerous breeding plumaged conspecifics; no other details given
PNIca200902022	Progressive greying	http://atowhee. wordpress.com/... (M. Rackley)	4 April 2009, Clear Lake, city park, Lakeport, North California, USA; photo showed pure white plumaged grebe; light grey bill, slightly pinkish; light grey legs; eyes appeared more pale rosy than usual; at least second calendar year
PNIca200903022	**Dilution**	http://groups.yahoo. com/group/south-bay-birds/... (A. Sinha)	19 May 2009, Salt Pond A12, Alviso, California, USA; a white individual among a group of breeding plumaged grebes; photo showed pale grey, but not really white grebe; whitish in fore neck and flanks; plumage generally mottled; chestnut hue in flanks; yellowish ear tufts
PNIca200904020	Whiteling	http://www. monolake.org/... (G. Reis)	7 October 2009, Mono Lake, near South Tufa, California, USA; about a million Eared Grebes present; one white grebe spotted a few times; no other details given

Numbering	Mutation/ aberration	Reference	Description
PNIca200905021	**Erythromelanism**	http://www.flickr.com/ (R. Michal)	5 July 2009, Henderson Bird Viewing Preserve, Henderson, Las Vegas, Nevada; in breeding plumage with upper breast and entire fore neck chestnut red; with two chicks on back
PNIca201002303	**Dilution**	Unpublished (A. Konter)	22 July 2010, Strawberry Lake, Utah, USA; entire plumage appeared floured, especially face, ear tufts (light yellow and white), neck and flanks; light rufous still dominating in flanks; back shining white, though interspersed with dark feathers; upper breast white; beak at onset yellowish ivory
PNIca201003303	**Progressive greying**	Unpublished (A. Konter)	11 July 2010, Great Salt Lake, causeway to Antelope Island, Utah, USA; grebe entirely mottled with white and darker feathers; yellowish flesh beak, darker towards tip; front, cheeks, chin and ear tufts mostly white, though some light yellow visible at tufts; nape still rather dark; neck mostly white with some rufous on the sides; narrow dark line at hind neck; greyish mantle heavily interspersed with white feathers; flanks mostly white
PNIca201005303	**Progressive greying**	Unpublished (A. Konter)	11 July 2010, Great Salt Lake, causeway to Antelope Island, Utah, USA; grey black upper head; paler grey on back; rufous yellow year tufts; cheeks and chin completely white, a white patch reaching to the hind neck; whitish yellow bill at onset; fore neck and sides heavily streaked with white feathers; breast about completely white; mostly white flanks with some dusty stripes
PNIca201006303	**Dilution**	Unpublished (A. Konter)	11 July 2010, Great Salt Lake, causeway to Antelope Island, Utah, USA; whitish appearance, just as if floured; face completely white; crest dark with some white; light yellow ear tufts; dark beak; some white in neck; quite white on back, though interspersed with dark feathers; flanks white, though interspersed with chestnut
PNIca201007020	Whiteling	http://oregonbirds.org/pipermail/... (C. Gates, K. Owen, S. Staats)	16 August 2010, Gutierrez Ranch, Crook County, Oregon, USA; all white grebe, except for dark wash on the neck; red eyes; leucistic; no other details given
PNIca201009022	**Dilution**	https://groups.google.com/group/easternsierrabirds/... (C. Howard)	12 to 23 August 2010, Bishop Sewer Ponds, Bishop, California USA; photo showed completely white plumage at lower face, front neck, upper breast and flanks; very pale grey at upper head (from eyes upward) and hind neck; even paler grey at mantle; bill steel grey; eyes red
PNIca201010303	**Erythromelanism**	Unpublished (A. Konter)	1 July 2010, Farmington Bay, Great Salt Lake, Utah, USA; grebe in breeding plumage with neck and upper breast interspersed with chestnut; cared for one chick, a few days old
PNIca201011022	**Dilution**	http://www.flickr.com/ (W. Bouton)	22 June 2010, Tule Lake National Wildlife Refuge, Siskiyou County, California, USA; photo showed grebe in breeding plumage; quite regular head pattern; pale grey back; greyish white on breast; pale grey flanks with only few tinges of rufous; normal bill; glowing red eye indicated at least second calendar year; in company of regular partner

