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"Leucism resulting in xanthochroism" – A report on colour aberration in Coppersmith Barbet *Psilopogon haemacephalus* from Asia

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Abstract Plumage colouration is important for birds as it helps them in camouflage, mate selection, social signalling and various other physiological and behavioural processes. The most common pigments responsible for colouration are melanins and carotenoids. In a few individuals, colouration is disrupted due to various causes. The most common colour aberrations found in birds are leucism, albinism, melanism, carotenism, schizochroism and dilution whereas xanthochroism is a lesser-known phenomenon. In this article, five records of colour aberrant Coppersmith Barbet *Psilopogon haemocephalus* are reported. The authors along with the help of citizen scientists observed four individuals with disruptions in plumage colouration from different areas of West Bengal and Assam, India and one from Rajsahi, Bangladesh. Due to the lack of melanins, the birds were mostly yellowish and whitish in colouration with or without some normally coloured feathers on the head and wings. The carotenoid deposition was unaffected in the case of the observed adults and juveniles. These records can be cited as xanthochroistic individuals resulting from leucism. This is the first record of such colour aberration for Coppersmith Barbet from the whole of its distribution range.

Keywords: xanthochroism, carotenoids, melanin, Megalaimadae, India, Bangladesh

Összefoglalás A tollazat színezetének fontos szerepe van a madaraknál, mivel segíti őket a rejtőzködésben, a párválasztásban, a szociális kommunikációban és számos egyéb élettani, viselkedési folyamatban. A színezetért felelős leggyakoribb pigmentek a melaninok és a karotinoidok. Némely egyednél a színezet különböző okok miatt eltér a normálistól. A madaraknál előforduló színezeti aberrációk közt a legáltalánosabb a leucizmus, az albinizmus, a melanizmus, a karotenizmus, a skizokroizmus és a fakulás, míg a xantokroizmus egy kevésbé ismert jelenség. Tanulmányunkban a sárgatorkú bajszika *Psilopogon haemocephalus* színezetére vonatkozóan mutatunk be öt aberráns esetet. A szerzők „közösségi tudomány" (citizen science) segítségével négy egyedet figyeltek meg Nyugat-Bengália és Assam különböző területein, valamint egyet a bangladesi Rajsahiban. A melaninok hiánya következtében a madarak sárgás és fehéres színűek voltak, a fejükön és a szárnyaikon néhány normális színű tollal vagy anélkül. A karotinoid depozíciója a megfigyelt felnőtt és fiatal egyedek esetében nem változott. Ezek az esetek a leucizmusból eredő xantokroizmusnak tekinthetők. Ez a sárgatorkú bajszika első ilyen típusú színaberrációs észlelése a faj teljes elterjedési területén.

Kulcsszavak: xantokroizmus, karotinoidok, melanin, Megalaimadae, India, Banglades

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Introduction

Plumage colouration is of great importance for birds as it helps them in camouflage (Barragán-Farías *et al.* 2019), mate selection (Hill *et al.* 1999), social signalling (Senar 2006) and various other physiological and behavioural processes. The plumage colourations in birds are mainly formed by two distinct mechanisms, structures and pigments of which some colours are produced by combining different pigments whereas some are produced by the combination of structure and pigment (Laczi *et al.* 2019). All types of colourations are a result of both gene expression and environmental effects (Venizelos & Benetti 1999, Mills & Patterson 2009).

