

On the occurrence of a golden colour variant in the Common Spadefoot Toad, *Pelobates fuscus* (Laurenti, 1768), in the state of Saxony, Germany

Mischa Lauterbach^{1,*}, Judith Adam¹, Leonard Bolte^{1,2}, Sandra Paule¹, and Timm Reinhardt^{1,3}

Colour abnormalities are a commonly observed phenomenon in herpetofauna, which often receives lots of attention (Pastors and Greven, 2016; Henle et al., 2017; Marushchak et al., 2021). The skin of amphibians typically gains its colouration from the interplay of three types of cells. Xanthophores contain yellow or brownish pigments, iridophores contain iridescent platelets that reflect light, and melanophores contain black or dark pigments (Henle et al., 2017; Gould and McHenry, 2024). Studies in the axolotl, *Ambystoma mexicanum* (Shaw and Nodder, 1798), demonstrated that mutations can influence each of the pigment cell types to alter the phenotype (Frost et al., 1984). Phenotypes that are light in colour are lacking the dark pigment melanin or the distribution of this pigment is impaired. The term albino herein refers to individuals in which all types of pigments are absent (narrow definition, cf. Henle et al., 2017), whereas amelanistic individuals only lack melanin, but the other pigments are expressed normally. Both these phenotypes typically have red eyes and are often referred to as “albino”. Amelanistic individuals typically feature patterns like the wild type that are just lacking the dark components. These individuals may appear reddish, orange, or yellow depending on the type and amount of pigment present, which is why this condition is known as chromatic albinism. When the colouration is yellow, it is also referred to as flavinistic albinism in some vertebrates such as reptiles, while true albinos are completely white (Devkota et al., 2021).

Additionally, in amphibians there is a developmental condition that disturbs the distribution of pigment cells in the skin resulting in a white, basic colouration. Such individuals lack a pattern but have dark or blue eyes and sometimes a freckle-like pattern on the head and back (Benjamin, 1970).

The Common Spadefoot (*Pelobates fuscus*) is a naturally variable species (Bisping and Kraskes, 2016). The typical colouration is a blotched pattern of grey, brown, and red spots that is more pronounced on the lower back and lower head region. The pupils are dark brown with an amber or golden iris. The colouration can range from very light grey with just slightly mottled patterns, almost black with just a few cream-coloured and red spots, or mostly brownish red with pronounced grey markings. Juveniles typically feature a more vivid pattern of darker markings divided by lighter stripes on the back. The belly is white or grey with few spots. The tadpole is mostly greyish with some dark and iridescent spots rather evenly distributed along the body and the tail fin with a herringbone pattern along the tail as a species diagnostic characteristic. Tadpoles are amongst the largest European amphibian larvae, normally reaching 8–10 cm or more before metamorphosis.

Some potentially genetic colour variants have been described in the scientific literature, such as a strikingly greenish individual (Kazimirski, 2020), a mostly red individual (Kolenda et al., 2017), or a cream-coloured and blackish individual (Bisping et al., 2016). The existence of “albino” and “white” individuals is mentioned in the monographic and grey literature (e.g., Nöllert, 1984; Andreone, 2006), yet a complete description of tadpole and resulting metamorph phenotype is lacking in the scientific literature. Here we provide a comprehensive assessment of a golden colour aberration, most likely amelanism, in *P. fuscus*. The individual was found as a larva and raised through metamorphosis (Fig. 1), so the phenotype of both the tadpole and the resulting metamorphic individual is described herein.

¹ Molekulare Evolution und Systematik der Tiere, Institut für Biologie, Universität Leipzig Talstrasse 33, 04103 Leipzig, Germany.

² Department Naturschutzforschung, UFZ – Helmholtz-Zentrum für Umweltforschung, Permoserstrasse 15, 04318 Leipzig, Germany.

³ Fachgebiet Zoologischer Artenschutz, Bundesamt für Naturschutz, Konstantinstrasse 110, 53179 Bonn, Germany.

* Corresponding author. E-mail: mischa.lauterbach@web.de



Figure 1. Amelanistic, golden *Pelobates fuscus* from Saxony, Germany, at the age of 11 months post-metamorphosis. Photos by Leonard Bolte.