Numbering	Mutation/ aberration	Reference	Description
PNIca201101022	**Progressive greying**	http://calphotos.berkeley.edu/... (R. Wolf)	20 March 2011, Shoreline Park. Mountain View, Santa Clara County, California, USA; photo showed grebe in full breeding plumage with generally black upperparts; long golden yellow ear tufts and rufous chestnut flanks; white spotting on chin and forehead; strong white mottling on black upper breast and lower neck reaching slightly into flanks; beak dark; eyes of normal red colour
PNIca201103022	Dilution	www.pbase.com/image/137181516 (M. Todd)	5 August 2011, West Wendover, Elko county, Nevada, USA; photo out of some distance showed grebe apparently completely white on back, whitish on upper breast and lower neck; rest of neck and head dark, mostly black; pale yellowish at region of ear tufts; bill dark
PNIca201105303	Unknown, no genetic mutation	Unpublished (A. Konter)	May 2011, Upper Klamath Lake, Oregon, USA; grebe in complete breeding plumage, with the exception of upper breast colouration; there bright rusty orange smudges present; underlying feathers seemed white
PNIca201106303	Age/illness	Unpublished (A. Konter)	May 2011, Tule Lake, northern California, USA; grebe with short crest; rough ear tufts showing little yellow, but a few white feathers; white chin and upper breast; front neck mostly white; white flanks with little grey mottling; mantle grey, not black
PNIca201107303	**Erythromelanism**	Unpublished (A. Konter)	May 2011, Lower Klamath Lake, California, USA; grebe in complete breeding plumage with upper breast displaying an intensive chestnut tinge; same tinge also present in front neck; presence of some black feathers in these areas
PNIca201111303	**Progressive greying**	Unpublished (A. Konter)	May 2011, Tule Lake, California, USA; grebe in breeding plumage with white striping on upper breast and lower front neck; some white feathers interspersed to otherwise black mantle
PNIca201113022	**Dilution**	http://www.lickr.com/ (R. P. O'Donnell)	8 October 2011, Utah, probably Great Salt Lake, causeway to Antelope Island, USA; photo showed very pale, nearly white grebe; greyish hues especially on head, much paler on back; slightly yellowish bill; red eyes (N. Jenson reported a white grebe far out on the same date from the causeway to Antelope Island; considered to have been the same bird)
PNIca201114022	**Melanism**	www.flickr.com/ (M. Forsman)	16 July 2011; Ventura Marina, California, USA; photo showed grebe in breeding plumage with partially chestnut red fore neck and completely brownish red belly; red eyes; dark bill; golden ear tufts
PNIca201115022	**Erythromelanism**	http://vtm.smugmug.com/ (unknown)	1 May 2011, Bolsa Chica Ecological Reserve, Orange County, California, USA; male in complete breeding plumage with golden red ear tufts; upper breast and lower front neck mostly chestnut red
PNIca201201022	**Progressive greying**	www.flickr.com/ (J. Ruckdeschel)	8 September 2012, Great Salt Lake, causeway to Antelope Island, Utah, USA; photo showed pure white bird with dark beak; normal red eyes; yellow ring to dark pupil
PNIca201204021	**Erythromelanism**	http://www.flickr.com/ (H. Cuthill)	1 June 2012, Klein Park, Calgary, Alberta, Canada; female in complete breeding plumage with upper breast and lower half of front neck covered with chestnut red feathers; paired

Numbering	Mutation/ aberration	Reference	Description
PNIca201205021	**Melanism**	http://www.flickr.com/ (H. Cuthill)	15 June 2012, Frank Lake, High River, Alberta, Canada; grebe in complete breeding plumage with flanks about entirely black, only some rufous shining through; black plumage generally more sooty; pale sooty yellow ear tufts; with two small regular chicks
PNIca201301022	**Dilution**	http://www.flickr.com/ (B. Olsen)	29 May 2013, probably Utah, USA; photo showed overall paler individual; still rather dark grey, perhaps slightly brownish at head and hind neck; short yellowish ear tufts; red eyes; dark beak slightly lighter than usual; chin region and front neck whitish; pale grey back mottled with white; flanks mostly white
PNIca201302032	**Dilution**	(D. Guthrie)	17 July 2013, Salton Sea near Lindsey, California, USA; photo showed mostly cream white adult with perhaps slightly pale red eyes; dark bill with light tip; bare line from gape to eye flesh coloured; slight yellowish tint in otherwise whitish ear tufts; darker at nape and hind neck; some grey blotches on back
PNIca201303022	**Dilution**	http://www.rexburgstandardjournal.com/ (B. Schiess)	Ca. 11 July 2013, Henrys Lake, Idaho, USA; partially leucistic grebe; photo showed grebe in company of regularly pigmented conspecific; dark grey crest and upper neck; slightly pale bill; eye colour blurred red; yellowish white ear tufts; dark feathers of lower neck interspersed with white, especially in the hind part; pale back strongly mottled with whitish feathers; flanks very light, only weak hue of light chestnut
PNIca201304022	**Dilution**	http://www.letsgobirding.com/… (L. Myers)	14 July 2013, Mono Lake, California, USA; photo showed whitish grebe with dark grey upper head and hind neck; very pale yellow ear tufts; white fore neck and flanks; floured whitish mantle; red eyes; normal bill
PNIca201305022	**Erythromelanism**	www.flickr.com/ (D. Delaney)	20 May 2013; John E. Poole Wetland, St. Albert, Alberta, Canada; photo showed grebe in breeding plumage with chestnut red lower fore neck and upper breast; red eyes; black bill; golden ear tufts, quite reddish in lower parts
PNIca201306022	**Dilution**	http://digest.sialia.com/… (J.A. Branca, C. Nycek, C. Titus)	8 April 2013, Pond 7, Henderson Bird Viewing Preserve east of Las Vegas, USA; photo showed overall pale grey to whitish grebe; nape darkest; dark grey in extreme upper neck, other parts mostly white; whitish face; perhaps slightly pale red eyes; dark bill will white tip; mottled in light grey and white on back and in flanks (initially identified as Horned Grebe)
PNIca201307020	Whiteling	http://digest.sialia.com/ (B. Reiling, M. Rogers)	19 October to 15 November 2013, Salt Pond A12, Alviso, Santa Clara Valley, California, USA; except for the indication leucistic, no description provided
PNIca201308022	**Progressive greying**	http:/calphotos.berkeley.edu/ (D. Getty)	21 April 2013, Bear River Migratory Bird Refuge, Utah, USA; grebe in full breeding plumage, except for white chin and white upper breast and lower neck; long golden yellow ear tufts; long black crest; glowing red eye; dark bill; a few white feathers in the chestnut flanks
PNIca201309022	**Dilution**	www.flickr.com/ (M. Hearell)	26 September 2013, Agricultural Issues Center, Davis, California, USA; overall light grey grebe; darkest in upper head; mostly white in lower face, front neck and flanks; red eyes; pinkish bill; sides of neck and back pale grey to white

Table 12: Aberrant Silvery Grebes.