Occasionally, the normal plumage colouration is disrupted which results in new, aberrant phenotypes (van Grouw 2013). Plumage abnormalities are mainly caused by an abnormal distribution of pigments (present mainly in the feathers), chemical changes of the pigments, changes in the microstructure of feathers (Harrison 1985), environmental or dietary factors and also genetic mutations (Dorst 1971, Gonçalves Jr. *et al.* 2008). The most extreme variations of colour aberrations occur in those individuals who show noticeable reductions or increase in the normal colour causing pigments like the melanins or the carotenoids (Smith 2016). According to van Grouw *et al.* (2021) the different forms of colour aberrations noticed in case of birds include leucism (complete lack of both melanin pigments from some or all of the skin due to a neural crest disorder along with melanised eyes, pink bill and feet or normally coloured bill or feet), progressive greying (complete lack of both melanin pigments from some or all of the skin due to loss of melanins with growing age along with normally coloured eyes, pink bill and feet or normally coloured bill or feet), albinism (complete lack of both melanins in feathers, eyes and skin due to the absence of tyrosinase enzyme in the cells along with red eyes and pink feet and bill), brown (qualitative reduction of eumelanin only due to incomplete synthesis of eumelanin along with the original black colour turning into brown and the plumage bleaches rapidly in the sunlight), ino (reduction of melanin and qualitative reduction of the remaining melanins resulted due to incomplete synthesis of both the types along with original black colour turning into pale brown to dark brown and original reddish or yellowish hardly observed to be slightly paler), dilution (abnormal clumped deposition of both the melanins or only the eumelanin in feathers along with original black turning into bluish or silvery grey and original reddish or yellowish brown turning into buff /cream or remains unaffected), melanism (abnormal production and distribution of melanins resulting in increase of black and reddish brown colouration). There are mixed views regarding the proportion of occurrence of colour aberrations in wild birds. According to Gonçalves Jr. *et al.* 2008, plumage aberrations are not rare in wild birds, but the published documents and reports greatly underrate the proportion of occurrence. In another study conducted on Collared Flycatchers *Ficedula albicollis* by Laczi *et al.* 2020 for over four decades and with more than 40,000 birds monitored, albinism was seen only once which suggests that colour aberrations are quite rare in natural populations. In India, reports on the bird colour aberrations like leucism, melanism and albinism are not that uncommon, examples have been reported for Large Grey Babbler *Argya malcolmi* (Taher 2020), Red-necked Falcon *Falco chicquera* (Adaki *et al.* 2020), Spotted Owlet *Athene brama* (Pande *et*

al. 2005), Changeable Hawk-Eagle *Nisaetus cirrhatus* (Parashar & Sharma 2010), Lesser Sand Plover *Charadrius mongolus* (Sathiyaselvam 2003), Indian Peafowl *Pavo cristatus* (Yadav & Arigela 2020), Ashy-crowned Sparrow Lark *Eremopterix griseus* (Pawashe *et al.* 2006) and many others species of birds. Only a few records exist for colour aberrant birds from Bangladesh (Rahman 2018, Islam *et al.* 2020, Sultana *et al.* 2020).

Leucism is a condition with total absence of melanin pigments in either some portions or whole of the plumage and skin due to a neural crest disorder which results in the congenital absence of the melanin cells from some or all of the plumage area. Unlike albinos, the tyrosinase enzyme is generally present in leucistic individuals. Leucism can vary from a few white feathers (partially leucistic) to fully white individuals (total leucistic), but eyes are always has normal colour whereas the beak may or may not be normal (van Grouw 2006, 2021). It is the most common inheritable colour abnormality occurring in birds and is documented in a lot of species in the Indian subcontinent. Examples of leucistic individuals from India includes Jungle Myna *Acridotheres fuscus* (Nandy 2019), Indian Peafowl *Pavo cristatus* (Yadav & Arigela 2020), Kalij Pheasant *Lophura leucomelanos* (Thareja & Thareja 2017), Collared Kingfisher *Todiramphus chloris* (Adhikary & Mondal 2019), Garganey *Anas querquedula* (Karuthedathu *et al.* 2014), Indian Spot-billed Duck *Anas poecilorhyncha* (Raju 2017), House Sparrow *Passer domesticus* (Sankpal *et al.* 2019), Red-crested Pochard *Netta rufina* (Mahajan 2016), Brahminy Starling *Sturnia pagodarum* (Phalke 2020), etc. Leucism is also reported in birds from Bangladesh like in Eurasian Collared Dove *Streptopelia decaocto* (Islam *et al.* 2020), Western Koel *Eudynamys scolopaceus* (Rahman 2018) and partial leucism is observed in Common Redshank *Tringa totanus* (Sultana *et al.* 2020).

