

Research paper

Rare colour morphs in the slow worm *Anguis fragilis* in NorwayBeate Strøm Johansen¹ and Pål Sørensen²

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The frequency of melanism in *Natrix natrix* and *Vipera berus* is known to be high in the Nordic countries. However, melanism in the slow worm *Anguis fragilis* has previously never been documented in Norway. Here, for the first time, melanism, amelanism, and erythrism in the slow worm in Norway is documented by photographs. There are several observations of erythristic or partly erythristic slow worms with various degrees of red colour as this depends on the amount of erythrocytes in the skin. This leaves some uncertainty about what could be named an erythristic slow worm based on field observations. We used the software CorelDRAW Graphics Suite for the RGB colour profile at the photographs of the slow worms as an extra support for the assessment of reddish colour. Because the photographs were taken under different light conditions and with different cameras, we could not make a defined threshold value to separate normal coloured brown and grey slow worms from erythristic slow worms using this RGB system. However, the RGB values support our visual observations.

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INTRODUCTION

In terms of pigmentation, there are several factors affecting the colour of the skin. Genetic mutations may cause failed production (hypopigmentation) or overproduction of pigments (hyperpigmentation) in the skin chromatophores of animals. Ectothermic vertebrates, such as amphibians and reptiles, have three distinct chromatophore types in three layers in the skin, named melanophores (brown, black), xanthophores (red, yellow) and iridophores (shiny, reflecting) (Bechtel 1991). Non-melanin pigments in reptiles are produced by cells called xanthophores, including erythrophores. The pigments, pteridines (red) and carotenoids (yellow), may play a major role in the colouration of reptiles even when melanin is not present, as in amelanism.

Amelanism is lack of melanin pigments normally caused by loss of tyrosinase function. Lacking melanins, amelanistic reptiles still have other functional pigments, and the absence of black pigment may have variable effects on the remaining colours and the animals may appear red or yellow (Borteiro *et al.* 2021). The lack of pigmentation in the iris allows the blood vessels within the eye to be seen, and the eyes will be red or pink.

Albinism is lack of melanin and all functional chromatophores. An albino individual appears all-white with red eyes. The presence of several types of chromatophores makes true albinos rare among reptiles (Borteiro *et al.* 2021). Albino animals may be confounded with leucistic individuals, but the eyes of leucistic animals are dark in colour. Leucism is a strong reduction or loss of all pigment types in skin cells, while melanin is still produced in the eye (Bechtel 1995). Eye colour is one of the more reliable ways to determine which colour anomaly an animal displays (Allain *et al.* 2023) and should always be used as one of the criteria.

Melanism is an increased production of melanin caused by melanocytes in the skin, and the animals are black to varying degrees (Bechtel 1995). Melanism is not uncommon in snakes from northern Europe, especially in *Vipera berus* and *Natrix natrix* in Norway (pers. obs.; Andrén & Nilson 1981; Fritz & Ihlow 2022), and melanism is a particularly common colour aberration in reptiles (Allain *et al.* 2023). In certain areas melanism may be regarded as a common colour morph.

Erythrism is red colouration caused by overproduction of

erythrophores (producing red and orange pigments) in the skin, and there are variations in intensity (Moore & Ouellet 2014). While the inheritance of red colour is controlled by a single set of alleles, the quantity of red is under control of multiple alleles (Bechtel 1978).

While melanism is one of the most reported colour aberrations in reptiles (Allain *et al.* 2023), other colour aberrations are rarely observed in wild reptiles, especially in secretive species like the slow worm *Anguis fragilis* (Linnaeus, 1758), a legless lizard. The slow worm is a common reptile species in Norway distributed from Bergen in the west, southward along the coast eastwards to the border of Sweden, and northwards in the inland valleys until Vinstra (Artsdatabanken, 2025). Although the species has a variable coloration from pale grey to dark red-brown and dark brown, sometime with blue spots in males (Elven & Johansen, 2024), colour aberrations (e.g. albinism/amelanism, melanism or erythrism) are generally rare in this species. Here, we present these three colour abnormalities in *A. fragilis* for the first time from Norway.