Numbering	Mutation/ aberration	Reference	Description
POCoc199401121	**Dilution**	Fuentes & González-Acuña 2011 (H. Koksch)	August 1994, Pacific Ocean at San Vicente, Region of Biobío, Chile; grebe with crest and hind neck still rather dark; flanks about completely white; mantle darkest towards neck (pale grey), but rather white from middle to rear end; flanks white
POCju199801303	**Staining**	Unpublished A. Konter	15 October 1998, Sajama National Park, Bolivia; grebe with a bright orange shine in its upper breast, leading into the front neck; otherwise regular plumage
POCju200401303	**Staining**	Unpublished A. Konter	23 July 2004, Sajama National Park, Bolivia; grebe with a bright orange shine in its upper breast, leading into the front neck; otherwise regular plumage
POCju200402303	Migration or atavism	Unpublished A. Konter	23 July 2004, Sajama National Park, Bolivia; grebe with pale yellowish ear tufts as they occur in the lowland subspecies *occipitalis*; otherwise regular plumage

Table 13: Aberrant Hooded Grebes.

Numbering	Mutation/ aberration	Reference	Description
PGAga200601303	**Staining**	Unpublished A. Konter	24 December 2006, small lagoon close to Laguna las Encantenadas, Patagonia, Argentina; grebe in regular breeding plumage; entirely pale rusty orange upper breast and lower front neck

Table 14: Aberrant Western Grebes.

Numbering	Mutation/ aberration	Reference	Description
AOCoc195501100	Ino	Weller (1959), Ross (1963), King (1973)	October 1955, Manitoba, Canada; pure white grebe; pink eyes; very pale, cream-yellow bill and feet; total albino (note that in 1955 Western and Clark's Grebes were considered as colour morphs of the same species; as Clark's Grebes are rare in Manitoba, the record is likely to have concerned a Western Grebe)
AOCoc200901303	Staining or chestnut melanism	Unpublished A. Konter	Early August 2009, Lake Almanor, California, USA; grebe with much rusty feathers in upper belly to upper breast , but fading quickly on lower neck
AOCoc200902303	Staining or chestnut melanism	Unpublished A. Konter	Early August 2009, Lake Almanor, California, USA; male grebe with dark rusty feathers on lower front neck and breast; paler rusty colour in normally white under parts, including belly; nesting with Clark's Grebe as partner
AOCoc200904303	Staining or chestnut melanism	Unpublished A. Konter	Early August 2009, Lake Almanor, California, USA; grebe with dark rusty feathers on lower front neck and breast; paler rusty colour in normally white under parts, including belly; different from previous as incubating in a different colony
AOCoc200905303	**Melanism** or hybridization	Unpublished A. Konter	July 2009, Tule Lake, California, USA; grebe in regular breeding plumage with black feathers of crest reaching far downward to close to chin, and covering cheeks completely; white dotting to sides of nape; some black dotting in sides and front of neck
AOCoc201001303	**Melanism** or hybridization	Unpublished A. Konter	July 2010, Bottle Hollow Reservoir, Utah, USA; grebe in breeding plumage with black feathers of crest reaching well into the cheeks; caring for one chick
AOCoc201002303	**Melanism** or hybridization	Unpublished A. Konter	July 2010, Minersville Reservoir, Utah, USA; male grebe in regular breeding plumage with grey smudges on cheeks reaching close to chin region
AOCoc201003022	Whiteling	http://utahbirds.org/pipermail/birdnet/... (J. St. Sauver)	17 October 2010, Salt Creek Wetlands near Promontory Mountains, Brigham, Utah, USA; almost all white individual with just a touch of grey; in company of other Western Grebes; therefore identified as Western Grebe, but species not entirely certain
AOCoc201101022	**Progressive greying**	http://robert-harrington.com/ (R. Harrington)	14 November 2011, Lake Hodges, southern California, USA; grebe with green yellow beak; upper parts of dark plumage heavily mottled with white, especially on very pale crest; mantle mottled heaviest towards neck and shoulders; darkest towards rear end; red iris indicated second calendar-year bird
AOCoc201102303	Melanism or staining	Unpublished A. Konter	20 May 2011, Upper Klamath Lake, Oregon, USA; at lower hind neck, dark grey plumage extends towards breast forming a kind of greyish band at the junction of fore neck and breast
AOCoc201201022	**Progressive greying**	http://www.flickr.com/ (F. Petersen)	13 November 2012, Virginia Lake, Reno, Washoe Co, Nevada, USA; photo showed grebe with upperparts of plumage (including crown and hind neck) heavily mottled and blotched with white; green-yellow beak, darker at culmen; looked very similar to AOCoc201101022; the brown eye colour seemed to indicate subadult status

Table 15: Aberrant Clark's Grebes.