Another less common and lesser-known colour aberration found in birds is 'xanthochroism' (also known as 'xanthochromism' and xanthism') which occurs rarely in the case of wild birds. Though it is commonly found in caged birds like in some varieties of birds belong to the families Psittacidae and Fringillidae (Smith 1966). Xanthochroism is generally defined as a genetic or diet-induced abnormal condition that affects the carotenoid pigment expression, resulting in the red colouration to be replaced by yellow (Gómez *et al.* 2013). Gross (1965) defined this phenomenon as an abnormal colouration of the plumage, possibly related to food or some pathological conditions where yellow replaces the normal plumage colouration. Additionally, Schnell and Caldwell (1966) proposed that the definition of xanthochroism should not only include the conditions where excessive yellow pigments are present and they replace the red pigments, but also, the situations where the yellow colour is revealed due to the lack of melanin pigments. However, Hailman (1984) found xanthochroism to have no stable meaning and is used to name at least five different conditions starting from original simple yellow colouration, via any type of abnormal yellow colouration due to various factors, to yellow colouration that appears due to the loss of melanin. Recently, some articles refer only to the expression of abnormal orange-red-yellow colourations as xanthochroism (Quigley 2017, Stagličić 2019). Reports of xanthochroism is noticed from different parts of the world namely North America, South America, Africa, Australia but no such report is available till now from Asia. Records of this less commonly known colour aberration are noted in the case of Cape May Warbler *Setophaga tigrina* (Schnell

& Caldwell 1966), Yellow-faced Grassquit *Tiaris olivaceus* (Smith 1966), House Finch *Haemorhous mexicanus* (Barragán-Farías *et al.* 2019), Vermilion Flycatcher *Pyrocephalus rubinus* (Gómez *et al.* 2013, Smith 2016), Norfolk Robin *Pteroica multicolor*, Flame Robin *Pteroica phoenicea* (Wall 1966) and Northern Cardinal *Cardinalis cardinalis* (McGraw *et al.* 2003).

Colour aberration in the case of barbets is also noted but no such report is available for Coppersmith Barbet *Psilopogon haemacephalus* from India and Bangladesh, as well as from its other distribution zones. Thus, we report evidences of colour aberrations noted in the case of Coppersmith Barbet for the first time from India and Bangladesh.

Observation

This article is aimed to document a total of five observations of colour aberrant Coppersmith Barber from different locations of India and Bangladesh *(Figure 1)*. On 21 November 2018, while birding at Arjun Bandh area (23.54°N, 87.32°E) of Durgapur, Paschim Bardhaman district, West Bengal, India; the authors observed an abnormally coloured bird flying from one tree to the other. We took photographs of that abnormally coloured individual *(Figure 2A)*. The bird was identified as Coppersmith Barbet on the basis of its small size, shape, beak structure, flight patterns and call. The individual was not normal in colouration like that of the typical Coppersmith Barbet *(Figure 3)*. The size of the photographed specimen resembles a Coppersmith Barbet with similar red (or crimson) marking at forehead (including fore-crown) and breast. Overall colouration of the specimen shows pale yellowish-green colouration, which is nearly similar to the facial yellow