MATERIALS AND METHODS

Through field work, the authors have recorded reptile species in the Kristiansand area, southern Norway and in the Oslo area for up to 40 years. During the years 2021–2024 approximately 1500 hours of field work were performed. In addition, observations are reported to us by citizens. This paper is based on own observations of one amelanistic slow worm and one completely black melanistic slow worm, two slightly reddish slow worms, as well as photographs of two red erythristic juvenile slow worms provided by others. Jablonski *et al.* (2022) mention that the assessment of a colouration red and reddish underlies subjective variations in their paper about erythristic *Natrix* species, where they proposed a useful method to make a standard for what colour is present on photographs of the snake's body, using CorelDRAW Graphics Suite software. Using that program, we measured the RGB (Red, Green, Blue) colours on photographs of both normal coloured, the amelanistic, the melanistic, and various red coloured slow worms (Table 1) to investigate whether it might be possible to find a limit value for red colouration that was clearly different from the normal coloured slow worms. We mainly measured the dorsal colouration in the photos. The RGB system works as follows: the range of the intensity goes from 0 to 255, meaning that 255 is the highest intensity and 0 being the lowest intensity. Pure red colouration will have values (255, 0, 0), with red at its maximum intensity (100%). Adding all three colours at their maximum intensity (255, 255, 255) will give the colour white, while totally black colour has values (0, 0, 0). A melanistic slow worm would thereby get RGB values near 0, and albino slow worms would get the three RGB values close to 255. If the red value is dominant compared to the other two, the colour will appear more red. RGB colours can also be called hexadecimal colours abbreviated as hex-colours. The hex-colour is written with # and a 6-digit code combining letters and numbers, which makes these codes easily integrated into the software code in software design. Since the light conditions and white balance are not consistent because all the photos have been taken in different conditions and with different equipment, the colour measures will not be accurate or may prove directly comparable.

To better assess the prevalence of colour aberrations in Norwegian *A. fragilis* we have inspected 229 photographs of *A. fragilis* from Norway on iNaturalist.org (<https://www.inaturalist.org/places/norway#taxon=26036>), an online social network presenting wildlife

photos. We also inspected 1258 photographs of *A. fragilis* from Norway on www.artsobservasjoner.no, an online national Norwegian data bank for species registrations, on 21st October 2024 for all observations.

RESULTS AND DISCUSSION

Amelanistic slow worm

On 15th September 2021 a neonate amelanistic slow worm was found by the first author under a piece of chipboard at Møvik Fortress in Kristiansand, southern Norway (58°5'51.95845" N 7°57'48.54466" E). It measured 10.2 cm in total length and weighted 00.55 grams, which is the normal size of newborn Norwegian slow worms (pers. obs.). The eyes were red, some reddish pigmentation appeared in the skin, and the dorsal stripe and the dark sides were visible. Larger blood vessels and inner organs were visible through the ventral side (Figure 1 a, b, c). Based on the definitions of albinism and amelanism by Borteiro *et al.* (2021), this is an amelanistic slow worm, and the only whitish (meaning albino/amelanistic/leucistic/hypomelanistic) slow worm from Norway to our knowledge. Albino or amelanistic slow worms are reported from Great Britain (Knight 1966) and France (Robert *et al.* 1965), and four leucistic slow worms with dark eyes are reported from Great Britain (Jablonski & Purkart 2018, Harkness & Allain 2020). Allain *et al.* (2023) found that albinism was the most reported chromatic anomaly in the herpetofauna of the British Isles, although several of these reports may not concern true albino individuals, but also amelanistic, leucistic or hypomelanistic due to inconsistency in term use.

The light colours of amelanistic individuals imply they are running a higher risk of predation. Lack of melanins in the skin also make them vulnerable to UV radiation.