Numbering	Mutation/ aberration	Reference	Description
ACLtr198601100	Hybridization	Janssen (1986); (K. LaFond)	23 May 1986, Lake Osakis, Minnesota, USA; individual with a very distinct white patch above and in front of the red eye; yellow orange beak; no other details given; drawing showed a black crest that a priori remained quite above eye height, but then connected to the lateral centre of the eye with a fine black line originating more centrally from the side of the crest; in a group of 12 *Aechmophorus* grebes of which 11 were Western Grebes
ACLtr200701022	**Progressive greying**	http://danstreiffert.smugmug.com/... (D. Streiffert)	30 November 2007, Bosque del Apache, southern Socorro County, New Mexico, USA; photo showed grebe with dark grey-black crest, hind neck and mantle, all completely mottled with white; dark crest touching upper eye; white line between bare gape line and crest; red brown eye of juvenile; bill very orange yellow with black culmen
ACLtr200901022	**Partial leucism**	http://www.pbase.com/image/... (K. Andersen, L. Miller)	February 2009, Port Orford, Oregon, USA; photo showed grebe with normal division line between black and white feathers absent in eye region; only white surrounding the eye and orange yellow bill identify individual as Clark's; bill lacks dark culmen; eyes serous red; front to middle of upper head mostly white; at height of bill, dark brown grey blotch extending over cheek to ear region and joining similar stripe extending from hind nape over neck to back and fading downwards; hind neck stripe appeared to have glided into a more lateral position in the lower part; back mostly brownish grey with white feathers in upper mantle; flanks rather dark; feet yellow; yellow bare parts possibly due to lack of eumelanin; then, species could be Western
ACLtr200903303	**Staining** or chestnut melanism	Unpublished A. Konter	July 2009, Lake Almanor, California, USA; grebe in breeding plumage with rusty tinges in the lower fore neck, breast and belly; incubating
ACLtr201101303	**Staining** or chestnut melanism	Unpublished A. Konter	20 May 2011, Upper Klamath Lake, Oregon, USA; grebe in breeding plumage with bright rusty orange lower neck and upper breast, the colour reaching into the flanks and perhaps present on belly
ACLtr201102303	**Staining** or chestnut melanism	Unpublished A. Konter	20 May 2011, Upper Klamath Lake, Oregon, USA; grebe in breeding plumage with more rusty yellow hues on lower neck; tinges apparently limited to there
ACLtr201202022	**Brown**	http://vtm.smugmug.com/ (V. Murayama)	24 September 2012, San Joaquin Wildlife Sanctuary, Irvine, Orange County, California, USA; photo showed a mostly brownish grebe with pale to darker brown tinges in all plumage parts normally grey; brownish hue in flanks; bill yellow; pale red eye; olive legs
ACLtr201301022	**Dilution**	http://www.flickr.com/ (c. von Rosbach)	15 June 2013, Tri-City Park, Placentia, California, USA; photo showed dark black crest; yellow orange bill; regular red eyes; back very pale grey; flanks mostly white

Table 16: Occurrences of hybridization between grebe species.

Species involved	Reference	Description
Common Little x Madagascar Grebe	Voous & Payne 1965	Suggestion of hybridization, however, according to BirdLife International (2004), there is no evidence of interbreeding
	Benson 1971, Collar & Stuart 1985	Possible hybrid in the collection of the Natural History Museum, London; collected by Betsileo between 1863 and 1921; in breeding plumage with dark greyish plumage of fore neck only stopping 5 mm before reaching the chin; the separating chestnut band normally has a size of about 40 mm there; wing size 103 mm; beak with 17 mm short
	Benson et al. 1976, Collar & Stuart 1985	Pond near Sakaraha, Madagascar, between 29 December 1972 and 5 January 1973; probable observation of a mixed pair bond with a chick; an adult *ruficollis* with one pullus on its back was always present and it was always closely followed by an adult *pelzelnii*
Common Little x Rusty Grebe	Voous & Payne 1965	Payne collected and described five adults with plumage characters that were intermediate between *T. pelzelnii* and *T. ruficollis*. Four specimens resembled a Rusty Grebe. The first differed by displaying a large grey chin spot and a brown iris. The second was more pale rufous on the sides of the neck and more rufous on the side of the head. Its chin was slightly spotted with dark grey. The third was short-billed, pale-brown-faced and it had a dark spotted chin. The third was brown or pale rufous faced and it had a dark grey chin patch. The last specimen resembled a long-billed Little Grebe, slightly paler and more buff brown on the sides of the head, and it had a light yellow iris. A hybrid *T. ruficollis* x *T. rufolavatus* in the collection of the Zoological Museum of Amsterdam possibly stemmed from Payne.
	Benson 1971	A specimen collected in Madagascar between 1863 and 1921 is classified as plausible hybrid; while the colouration of the grebe in pre-breeding plumage does not deviate from the patterns observed in *ruficollis*, the extremely long beak (24 mm or 28.5 mm at culmen) is well within the size range observed for *rufolavatus* (21-27 mm)
	O'Donnel & Fjeldså 1997	Hybridization of *T. rufolavatus* with *T. r. capensis* occurred at least since the 1920s and already the type specimen of rufolavatus had hybrid characters
	Wilmé 1994	Surveys at Lake Alaotra in the second half of the 20th century were already unable to detect purebred Rusty Grebes
	Hawkins et al. 2000	Hybrids reported, the authors referring to an unpublished report to the Jersey Wildlife Preservation Trust, Madagascar
Common Little x Australasian Grebe		No direct examples of hybridization, but complex pattern of distribution between subspecies of both in the Indo-Malayan region leave room for speculation about historic interbreeding
Common Little x Pied-billed Grebe	Parkin & Knox 2010	1993, Stithians Reservoir, Cornwall, England; three pulli hatched, resulting from hybridisation of a Pied-billed Grebe, present from April to the end of the year, with a Little Grebes; fate of chicks unknown
	Rogers et al. 1995	1994, Stithians Reservoir, Cornwall, England; again three chicks hatched, resulting from hybridisation of perhaps the same Little Grebe with the same Pied-billed Grebe as in 1993; one chick survived to October, a second to 28 March 1995; one hybrid from 1994 was still seen in October 1995
	Bräuning 2002, Bunes & Solbakken 2002	August 2002, Smukkevannet, Rogaland, Norway; female Pied-billed Grebe caring for a chick; appearance of descendant suggested that a Little Grebe was the father; the intermediate was not described and its fate is unknown