Origin of the tadpole. The colour-aberrant *P. fuscus* tadpole was discovered on 22 May 2024 during an amphibian monitoring activity at Krippelwasser, an oxbow of the Mulde River in Kollau, Thallwitz Municipality, Leipzig District, Saxony, Germany (51.4317°N, 12.6556°E). The monitoring is primarily focussed on Fire-Bellied Toad (*Bombina bombina*) populations in this formerly near-natural floodplain area. *Pelobates fuscus* and *B. bombina* are syntopic with Smooth and Great Crested Newts (*Lissotriton vulgaris*, *Triturus cristatus*, respectively), waterfrogs (genus *Pelophylax*), European Treefrogs (*Hyla arborea*), brown frogs (*Rana temporaria*, *R. arvalis*, *R. dalmatina*), and Common Toads (*Bufo bufo*). Newts and tadpoles were collected using Ortmann's funnel traps over a period of 24 h (Drechsler et al., 2010), as was the golden *P. fuscus* tadpole. A similarly coloured tadpole of *P. fuscus* was caught in 2020 in the same area (Kathrin Garlichs, pers. comm.). The individual we collected in 2024 is the first for which we could document the entire development systematically. For comparison, two typically coloured *P. fuscus* tadpoles were caught in the same water body a few days later and raised alongside the colour aberrant tadpole.

Husbandry and development. The larvae were kept in a glass aquarium (17 x 25 cm) filled with water from the site of origin and conditioned (i.e., stale) tap water to achieve a water level of about 20 cm. It was placed inside a heated room nearby a window to allow for a normal day-night cycle and a constant temperature of 18–20°C. One third of the water was replaced at five- to seven-day intervals to remove accumulated detritus. To provide shelter and remove excess nitrogen from the

water, each tank was equipped with a cutting of Golden Pothos (*Epipremnum aureum*) and Water Trumpet (*Cryptocoryne* sp.).

Tadpoles were fed a mixture of different commercially available tadpole foods and algal pellets (Ben's Jungle Tadpolefood – powder, containing cereals, yeast, fish and fishery byproducts; and Lucky Reptile Quappo – pellets, containing algae). Live *Daphnia* were also accepted by the larvae. Length and weight of all three tadpoles were measured in two- to three-day intervals (Fig. 2). Three weeks post-capture, as the front legs broke through the buccal cavity, tadpoles were relocated to larger glass aquaria (29 x 29 cm) to complete metamorphosis. These aquaria had a lower water level (< 10 cm) and some rocks to enable the metamorphs to leave the water. Five weeks after collection, all larvae had completed metamorphosis (Fig. 2) and started exhibiting burrowing behaviour. All juveniles were transferred to a common terrarium with 15 cm of substrate, a mixture of soil and sand, some retreats and a water bowl. Metamorphs were fed with micro and small House Crickets, *Acheta domesticus*.

Description of colour-aberrant spadefoot tadpole and metamorph. The colour-aberrant tadpole had a mostly yellowish-golden colouration with some iridescent spots on the body and tailfin (Fig. 3A–C) with light pink eyes. The typical herringbone pattern on the tail was lighter compared to tadpoles with typical colouration (Fig. 4A–C; E–G).

No noteworthy difference in developmental speed, lengths, weight increase, or developmental timing could be observed between the golden and typically coloured tadpoles. The golden tadpole appeared

somewhat more sensitive to light and spent more time hiding than the other two larvae. However, these behavioural differences were not quantified. After metamorphosis, the colour aberrant spadefoot toad featured a predominantly light yellow to white colouration. A light pattern of four larger patches

divided by a line occurred on the back. Additionally, it featured some reddish and yellowish spots on the lower back and legs and pinkish white eyes. The overall pattern and distribution of reddish, yellow, and iridescent pigments appeared normal except for the lack of dark pigments (Fig. 1).