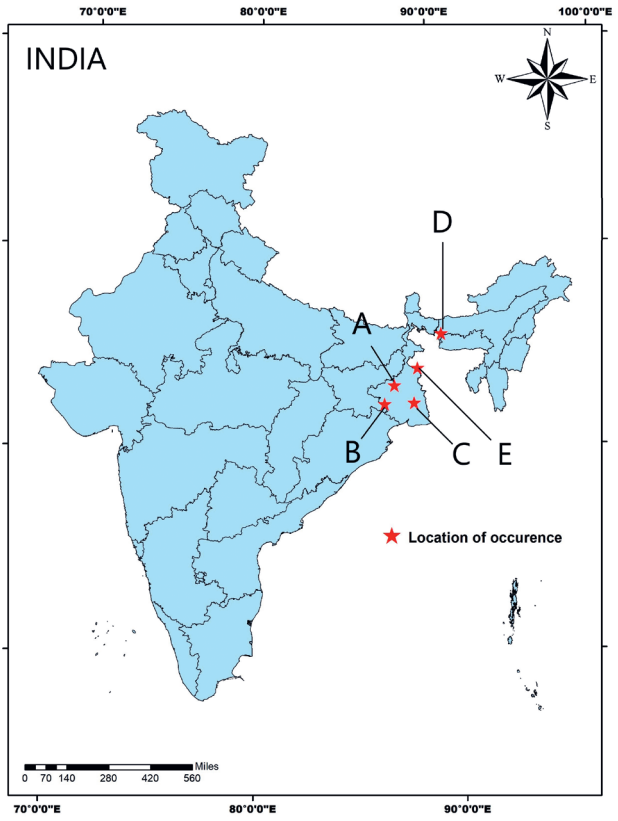

Figure 1. Relative location of the observations of the colour aberrant Coppersmith Barbets in the map of India. A: Durgapur, West Bengal, India; B: Belpahari, West Bengal, India; C: Bally, West Bengal, India; D: Lakhimari, Assam, India; and E: Rajshahi, Bangladesh

1. ábra A színaberráns sárgatorkú bajszika észleléseinek viszonylagos elhelyezkedése India térképén. A: Durgapur, West-Bengal, India; B: Belpahari, West-Bengal, India; C: Bally, West-Bengal, India; D: Lakhimari, Assam, India; és E: Rajshahi, Banglades

Figure 2. Photographs of colour aberrant Coppersmith Barbets recorded from India & Bangladesh. A: The adult with colour aberration photographed in Durgapur, West Bengal, India (Photo courtesy: Subhajit Roy); B: The adult with colour aberration photographed in Belpahari, West Bengal, India (Photo courtesy: Avik Dutta); C: The juvenile with colour aberration photographed in Bally, West Bengal, India rescued by Mana dada (Photo courtesy: Sriparna Dinda) [Source: https://www.facebook.com/groups/AskidsofIndianBirds/posts/1466737543464947/]; D: The adult with colour aberration photographed in Lakhimari, Assam, India (Photo courtesy: Tahijul Ali) [Source: https://www.facebook.com/groups/sundaywatch.org/posts/1488728064603351]; E: The colour aberrant adult photographed from Rajshahi, Bangladesh (Photo courtesy: Maroof Rana) [Source: https://www.facebook.com/groups/AskidsofIndianBirds/posts/2218427248295969/]

2. ábra Az Indiában és Bangladesben észlelt színaberráns sárgatorkú bajszikák fényképei. A: A Durgapurban (West-Bengál, India) fényképezett színaberráns adult (fotó: Subhajit Roy); B: A Belpahariban (West-Bengal, India) fényképezett színaberráns adult (fotó: Avik Dutta); C: A Ballyban (West-Bengal, India) fényképezett színaberráns fiatal (fotó: Sriparna Dinda) [Forrás: https://www.facebook.com/groups/AskidsofIndianBirds/posts/1466737543464947/]; D: A Lakhimariban (Assam, India) fényképezett színaberráns adult (fotó: Tahijul Ali) [Forrás: https://www.facebook.com/groups/sundaywatch.org/posts/1488728064603351]; E: A Rajshahiban (Banglades) fényképezett színaberráns adult (fotó: Maroof Rana) [Forrás: https://www.facebook.com/groups/AskidsofIndianBirds/posts/2218427248295969/]

Figure 3. Normal coloured individuals of Coppersmith Barbet. A: An adult (Photo courtesy: Sagar Adhurya); B: A juvenile (Photo courtesy: Saikat Adhurya) [Source: https://bdwb.wildwingsindia.in/share.php?id=B6VeBiPiMePshax4]