Species involved	Reference	Description
Least x Pied-billed Grebe	http://suchbros.blogspot.com/ (M. Such)	Late February 2009, Estero Llano Grande State Park, Texas; adult resembling mostly Least Grebe with an heavy beak, suggesting hybridization with Pied-billed Grebe
Atitlan x Pied-billed Grebe	BirdLife International 2004, Hunter 1988, LaBastille 1974, O'Donnel & Fjeldså 1997	Hybridization is suggested to have contributed to the extinction of the Atitlan Grebe, but positive proof is missing
Red-necked x Slavonian Grebe	King 1985	28 December 1981, Penzance, Cornwall, UK; individual initially identified as a rather bulky and thick billed Slavonian Grebe; Simmons thought that it was rather a hybrid, presumably with a Red-necked Grebe; assessment based on size of bird and of its beak, but also on the greyish smudges in those plumage parts that normally are pure white in Slavonian Grebes, but covered with greyish feathers in Red-necked Grebes
Slavonian x Black-necked Grebe	Koblik & Tsvetkov 1998	1994, fish-rearing farm in Moscow district, Russia; hybrid adult grebe caring for one chick; while the general constitution and the ornamental feathers of the parent's head reminded more a Black-necked Grebe, the red-brown colour of the lower neck and the rather massive bill recalled a Slavonian Grebe; half-grown chick lacked the usual striped pattern of the head and neck plumage; instead its upper parts were monotonous dark grey, its belly was white
	Dennis 1973	1972, Scotland; a Black-necked and a Slavonian Grebe cared for a chick; no obvious difference in appearance between the presumed hybrid pullus and the chicks of Black-necked Grebe pairs around was detected
Great Crested x Slavonian Grebe	Toon 2007	2006, central England; mixed breeding of a Great Crested and a Slavonian Grebe; four eggs in the nest; two chicks were predated shortly after hatching by a Great Cormorant *Phalacrocorax carbo*; the remaining two eggs did not hatch
Great Crested x Red-necked Grebe	Dvorak et al. 1993	Interbreeding reported from Austria in 1983, but the eggs did not hatch
	Van Dijk et al. 1994	In North-Brabant, in 1989, and in Friesland, in 1991, a mixed pair did not proceed to egg laying
Hooded x Silvery Grebe	Storer 1982	1982, Patagonia; pale headed hybrid female, apparently mated to a Hooded Grebe, but no successful nesting recorded; the hybrid between a Hooded and a Silvery Grebe was at least two years old; forehead and lores grey; black nape; anterior part of the crown whitish, blending with pale straw coloured plumes to the front; no sharp demarcation between head colours as in parental species, but mixing of straw coloured and black feathers; chin and throat grey; elongate feathers at the ears as in Silvery Grebes, but fewer, shorter and paler; no trace of a post ocular wattle; back dark grey as in Silvery Grebes; amount of white in wings intermediate between both parental species; six outer primaries dark; in the inner primaries, white confined almost entirely to inner web
Short-winged x Silvery Grebe	Fjeldså 1981, 2004	No records of interbreeding or mixed pairing, only observations of common penguin dancing
Western x Clark's Grebe	Eichhorst & Parkin 1991, Feerer & Garrett 1977, Konter 2009, 2011, 2012, Nuechterlein 1981a , 1981b, Nuechterlein & Buitron 1998, Nuechterlein & Storer 1982, Ratti 1979, 1981, Storer & Nuechterlein 1992	Occasional broods with both Western and Clark's young observed by Ratti may be the result of parasitic egg dumping or hybridization; observation of individuals displaying intermediate character traits recorded in many publications; mostly unusual black or white feathers in parts of face or colour of the bill not matching with plumage subdivision between white and blackish feathers

INSTRUCTIONS TO AUTHORS

Please check our internet site http://www.mnhn.lu for the latest version of these instructions!

Scope

FERRANTIA is a series of monographic works (20-250 pages in final layout) dealing with life and earth sciences, preferably related in some way or other to the Grand-Duchy of Luxembourg.

It publishes original results of botanical, zoological, ecological, geological, mineralogical, paleontological, geophysical and astrophysical research and related fields.

A complete issue of FERRANTIA may be devoted to several papers on a single topic as the responsibility of an invited editor.

Copyright

The submission of a manuscript to FERRANTIA implies that the paper must not have been accepted for publication or be under consideration elsewhere.

Copyright of a published paper, including illustrations, becomes the property of the publisher. Requests to reproduce material from FERRANTIA should be addressed to the editor.

Reviewing

Articles submitted for publication are reviewed by the editorial board and by one or two referees. The final decision on acceptance or rejection of the manuscript is taken by the editorial board. Manuscripts not prepared according to the following instructions to authors will be returned for correction prior to review.

Nomenclature

Papers with a systematic content should strictly follow the International Codes of Nomenclature.

Specimens

We recommend that the authors should deposit at least a part of the type material in the MNHN collections.

Publication dates

FERRANTIA pays special attention to publication dates, which are always specified to the day of publication.

Manuscripts

Manuscripts, without limitation of the number of pages, must conform strictly to the instructions to authors, and should be sent to the Editor:

FERRANTIA
Travaux scientifiques du Musée national d'histoire naturelle de Luxembourg
25, rue Munster
L-2160 Luxembourg

Format

Manuscripts must be submitted as paper copy in triplicate in A4 format, preferably double-spaced, with margins of at least 3 cm and all pages numbered.

If possible, an electronic version of the text may also be sent as unformatted Word document (PC or MAC) (font Times New Roman, 10 pt). Tables (Word, Excel) and figures (300 dpi in the page size of the journal) may also be sent electronically.