Melanistic slow worm

On 23rd June 2024 an adult female melanistic slow worm (Figure 2) was found by the second author at Svestad, Nesodden near Oslo (59°46'41.0648" N 10°35'42.57518" E). While melanistic adders *Vipera berus* and grass snakes *Natrix natrix* are common in Norway (pers. obs.) this is the first truly melanistic slow worm recorded in Norway. Melanistic slow worms are reported from several locations in Sweden (Tommie Lundstedt, Daniel Iglesias, Lin Johanna Rylander, pers. comm.), from The Netherlands (Struijk 2007), England (Gleed-Owen 2012) and the French Pyrenees (Eduardo Fernández, pers. comm.). Based on these few reports, we cannot see a clear pattern of increasing prevalence of melanism among slow worms towards the northern pole, as is the case for the adder and grass snake (Jansen *et al.* 2024, Fritz & Ihlow 2022). Melanism is generally regarded as a thermoregulatory advantage for ectotherms in cold environments. Exposed to solar radiation, black animals are shown to heat up faster than normal coloured ones (Forsmann 1995). However, an increased risk of predation is also seen (Andrén & Nilson 1981). The slow worm is a secretive species spending most of its life hidden in vegetation or under objects. The advantage and disadvantage of melanism may be reduced under such conditions. In the common lizard *Zootoca vivipara* melanism is rare but widespread within the species' distributional range. A higher prevalence in cold environments is not seen (San-Jose 2008, Recknagel *et al.* 2018). Nahrung & Allen (2005) suggest that melanism could be controlled by neutral alleles in some species giving neither advantage nor disadvantage to survival or reproduction. As a result, such alleles are maintained at a constant low level in the

populations, a situation possibly relevant for both the slow worm and the common lizard in Norway.

Adders and grass snakes normally become melanistic with age because of accumulation of melanin. The situation regarding ontogenetic development of melanism in *A. fragilis* is not known. Melanism is possibly more frequent than widely supposed since recognition needs that the observer is familiar with the species' normal colour range (Bechtel 1995; Borteiro *et al.* 2021), and

potentially black slow worms may not be recognized as slow worms and therefore are underreported.

Erythristic slow worms

On 17th August 2024 a young erythristic slow worm (Figure 3) was found in a potato field by Karin Helen Skipø on the island Hidra in Flekkefjord, southern Norway (58°12'58.04127" N 6°34'42.49018" E). The colour was bright red and there was no doubt that this specimen



Figure 1 a. Amelanistic juvenile slow worm *Anguis fragilis* with red eyes, from Kristiansand, southern Norway 15th September 2021. Photo: Beate Strøm Johansen; Figure 1 b. Amelanistic juvenile slow worm *Anguis fragilis* from Kristiansand, southern Norway 15th September 2021. Photo: Beate Strøm Johansen; Figure 1 c. Amelanistic juvenile slow worm *Anguis fragilis* from Kristiansand, southern Norway 15th September 2021. Note the transparent belly with visible inner organs. Photo: Beate Strøm Johansen.



Figure 2. Melanistic slow worm *Anguis fragilis* adult female at Nesodden near Oslo, Norway 23rd June 2024. Photo: Pål Sørensen.

was substantially more red than normal colouration and we define this specimen as erythristic. Two medium sized reddish specimens (Figure 4) were found on 29th July 2007 by the first author on the mainland of Flekkefjord, at Svege farm (58°17'22.68419" N 6°38'44.59693" E). Another reddish juvenile slow worm (Figure 5) was found by Tarald Reinholt Aas the 18th of August 2024 in Homme, Lindesnes (58° 03'42.4" N 7°17'53.9" E), southern Norway. These individuals we classify as having a tendency towards erythrism. The juvenile from Homme was more bright towards orange than the two older, medium sized individuals from Svege farm. We find slightly reddish slow worms in Norway from time to time, but since erythrism is a variable degree of red pigmentation, it is questionable when we may label them as erythristic. This is the case with individual Figure 6 in Table 1, a slow worm from Oslo with only slightly more red colour than the normal warm brown colour. We do not define this individual as erythristic, but it has a weak tendency towards erythrism.

Erythristic slow worms are reported from Sweden (Iversen 1999) and England (Allain *et al.* 2023) and from these few published cases it appears that erythristic slow worms are rare in Europe. However, the lack of a quantitative assessment tool to tell if a reddish slow worm is erythristic or within the normal colour regime might be the cause of this, as observers might be unsure about the erythristic status.