3. ábra Normális színezetű sárgatorkú bajszika. A: Adult (Fotó: Sagar Adhurya); B: Fiatal (fotó: Saikat Adhurya) [Source: https://bdwb.wildwingsindia.in/share.php?id=B6VeBiPiMePshax4]

colouration of a normal Coppersmith Barbet. The yellowish breast-line flanking below the red breast-line is as similar in colouration like a normal specimen. The most striking difference is the complete replacement of black facial pattern (continuous black line in normal specimen extending lore, eye stripe, moustachial stripe, hind crown and edges of ear coverts) with the white colouration. The breast is more or less uniform white instead of presence of broad olive-green streaking. The bill is pale whitish instead of blackish in normal. The leg is showing normal colouration. Though black colour is absent from the body, tail tip and tips of primaries strikingly showing expression of black colouration. These characters clearly indicate that the observed specimen was a colour aberrant individual.

After that on 10 November 2020, the fifth author observed another colour aberrant individual of the same species from Belpahari, Jhargram district in West Bengal (22.63°N, 86.76°E). The individual was identified as an adult based on the red colour patches on its crown and breast. Also, this individual shows exactly the same features as the first except it has some normal green coloured feathers in its wings and a little on its head. Additionally, it has some blue coloured feathers on its wings but the overall colouration on the body looks very similar to the other individuals *(Figure 2B)*.

Apart from our observations, three more similar kinds of colour aberrant individuals were recorded from India and Bangladesh. Sriparna Dinda and Mana Dada also rescued and photographed a third individual of the same species with similar condition in Bally, Howrah

district, West Bengal (22.65°N, 88.34°E) on 20 July 2019 posted it in Ask Ids of Indian Birds Facebook group for its identification (Patra 2019) *(Figure 2C)*. The identification was confirmed as a juvenile [refers to young bird having different colouration than adult, not 'juvenal' plumage (Bostwick 2016)] of Coppersmith Barbet having abnormal yellow colouration. This individual shows exactly the same features as the first except it has no red coloured patches in its crown and breast and also the overall colouration is more yellowish than the other two individuals. The juvenile normal Coppersmith Barbet also shows no red marking in its body *(Figure 3B)*. So, this bird was identified as a juvenile colour aberrant specimen.

Tahijul Ali photographed another individual of Coppersmith Barbet with abnormal yellow colouration from Lakhimari Village, Dhubri district, Assam, India (26.02°N, 89.97°E) on 5 January 2019 (Patra 2019) *(Figure 2D)*. The individual shows similar colouration as the second individual except the absence of blue-coloured wing feathers. So, this individual was identified as an adult.

Maroof Rana also photographed an individual of the same species with aberrant colouration from Rajsahi, Bangladesh (24.37°N, 88.60°E) on 27 November 2021 (Rana 2021) *(Figure 2E)*. This individual is also an adult as it has red colour patches on its crown and breast and for the rest of the body it shows similar kind of colouration like that of the second individual.

Discussion

Coppersmith Barbet is a widespread resident across Asia, occurring in the mainland of Asia starting from Pakistan and Sri Lanka in the west to south China and Indochina in the east and south into the Malay Peninsula. It can also be found in the islands of Sumatra, Java and Bali (Dickinson *et al.* 1991). It generally prefers woodlands, grooves and forests but can also be found in gardens and orchards of the urban areas where there is plenty of fruiting trees. They mainly take fruits (especially figs, *Ficus* spp.) as their main food resource, but sometimes also take insects (Short & Horne 2001, Grimmett *et al.* 2011). Two colour morphs are known for this species across their distribution zone. One is the red colour morph in which the face and throat are mostly red coloured alongside the red forehead and a red patch below the throat and its distribution is restricted only to Java, Bali and some Philippine islands. Another one is the yellow colour morph where the face and the throat is yellow coloured alongside the red forehead and a red patch below the throat and is found over most of its distribution zone (den Tex & Leonard 2014).