Structure

Papers are to be written in simple, correct and concise French, German or English. They should be organized as follows:

- a brief title (should not include the name of new taxa);
- a suggested running head (no more than 50 characters);
- name(s) and first name(s) of author(s), followed by their full address(es) and, if possible, e-mail or fax number;
- abstracts in English, French and German, each 200-800 words long; new taxa names should be included in the abstract; the abstract should be precise and descriptive, in order to be reproduced as such in data bases; avoid vague sentences such as "three new species are described" or "species are compared to species already known"; include precise differential characters;
- text of the article, in the following order: Introduction, Abbreviations used, Material and methods, Results and/or Observations, Discussion, Acknowledgements, References. The arrangement of the parts "Results/ Observations" and "Discussion" may be modulated according to the length and subject of the article; very long papers may include a table of contents;
- for systematic descriptions, each description should follow the order: name of taxon with author and date, synonymy, type material, etymology, material examined, distribution, diagnosis and/or description, remarks.
- description of geological features should include type level, type horizon, type locality. This order may be adapted according to the concerned groups: consult a recent issue of FERRANTIA;
- taxon names must be stated with author (and publication date, separated by a comma, where appropriate) at least once at the first mention. At subsequent mentions

of the same taxon, or other taxa of the same genus, the genus name may be abbreviated (*Rosa canina* L. to *R. canina*).

- use n. sp., n. gen., n. fam., etc. for new taxa;
- use italicized words only for taxa of generic and subgeneric ranks;
- use lowercase characters for authority names
- references to illustrations and tables should be indicated as follows: (Fig. 1), (Fig. a, d), (Fig. 2a-d), (Figs 3; 6), (Figs 3-5; Tab. 2); (Tab. 1); for German texts use Abb. instead of Fig.
- footnotes should not be used.

Tables and figures

Copies of all figures and tables should be included with the manuscript. They can be either included in the text at the correct locations with their legends or referenced in the text and included as annexes.

For printing all figures must be provided as separate image files in a convenient format and resolution (TIF or JPEG for photographs, GIF, PNG or TIF for graphs and figures).

The editorial board will pay special attention to the quality and relevance of illustrations. Colored illustrations are accepted where appropriate and necessary.

Line drawings must be in Indian ink or high quality laser printouts; high contrast Fotographs are required,

Illustrations can be grouped into composite plates the elements of which are identified by letters (a, b, c...). Plates are not placed at the end of the article: they will be considered as figures and numbered as such. Arrange figures to fit in one (70 x 200 mm) or two columns (144 x 200 mm) or one half page (144 x 100 mm). Letters, numbers, etc., for each figure, are to be indicated on an accompanying overlay, not on the original figure. They will be inserted by the printer. A scale bar is required for each figure, when appropriate. No diagram or table is to exceed one page; longer tables should be divided.

References

In main text, references to authors, in lower case, should be presented without comma before year, as follows: Smith (2001), Smith (2001, 2002), (Smith 2001), Smith et al. (2003), (Smith 2001; Jones 2002), (Smith & Jones 2003, 2005), (Smith, Jones & Johnson 2003), (Smith et al. 2003), Smith (2001: 1; 2003: 5), Smith (2001: fig. 2).

References should be presented as follows, in alphabetical order. Do not abbreviate journal names:

Høeg J. T. & Lützen J. 1985. - Comparative morphology and phylogeny of the family Thompsoniidae (Cirripedia: Rhizocephala: Akentrogonida) with description of three new genera and seven new species. Zoologica Scripta 22: 363-386.

Marshall C. R. 1987. - Lungfish: phylogeny and parsimony, in Bernis W. E., Burggren W. W. & Kemp N. E. (eds), The Biology and Evolution of Lungfishes, Journal of Morphology 1: 151-152.

Röckel D., Korn W. & Kohn A. J. 1995. - Manual of the Living Conidae. Volume 1: Indo-Pacific Region. Christa Hemmen, Wiesbaden, 517 p.

Schwaner T. D. 1985. - Population structure of black tiger snakes, *Notechis ater niger*, on off-shore islands of South Australia: 35-46, in Grigg G., Shine R. & Ehmann H. (eds), Biology of Australasian Frogs and Reptiles. Surrey Beatty and Sons, Sydney.

Gerecke R., Stoch F., Meisch C. & Schrankel I. 2005. - Die Fauna der Quellen und des hyporheischen Interstitials in Luxemburg unter besonderer Berücksichtigung der Milben (Acari), Muschelkrebse (Ostracoda) und Ruderfusskrebse (Copepoda). Ferrantia 41, Musée national d'histoire naturelle, Luxembourg, 140 p.

Proofs and reprints

Proofs will be sent to the author (or the first author) for correction and must be returned within two weeks by priority air mail. Authors will receive twenty-five reprints free of charge; further reprints can be ordered at a charge indicated on a form supplied with the proofs.

Page layout of final publication

paper size	170 x 240 mm
page size	144 x 200 mm
nomber of columns	2
column width	70 mm
space between columns	4 mm
top margin	22 mm
bottom margin	18 mm
inside margin	15 mm
outside margin	11 mm

Fonts

Body text: Palatino linotype (serif), 9pt

Titles, legends, headers, footers: Trebuchet (sans-serif)

Les volumes de la série FERRANTIA paraissent à intervalles non réguliers. Ils peuvent être consultés en ligne à l'adresse suivante:

http://www.mnhn.lu/ferrantia/

Adresse de courriel pour les commandes:

diffusion@mnhn.lu

LISTE DES NUMÉROS PARUS À CETTE DATE

Travaux scientifiques du Musée national d'histoire naturelle (1981-1999)

I Atlas provisoire des Insectes du Grand-Duché de Luxembourg. Lepidoptera. 1ère partie (Rhopalocera, Hesperiidae). Marc Meyer et Alphonse Pelles, 1981.

II Nouvelles études paléontologiques et biostratigraphiques sur les Ammonites du Grand-Duché de Luxembourg, de la Province du Luxembourg et de la région Lorraine attenante. Pierre L. Maubeuge, 1984.