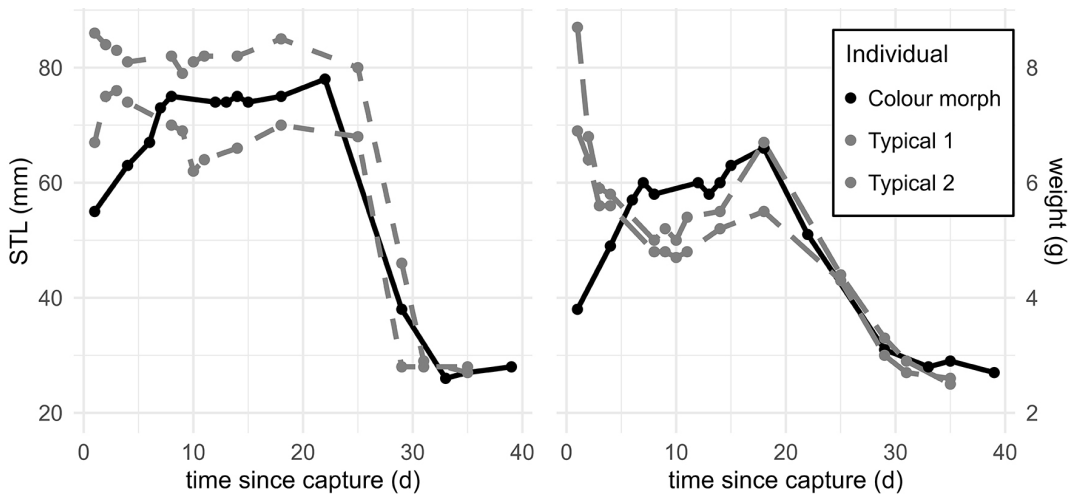


Figure 2. Length and weight development of three *Pelobates fuscus* tadpoles from Saxony, Germany, before metamorphosis. The colour aberrant individual (black line) is shown in comparison with two typically coloured individuals (grey lines).

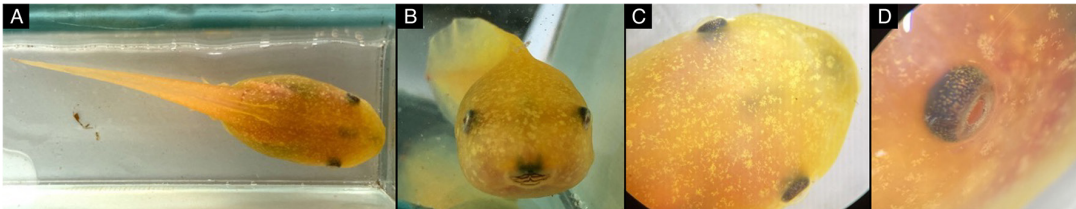


Figure 3. Colour-aberrant tadpole of *Pelobates fuscus* from Saxony, Germany, in (A) dorsal, (B) cranial, and (C) dorsal head views (5x magnification). (D) Detail view of the left eye (10x). Photos by Mischa Lauterbach.

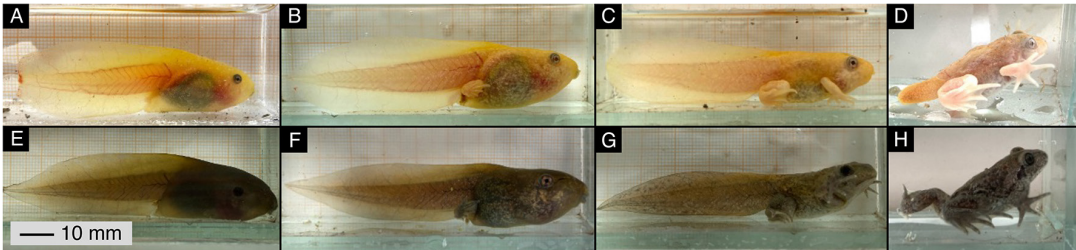


Figure 4. Tadpoles of *Pelobates fuscus* from Saxony, Germany, at different developmental stages, including metamorphosis. We compare the golden colour variant (A–D) and typical individuals (E–H). Photos were taken at 2 days post capture (A, E), 16 days (B, F), 23 days (C, G), 30 days (D), and 33 days (H). Photos by Mischa Lauterbach.

The behaviour of the atypical metamorph was comparable to that of typically coloured conspecifics. All individuals spent a significant time underground and emerged only sporadically to feed, mostly at night or in the morning. When fed separately with crickets, the golden individual reacted later to the prey's movement and had a lower success rate ingesting prey compared to the normally coloured individuals. We attribute this to either an impairment in vision or a higher light sensitivity. The golden individual spent more time active on the soil surface compared to the normally coloured individuals where it was also more conspicuous, probably to compensate for the lower hunting success rate.

Discussion

Comparing the golden *P. fuscus* individual to its normally coloured conspecifics and other species for which colour morphs are formally described, we conclude that our individual is a true colour mutant outside of the typically diverse range of appearance in the species. The individual featured a normal pattern with iridophores present in the larval stage and both yellow and red colouration was present after metamorphosis. Dark pigments were absent, and the eye colour was pinkish red. This makes it plausible to assume that amelanism is the likely cause for the colour aberration (Pastors and Greven, 2016; Henle et al., 2017). The specimen was thus not a true albino, which would mean complete absence of all pigments.