In the case of birds, black, grey, rufous and brown colours are associated with the two varieties of melanins (eumelanin and pheomelanin) whereas yellow, red and orange colours are produced by the carotenoids (Olson & Owens 1998, Jawor & Breitwisch 2003). The greenish tone in the plumage of many bird results from either the combination of these two classes of pigments or from the combination of pigment and structural properties of the feathers (Dyck 1976, Guay *et al.* 2012). So the normal green colour in the plumage of both adult and juvenile Coppersmith Barbet is probably the product of the conjugated effects of melanins and carotenoids. The red colour on the forehead and chest (present only in adults

and absent in juveniles) and the yellow colour on the face and throat in both adults and juveniles are the results of carotenoid pigmentation. However, the black coloured facial pattern and the dark beak are the results of melanin pigmentation. Though the facial and throat colour varies between the two kinds of colour morphs, but the variation in plumage colouration exhibited by the observed individuals is totally different and cannot be found in any of the previous literature.

The specimens in *Figure 2A, 2B, 2D* and *2E* were the adult individuals because of the presence of red forehead and red patch in the chest. The remaining specimen *(Figure 2C)* was a juvenile because it lacks the red colouration on forehead and chest. All the individuals not only lacked the normal olive-green colouration on the body, they also lacked blackish facial colouration, olive green streaks on the abdomen and dark coloured beak. These areas mostly had yellowish green or whitish tones, as did much of the body. The changes were such that the colour patterns were hardly recognizable for a Coppersmith Barbet. This can be due to the fact that melanin pigments are absent in those individuals. The olive-green streaking pattern on the underside of the body was also absent and an off-whitish colouration replaced it in all the observed individuals. Again, in the facial regions, the blackish pattern is replaced by white and the beak also appeared paler in comparison to a normal individual. But the colours caused by the carotenoid pigments in the case of a normal individual (red in forehead and chest and yellow in the face and throat) are present in their normal position in these individuals. Thus, the noticeable absence of the green colour from the plumage, unmasking of the yellow colouration, absence of black colour from the face and beak and the appearance of the red colouration in their normal positions without any changes supports the absence of the melanin in these individuals. As the birds simply lack one or the other or both the types of melanins on its plumage, and they consistently fail to produce it, certainly qualifies them as leucistic following the definitions of Guay *et al.* (2012).

But according to the definitions of xanthochroism provided by Gross (1965) and Schnell and Caldwell (1966), these reports certainly qualify also as an example of xanthrochroism too, as here the yellow colour replaces the original plumage colouration and is unmasked due to the lack of melanin pigments. Thus, we can say that it is an example of leucism resulting in xanthochroism in case of Coppersmith Barbet.

The birds having this kind of colour aberrations face a lot of hardship in the wild. As these birds are more conspicuous than the normal individuals, the risk of predation could be greatly increased. These abnormal conditions could also make them more susceptible to feather weakening, which can also hamper the flight (Harrison 1985). Additionally, it is also reported that these colour aberrant individuals, in occasional cases, may not be accepted by its potential mating partner and are harassed by its conspecifics (Smith & Rios 2017). Though we could only note its weak flight pattern but could not study whether the other conditions are also true for the individuals observed by us. So, a more detailed and prolonged study on the colour aberrant individuals in India is sure to unveil various new information about them.

Colour aberrations is known from only two varieties of barbets, namely in Black-collared Barbets (albinism, Blaker 1980; xanthochroism, Davies & Symes 2012) and Great Barbets (albinism and xanthochroism, Short & Horne 2001), but no report is available for colour

aberrations in the Coppersmith Barbet from any part of its distribution zone including India and Bangladesh. Thus, the present report represents the first record of colour aberration in the case of Coppersmith Barbets from the India and Bangladesh as well from its whole distribution zone.

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