III Revision of the recent Western Europe species of genus *Potamocypris* (Crustacea, Ostracoda). Part 1: Species with short swimming setae on the second antennae. Claude Meisch, 1984.

IV-1 Hétéroptères du Grand-Duché de Luxembourg: *Psallus (Hylopsallus) pseudoplatani* n. sp. (Miridae, Phylinae) et espèces apparentées. Léopold Reichling, 1984.

IV-2 Hétéroptères du Grand-Duché de Luxembourg: Quelques espèces peu connues, rares ou inattendues. Léopold Reichling, 1985.

V La bryoflore du Grand-Duché de Luxembourg: taxons nouveaux, rares ou méconnus. Ph. De Zuttere, J. Werner et R. Schumacker, 1985.

VI Revision of the recent Western Europe species of genus *Potamocypris* (Crustacea, Ostracoda). Part 2: Species with long swimming setae on the second antennae. Claude Meisch, 1985.

VII Les Bryozoaires du Grand-Duché de Luxembourg et des régions limitrophes. Gaby Geimer et Jos. Massard, 1986.

VIII Répartition et écologie des macrolichens épiphytiques dans le Grand-Duché de Luxembourg. Elisabeth Wagner-Schaber, 1987.

IX La limite nord-orientale de l'aire de *Conopodium majus* (Gouan) Loret en Europe occidentale. Régine Fabri, 1987.

X Epifaune et endofaune de *Liogryphaea arcuata* (Lamarck). Contribution à l'écologie des populations de *Liogryphaea arcuata* (Lamarck) dans le Sinémurien au NE du Bassin de Paris. Armand Hary, 1987.

XI Liste rouge des Bryophytes du Grand-Duché de Luxembourg. Jean Werner, 1987.

XII Relic stratified scress occurences in the Oesling (Grand-Duchy of Luxembourg), approximate age and some fabric properties. Peter A. Riezebos, 1987.

XIII Die Gastropodenfauna der "angulata-Zone" des Steinbruchs "Reckingerwald" bei Brouch. Hellmut Meier et Kurt Meiers, 1988.

XIV Les lichens épiphytiques et leurs champignons lichénicoles (macrolichens exceptés) du Luxembourg. Paul Diederich, 1989.

XV Liste annotée des Ostracodes actuels non-marins trouvés en France (Crustacea, Ostracoda). Claude Meisch, Karel Wouters et Koen Martens, 1989.

XVI Atlas des lichens épiphytiques et de leurs champignons lichénicoles (macrolichens exceptés) du Luxembourg. Paul Diederich, 1990.

XVII Beitrag zur Faunistik und Ökologie der Schmetterlinge im ehemaligen Erzabbau-gebiet "Haardt" bei Düdelingen. Jos. Cungs, 1991.

XVIII Moosflora und -Vegetation der Mesobrometen über Steinmergelkeuper im Luxemburger und im Bitburger Gutland. Jean Werner, 1992.

19 Ostracoda. Nico W. Broodbakker, Koen Martens, Claude Meisch, Trajan K. Petkovski and Karel Wouters, 1993.

20 Les haies au Grand-Duché de Luxembourg. Konjev Desender, Didier Drugmand, Marc Moes, Claudio Walzberg, 1993.

21 Ecology and Vegetation of Mt Trikora, New Guinea (Irian Jaya / Indonesia). Jean-Marie Mangen, 1993.

22 A checklist of the recent non-marine ostracods (Crustacea, Ostracoda) from the inland waters of South America and adjacent islands. Koen Martens & Francis Behen, 1993.

23 Ostracoda. Claude Meisch, Roland Fuhrmann, Karel Wouters, Gabriele Beyer and Trajan Petrovski, 1996.

24 Die Moosflora des Luxemburger Oeslings. Jean Werner, 1996.

25 Atlas des ptéridophytes des régions lorraines et vosgiennes, avec les territoires adjacents, Georges Henri Parent, 1997.

26 Evaluation de la qualité des cours d'eau au Luxembourg en tant qu'habitat pour la loutre. Groupe Loutre Luxembourg, 1997.

27 Notes Paléontologiques et Biostratigraphiques sur le Grand Duché de Luxembourg et les régions voisines. Pierre Louis Maubeuge & Dominique Delsate, 1997.

28 Die Moosflora der Kleinen Luxemburger Schweiz (Müllertal). Florian Hans, 1998.

29 Etude sur les genres *Globorilusopsis* Maubeuge, 1994 et *Simoniceras* n. gen. du Lias Supérieur du Grand-Duché de Luxembourg (Calyptoptomatida). Pierre Louis Maubeuge, 1998.

30 L'Ichthyofaune du Toarcien luxembourgeois. Cadre général et catalogue statistique. Dominique Delsate, 1999.

31 Proceedings of the 3rd European Batdetector Workshop. 16-20 August 1996 Larochette (Lux.). Christine Harbusch & Jacques Pir (eds.), 1999.

32 Les collections paléontologiques du Musée national d'histoire naturelle de Luxembourg. Fossiles du Trias et du Jurassique. Dominique Delsate, Chris Duffin & Robi Weis, 1999.

FERRANTIA (2002-)

33 Die Fledermäuse Luxemburgs (Mammalia: Chiroptera). Christine Harbusch, Edmée Engel, Jacques Pir, 2002.

34 The Protura of Luxembourg. Andrzej Szeptycki, Norbert Stomp, Wanda M. Weiner, 2003.

35 Liste rouge des bryophytes du Luxembourg. Jean Werner, 2003.

36 Paléontologie au Luxembourg. Simone Guérin-Franiatte (éd.), 2003.

37 Verbreitungsatlas der Amphibien des Großherzogtums Luxemburg. Roland Proess (éd.), 2003.

38 Trois études sur la Zone Rouge de Verdun. I. Herpétofaune. II. La diversité floristique. III. Les sites d'intérêt botanique et zoologique. Georges H. Parent, 2004.