Nöllert (1984) featured two pictures (also Berger, 1977) of white *P. fuscus*, both of which appear to have dark eyes and are lacking a recognisable pattern. These would be considered leucistic individuals (Henle et al., 2017; Marushchak et al., 2021). Nöllert (1984) also remarked that these colour morphs can be induced by removing the anterior pituitary gland or by specific feeding of the tadpoles. This makes it likely that the "albinos" described by Freytag (1956) were in fact developmental abnormalities. Wolterstorff (1932) and Juszczak (1974) seem to be describing a similar colour morph to the individual we observed.

We do not know how common white or golden colour variants are in wild populations of *P. fuscus*. Our observation was a rare occurrence in an opportunistic monitoring event (one individual amongst 98 *P. fuscus* tadpoles in 15 traps). Wolterstorff (1932) reported 13 'albinotic' tadpoles amongst 'thousands' of normally coloured individuals. Likewise, in another project conducted approximately 45 km southwest of Kollau,

we only found a single clutch of partly white hatchlings of *Epidalea calamita* (Laurenti, 1768) (Fig. 5), while the other 1315 clutches detected in three years seemed normally pigmented. However, we could not track their development. Thus, we cannot confirm whether they became pigmented in later stages (transient albinism). Golden and white post-metamorphs have been observed in populations of several amphibian species (Henle et al., 2017). As in our cases, rates of albinism were generally low (less than 0.01%). The scientific literature refers to sometimes considerably higher rates, though these were primarily reported from radioactively contaminated areas (Henle et al., 2017).

It is likely that colour aberrant individuals occur more frequently amongst freshly hatched tadpoles. However, in natural habitats, the survival of such light-coloured variants is strongly reduced due to colour morphs being more conspicuous to predators (Childs, 1953). Thus, white or golden individuals might only survive to metamorphosis or even adulthood under very few circumstances.

Pelobates fuscus is considered an endangered species (Rote-Liste-Gremium Amphibien und Reptilien, 2020) in Germany, but the conservation status varies between western and eastern populations. In the eastern German states like Saxony, *P. fuscus* is common, reflecting its distribution focus in the continental regions of Eurasia (Dufresnes et al., 2019) where the species is of Least Concern (Krása et al., 2024). Due to the healthy population of the species at our field site, we have no reason to assume that the occurrence of this colour-aberrant individual is indicative for genetic issues, such as inbreeding. However, monitoring the prevalence of atypical specimens in populations could provide further insights on the genetic processes which might be ongoing in currently declining and increasingly fragmented amphibian populations.

Acknowledgements. All work was conducted in accordance with permit 364.620/61/5/3, issued by the Umweltamt/SG Natur- und Landschaftsschutz, Landratsamt Landkreis Leipzig. We thank Sebastian Steinfartz and Ronny Wolf for their logistical support and supervision as well as Svenja Degebrodt for temporarily taking care of the tadpoles. Special thanks to Hinrich Kaiser and Wolfgang Böhme for providing us with the difficult to obtain grey literature.

References

- Andreone, F. (2006): *Pelobates fuscus* (Laurenti, 1768): In: Atlante degli Anfibi e dei Rettili d'Italia [Atlas of Italian Amphibians and Reptiles], p. 292–297. Sindaco, R., Doria, G., Razzetti, E., Bernini, F., Eds., Florence, Italy, Edizioni Polistampa.



Figure 5. White to grey hatchlings of *Epidalea calamita* found in July 2023 in the lignite mining site Profen in Saxony, Germany. Photo by Leonard Bolte.