As in melanism, an ontogenetic variation in the amount of red pigmentation might be seen. The fact that most highly red specimens in our study are young animals indicate an ontogenetic reduction in red pigments or rather an increase in covering melanins. The conspicuousness of erythristic slow worms may increase the risk of predation, contributing to the rareness of this colour aberration,

despite the fact that the slow worms spend most of their time under vegetation or objects. In early spring the individuals may be found heating up in the sun openly (own observations), and also at this time of the year the vegetation cover is less. We may imagine that a bright red colour may be more susceptible for predation at this time of the year.

Test of software

We tried to establish an objective method for categorising a specimen as erythristic, using the CorelDRAW Graphics Suite software, reading the red, green and blue intensity in the photographs. The RGB values as well as the Hex codes are presented in Table 1. We have included also normal coloured slow worms in this table to demonstrate how the RGB values differs between normal grey or brown individuals, to reddish, black or white aberrations. As expected the RGB values of the whitish amelanistic individual (Figure 1) were all over 200 towards the maximum of 255 that is white. The melanistic slow worm (Figure 2) had all three RGB values at 3, which means that this individual is truly very black. For an object to be perceived as red, the R value should be significantly higher than the G and B values. The slow worms in Figures 3, 4 and 5 are more red than normal based on our eye perception of the photos, and according to Table 1 the R values are 2–4 times higher than the G and B values for these three individuals. The reddish female in Figure 6 also has R values mainly as the double of G and B, but all the values are lower than the slow worms in Figure 3 and 5. The values for the slow worms in Figures 4 and 6 are quite similar, showing R values the double of G and B values. However, the latter is also true for the deep brown female in Figure 8, which also has



Figure 3. Erythristic slow worm *Anguis fragilis* from island Hidra in Flekkefjord, southern Norway 17th August 2024. Photo: Karin Helen Skipø; Figure 4. Reddish slow worm *Anguis fragilis* of medium size from Svege farm, mainland Flekkefjord, Southern Norway 29th July 200. Normal coloured slow worm in the background. Photo: Beate Strøm Johansen; Figure 5. Reddish juvenile slow worm *Anguis fragilis* from Homme in Lindesnes, Southern Norway 18th August 2024. Photo: Tarald Reinholt Aas; Figure 6. Reddish slow worm *Anguis fragilis* 26th May 2020 inner Oslo fiord, Bunnefjorden. Photo: Pål Sørensen.

Table 1. *Anguis fragilis* color variants in Norway. CorelDraw Graphics Suite software RGB (Red, Green, Blue) measures of photographs.

Figure Nr.	Sex, age	Color	Spot on body	R (Red)	G (Green)	B (Blue)	Hex	Location
Fig 1	Neonatal	Whitish, amelanistic	Head top, on white spot	207	221	204	#CFDDCC	Kristiansand
Fig. 2	Female, adult	Black, melanistic	Back, side, shadow	3	3	3	#030303	Oslo
Fig.3	Unknown, juvenile	RED, erythristic	Back, top, rear end	234	107	64	#EA6B40	Hidra, Flekkefjord
Fig. 3	Unknown, juvenile	RED, erythristic	Tail, top	253	109	46	#FD6D2E	Hidra, Flekkefjord
Fig. 4	Unknown, adult	Reddish, tendency erythrism	Back, top	177	84	66	#B15442	Svege, Flekkefjord
Fig. 4	Unknown, adult	Reddish, tendency erythrism	Back, Top	171	96	91	#AB605B	Svege, Flekkefjord
Fig. 5	Unknown, juvenile	Reddish, tendency erythrism	Back, top	231	158	143	#E79E8F	Homme, Lindesnes
Fig. 5	Unknown, juvenile	Reddish, tendency erythrism	Back, top, rear end	232	165	149	#E8A595	Homme, Lindesnes
Fig. 6	Female, juvenile	Reddish, not erythristic	Back, top	169	87	49	#A95731	Oslo
Fig. 6	Female, juvenile	Reddish, not erythristic	Neck, top	161	87	60	#A1573C	Oslo
Fig. 7 a	Female, adult, mating	Brown-grey, normal	Back, top	184	139	118	#B88B76	Oslo
Fig. 7 a	Female, adult, mating	Brown-grey, normal	Back, top	169	125	100	#A97D64	Oslo
Fig. 7 b	Male, adult, mating	Grey	Back, top	226	209	199	#E2D1C7	Oslo
Fig. 7 b	Male, adult, mating	Grey	Back, top	219	202	194	#DBCAC2	Oslo
Fig. 8	Female, adult	Deep brown	Back, top	116	74	49	#744A31	Kvisle, Kristiansand
Fig. 8	Female, adult	Deep brown	Back, top	122	85	59	#7A553B	Kvisle, Kristiansand
Fig. 9	Male, adult	Grey, pale	Back, top	130	125	119	#827D77	Kristiansand
Fig.10	Male, adult	Pale	Head, top	192	153	122	#C0997A	Svege, Flekkefjord
Fig.10	Male, adult	Pale	Head, top, neck	234	199	177	#EAC7B1	Svege, Flekkefjord