39 Verbreitungsatlas der Heuschrecken des Großherzogtums Luxemburg. Roland Proess, 2004.

40 Les macrolichens de Belgique, du Luxembourg et du nord de la France - Clés de détermination. E. Sérusiaux, P. Diederich & J. Lambinon, 2004.

41 Die Fauna der Quellen und des hyporheischen Interstitials in Luxemburg unter besonderer Berücksichtigung der Milben (Acari), Muschelkrebse (Ostracoda) und Ruderfusskrebse (Copepoda). Reinhard Gerecke, Fabio Stoch, Claude Meisch, Isabel Schrankel, 2005.

42 Red List of the Vascular Plants of Luxembourg. Guy Colling, 2005.

43 Contribution à la climatologie du Luxembourg. Analyses historiques, scénarios futurs. Christian Ries (éd.), 2005.

44 Sandstone Landscapes in Europe - Past, Present and Future. Proceedings of the 2nd International Conference on Sandstone Landscapes. Vianden (Luxembourg) 25-28.05.2005. Christian Ries & Yves Krippel (eds.), 2005.

45 Additions et corrections au catalogue des plantes vasculaires de l'arrondissement de Montmédy. Etude sur l'évolution séculaire de la flore. Georges H. Parent, 2006.

46 Beiträge zur Paläontologie des Unterdevons Luxemburgs (1). Christian Franke (Hrsg.), 2006.

47 Verbreitungsatlas der Libellen des Großherzogtums Luxemburg. Roland Proess, 2006.

48 Les Hêtres tortillards, *Fagus sylvatica* L. var. *tortuosa* Pépin, de Lorraine, dans leur contexte européen. Georges H. Parent, 2006.

49 Inventaire minéralogique du Luxembourg - Stolzembourg, Schimpach, Goesdorf. Simon Philippo (éd.), 2007.

50 Inventaire de la biodiversité dans la forêt "Schnellert" (Commune de Berdorf) - Erfassung der Biodiversität im Waldgebiet "Schnellert" (Gemeinde Berdorf). Marc Meyer & Evelyne Carrières (éds.), 2007.

51 Proceedings of the first international Recorder conference. Luxembourg 2-3 December 2005. Tania Walisch (ed.), 2007.

52 Verbreitungsatlas der Reptilien des Großherzogtums Luxemburg. Roland Proess (éd.), 2007.

53 Les arbres introduits au Luxembourg. Inventaire des essences arborescentes non indigènes de pleineterre présentes sur le territoire du Grand-Duché de Luxembourg. Antoinette Welter, Jean Turk, Joé Trossen, 2008.

54 Fossils as Drugs: pharmaceutical palaeontology. Christopher J. Duffin, 2008.

55 Proceedings of the first conference on faunistics and zoogeography of European Trichoptera. Luxembourg 2nd - 4th September 2005. Marc Meyer & Peter Neu (eds.), 2008.

56 Colonial nesting in the Great Crested Grebe *Podiceps cristatus* (Linné 1758). Research results from a colony on the Dutch IJsselmeer in comparison to other studies on colonial nesting in the species. André Konter, 2008.

57 Die Waldgesellschaften Luxemburgs. Vegetation, Standort, Vorkommen und Gefährdung. Thomas Niemeyer, Christian Ries & Werner Härdtle, 2010.

58 Beiträge zur Paläontologie des Unterdevons Luxemburgs (2). Christian Franke (Hrsg.), 2010.

59 Proceedings of the 3rd international symposium Coleoid Cephalopods Through Time. Luxembourg 8th - 11th October 2008. Dirk Fuchs (editor), 2010.

60 Verbreitungsatlas der Zikaden Luxemburgs - Textband. Rolf Niedringhaus, Robert Biedermann, Herbert Nickel, 2010.

61 Verbreitungsatlas der Zikaden Luxemburgs - Atlasband. Rolf Niedringhaus, Robert Biedermann, Herbert Nickel, 2010.

62 Le Jurassique inférieur et moyen au Luxembourg - Nouvelles données paléontologiques et biostratigraphiques. Robert Weis & Simone Guérin-Franiatte (éds.), 2010

63 La Flore calcicole et basophile du Massif vosgien. Georges H. Parent, 2011.

64 Rearing of unionoid mussels (with special emphasis on the Freshwater Pearl Mussel Margaritifera margaritifera). Frank Thielen (editor), 2011.

65 Les bryophytes du Luxembourg - Liste annotée et atlas. The bryophytes of Luxembourg - Annotated list and atlas. Jean Werner, 2011.

66 Die Graslandgesellschaften Luxemburgs. Simone Schneider, 2011.

67 Comparative studies of behaviour in allopatric subspecies of Grebes, Podicipedidae. Black-necked Grebe *Podiceps nigricollis* (Brehm 1831) and White-tufted Grebe *Rollandia rolland* (Quoy & Gaimard 1824). André Konter, 2012.

68 Beiträge zur Paläontologie des Unterdevons Luxemburgs (3). Christian Franke (Hrsg.), 2012.

69 Die Höhlenfauna Luxemburgs. Dieter Weber (Hrsg.), 2013.

70 Verbreitungsatlas der Weberknechte des Großherzogtums Luxemburg. Christoph Muster & Marc Meyer, 2014.

71 Le Jurassique au Luxembourg (1) - Vertébrés, échinodermes et céphalopodes du Bajocien. Roby Weis & Ben Thuy (éds.), 2015.

72 Aberrant plumages in grebes Podicipedidae - An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide. André Konter, 2015.