- Berger, H. (1977): Beobachtungen an albinotischen Knoblauchkröten (*Pelobates f. fuscus*) aus dem Raum Wurzen. Faunistische Abhandlungen, Staatliches Museum für Tierkunde Dresden **6**(17): 215–217.
- Benjamin, C.P. (1970): The biochemical effects of the d, m, and a genes on pigment cell differentiation in the axolotl. *Developmental Biology* **23**(1): 62–85.
- Bisping, M., Göcking, C., Kraskes, F., Menke, N., Thiesmeier, B. (2016): Farbanomalien bei Larven der Knoblauchkröte. *Feldherpetologisches Magazin* (6): 15–19.
- Bisping, M., Kraskes, F. (2016): Die Knoblauchkröte (*Pelobates fuscus*): Verbreitung, Biologie, Ökologie, Schutzstrategien und Nachzucht. LANUV-Fachbericht 75. Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen, Recklinghausen, Germany.
- Childs, H.E., Jr. (1953): Selection by predation on albino and normal spadefoot toads. *Evolution* **7**(3): 228–233.
- Devkota, K., Mandal, D.N., Kaiser, H. (2021): First report of flavinistic albinism in the checkered keelback, *Fowlea piscator* (Schneider, 1799), from Nepal. *Herpetology Notes* **14**: 185–187.
- Drechsler, A., Bock, D., Ortmann, D., Steinfartz, S. (2010): Ortmann's funnel trap – a highly efficient tool for monitoring amphibian species. *Herpetology Notes* **3**(1): 13–21.
- Dufresnes, C., Strachinis, I., Tzoras, E., Litvinchuk, S.N., Denoël, M. (2019): Call a spade a spade: taxonomy and distribution of *Pelobates*, with description of a new Balkan endemic. *ZooKeys* **859**: 131–158.
- Freytag, G.E. (1956): Weitere Naturfunde albinotischer Amphibien. *Der Zoologische Garten (NF)* **21**(5/6): 383–385.
- Frost, S.K., Briggs, F., Malacinski, G.M. (1984): A color atlas of pigment genes in the Mexican axolotl (*Ambystoma mexicanum*). *Differentiation* **26**(1–3): 182–188.
- Garlichs, K. (2020): Amphibien-Monitoring am Beispiel der Rotbauchunke (*Bombina orientalis*) in ausgewählten Teichen der Muldenaue des Landkreises Leipziger Land [Amphibian monitoring on the example of the fire-bellied toad (*Bombina orientalis*) in selected ponds of the Mulde floodplain in the district of Leipziger Land]. Unpublished BSc thesis, Universität Leipzig, Leipzig, Germany.
- Gould, J., McHenry, C. (2024): It's not easy being green: comparing typical skin colouration among amphibians with colour abnormalities associated with chromatophore deficits. *Ecology and Evolution* **14**(5): e11438.
- Henle, K., Dubois, A., Vershinin, V. (2017): A review of anomalies in natural populations of amphibians and their potential causes. *Mertensiella* **25**: 57–164.

- Juszyzyk, W. (1974): *Plazy i gady krajowe. Cz. 2, Plazy* [Amphibians and Reptiles. Part 2. Amphibians]. Warsaw, Poland, Państwowe Wydawnictwo Naukowe.
- Kazimirski, P.P. (2020): An unusually coloured individual of the common spadefoot toad *Pelobates fuscus* (Laurenti, 1768). *Fragmenta Faunistica* **63**(2): 137–140.
- Kolenda, K., Najbar, B., Najbar, A., Kaczmarek, P., Kaczmarek, M., Skawiński, T. (2017): Rare colour aberrations and anomalies of amphibians and reptiles recorded in Poland. *Herpetology Notes* **10**: 103–109.
- Krása, A., Avci, A., Tuniyev, B., Cogălniceanu, D., Mizsei, E., Ficetola, F., et al. (2024): *Pelobates fuscus*. The IUCN Red List of Threatened Species 2024: e.T196236126A228187875.
- Marushchak, O.Y., Nekrasova, O.D., Tytar, V.M., Smirnov, N.A., Korshunov, O.V., Pupins, M., et al. (2021): A GIS approach to the study of colour anomalies in amphibians of Ukraine reveals the deleterious effect of human impacts. *Herpetology Notes* **14**: 1239–1251.
- Nöllert, A. (1984): *Die Knoblauchkröte*. Wittenberg, Germany, A. Ziemsen Verlag.
- Pastors, J., Greven, H. (2016): Die schwierige Klassifizierung von Farbabweichungen bei einheimischen Amphibien. *Feldherpetologisches Magazin* (5): 8–15.
- Rote-Liste-Gremium Amphibien und Reptilien (2020): Rote Liste der Tiere, Pflanzen und Pilze Deutschlands: Amphibien. *Naturschutz und Biologische Vielfalt* **170**(4): 1–86.
- Wolterstorff, W. (1932): Rotäugige Albinos der Knoblauchkröte (*Pelobates fuscus*) bei Linz a. Donau. *Blätter für Aquarien- und Terrarienkunde* **43**: 388–389.