Figure 7 a, b. Mating couple of slow worm *Anguis fragilis* on 27th May 2021 Inner Oslofiord, Bunnefjorden. Female (Figure 7 a) has a more brown colour than the pale grey male (Figure 7 b). Photo: Pål Sørensen; figure 8. Dark brown female slow worm *Anguis fragilis*. 7th September 2020. Kvislevann, Kristiansand, Southern Norway. Photo: Beate Strøm Johansen; figure 9. Slow worm *Anguis fragilis* male adult 8th April 2019. Kvislevann, Kristiansand, southern Norway. Photo: Beate Strøm Johansen; figure 10. Large and pale male slow worm *Anguis fragilis* 1st May 2018 at Svege farm, Flekkefjord, southern Norway. Photo: Beate Strøm Johansen.

R values about the double of G and B. The pale males in Figures 9 and 10 have quite similar and high R, G, and B values as expected, since these resemble whitish colour and we expect the three colour values to approach the maximum of 255 as white would be. For the mating couple in Figure 6, the paler male has higher values of all three colours than the more brown female, as expected.

The shiny skin of the slow worm is highly reflective. Body parts in different angles reflect light differently causing specifically B values to vary significantly over the body. Setting limits for RGB values to categorise erythrism is therefore difficult. We consider the CorelDRAW Graphic Suite software a supportive tool in categorising erythristic animals but still leaving the assessment with a subjective element.

The inspection of a total of 1487 photos of *A. fragilis* on iNaturalist and Artsobservasjoner did not reveal any photos of albino/white, melanistic or erythristic individuals, and this supports our impression that these colour aberrations in *A. fragilis* are very rare in Norway.

CONCLUSION

Melanism and amelanism are rare colour aberrations in *A. fragilis* in Norway, both are here recorded for the first time, and only one individual of each colour morph. The many hours of reptile field work of the two authors in two regions of Norway indicate that these colour aberrations are rare, and not only underreported by the public. Red pigments are normal elements of skin colouration in *A. fragilis*. Setting a distinct limit for what should be categorised an erythristic animal, using the software CorelDRAW Graphic Suite, was not successful. From our observations of four reddish individuals, the erythristic colour morph or animals with tendency towards erythrism are the most common among the aberrant colour morphs in *A. fragilis* in Norway. Three of the four reddish *A. fragilis* were observed in Southern Norway in Lindesnes and Flekkefjord, and only one in Oslo which is 425 km to the north-east of Flekkefjord along the road. From this limited data we may speculate that the reddish colour morph is more widespread in the southern part of Norway. We question if the red colour is becoming less bright red with increasing age in *A. fragilis*, hopefully future chromatic research will shed light on this. Because of the secretive life of *A. fragilis* and the preference for heating up under objects and vegetation, we do not think that the different colour aberrations are more subject to predation. We hope that future field work and photographs by citizen science will shed more light on the frequency and regional distribution of different colour aberrations of *A. fragilis* in Norway. Through this study, we might contribute to increased knowledge about colour variants of *A. fragilis* in Norway, hopefully encouraging the public to poste more photos of reptiles.

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