REPTILES & AMPHIBIANS

Color Aberrations of Reptiles and Amphibians from Montenegro

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Phenotypic adaptation is an evolutionary process that enhances survival in a prey species such as amphibians (Michimae 2006), reptiles (McLean et al. 2014), mice (Hoekstra et al. 2005), fish (Stevens et al. 2014), and invertebrates (Cuthill et al. 2005). Animal colors have evolved to serve different adaptive functions, including camouflage, thermoregulation, warning or startling predators, and communicating with conspecifics (Pérez i de Lanuza and Font 2016). Chromatophores are pigment-containing cells in the skin of ectothermic animals such as amphibians and reptiles (Taylor and Hadley 1970), so polymorphism in skin color is associated with these cells. Any changes related to these cells can lead to abnormal coloration that includes melanism, albinism, axanthism, cyanism, erythrism, hypomelanism, and leucism.

Melanism, when affected individuals are black in color, often is considered the opposite of albinism, which is characterized by the absence of pigmentation (Allain et al. 2023). Axanthism is described as the lack of xanthophores, erythrophores, and iridophores in the skin, leaving animals unable to reflect red, orange, and yellow light (Jablonski et al. 2014). Cyanism is characterized by individuals being a vibrant blue and is possibly caused by a proliferation of cyanophores in the skin (Allain et al. 2023). Erythrism leads to the color of affected animals being red due to an excessive deposition of erythrophores (which produce red and orange pigments) in the skin, with various shades and degrees of intensity possible (Moore and Ouellet 2014). Hypomelanism is a condition characterized by reduced pigmentation, and affected animals typically have impaired visual acuity (Balkema and Dräger 1991). Leucism is characterized by a partial loss of pigmentation, resulting in white or pale coloration; affected individuals can superficially resemble albinos but their eyes are dark (Bechtel 1991).

Various color abnormalities in herpetofauna have been documented and described by, for example, Gvozdenović and Schweiger (2014), Jablonski et al. (2014), Kolenda et al. (2017), Borteiro et al. (2021), Fănaru et al. (2022), and Allain et al. (2023). Color abnormalities such as melanism are more frequent in cooler climates where the body tends to warm up faster than in lighter individuals (e.g., Hodges 2008; Iković et al. 2014; Nash et al. 2016). Although, natural selection usually eliminates aberrations (Andrén and Nilson 1981),

Figure 1. An unusual color pattern in a European Treefrog (*Hyla arborea*) from Montenegro. Photograph by Aleksandar Simović.

Figure 2. An unusual color pattern in a Yellow-bellied Toad (*Bombina variegata*) from Montenegro. Photograph by Vuk Iković.

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instances are known when individuals or even populations characterized by aberrant coloration survive and reproduce (Jablonski et al. 2014).

Few color abnormalities of amphibians and reptiles from Montenegro have been described. To the best of our knowledge, only melanism in *Natrix natrix*, *Natrix tessellata*, and *Zootoca vivipara* has been documented (Gvozdenović and Schweiger 2014; Iković et al. 2014). We herein report abnormal color patterns in *Hyla arborea*, *Bombina variegata*, *Dinarolacerta mosorensis*, and *Zamenis situla* from typical habitats in Mediterannean and Alpine biogeographical regions in Montenegro. The discovery of affected individuals was incidental during authors' various field activities or, in the case of *Z. situla*, information was provided by local fisherman Miloš Ćetković (see Acknowledgements).

We encountered a single European Treefrog (*Hyla arborea*) with brown skin and dark spots (Fig. 1) on a cool (<10 °C), cloudy day in "Orjenska lokva" (42.55782, 18.55181; elev. 1,586 m asl), a pond that is one of the largest permanent bodies of water in the area around Sedlo, Orjen, Herceg Novi. That area is characterized by alpine grasslands on a carbonate substrate. Despite high annual precipitation, the region is quite dry and permanent bodies of water are rare due to the permeable substrate (Nature Park Orjen 2024). *Hyla arborea* typically has a green dorsum that enables it to blend into vegetation (Pinto et al. 2013), although color can vary depending on temperature and time of day (Speybroeck et al. 2016) or on substrate or background coloration (Nielsen 1980). Koren and Jelić (2011) reported different color patterns, including a brown type, in *H. arborea* from various locations in Croatia; Đorđević et al. (2016) recorded European Treefrogs with grayish gound color as well as nearly black individuals with "golden" lateral stripes in Vojvodina Province, Serbia; and Zimić and Agović (2018) documented 16 color patterns in *H. arborea* from various locations in Bosnia and Herzegovina, including a brown type. All the above authors noted that green was the dominant ground color in *H. arborea*.

We encountered a single Yellow-bellied Toad (*Bombina variegata*) with an intense bright-green dorsum and hardened warts with black tips (Fig. 2) during a warm (~28 °C) sunny day in a stream running through oak-hornbeam forest in Kuljače, Paštrovići, Budva (42.28096, 18.90244; elev. 324 m asl). According to Speybroeck et al. (2016), *B. variegata* typically has a light to dark brown or grayish dorsum with scattered warts, occasionally with hardened black tips. A green dorsum appears to be very rare. Deschandol (2024) included in a Flickr photostream a photograph by Frank Canon of a green *B. variegata* from Montenegro, but without a precise location. The typically cryptic dorsal coloration of Yellow-Bellied Toads is known to blend into the natural environment and appears to provide protection from avian predators (Preißler et al. 2021). About 20 other individuals found in the stream with the bright green toad had the usual dorsal coloration.

We found a single Mosor Rock Lizard (*Dinarolacerta mosorensis*) with a bright green dorsum and dark spots (Fig. 3) basking on a rock during a sunny day (ca. 21 °C) in Komarnica, Kozarica, Šavnik (43.03304, 19.04523; elev. 1,029 m asl). The area is characterized by grasslands on a carbonate substrate and oak, hornbeam, and beech forests, in both of which Mosor Rock Lizards occur where rocks are present. The dorsum in *D. mosorensis* typically varies from a uniform pale gray to chocolate brown, sometimes with small dark spots. The back also can be shiny (Speybroeck et al. 2016). Coloration in lizards has biological functions such as mimicry, warning signals, sexual dimorphism, and mate selection, and some of the factors that can affect color include sex, temperature, ontogenetic state, the color and season of the environment, state of excitation, physical condition, and

Figure 3. An unusual color pattern in a Mosor Rock Lizard (*Dinarolacerta mosorensis*) from Montenegro. Photograph by Vuk Iković.

lighting (Smith 1995). We were unable to find any similar color aberrations in *D. mosorensis* in the literature, so we suspect that this variant is rare. Color abnormalities in various lizard species have been reported; melanism, cyanism, and hypomelanism in *Zootoca vivipara* (Gvozdenović et al. 2014; Kolenda et al. 2017; Allain et al. 2023); albinism, melanism, axanthism, leucism, piebaldism, and hypomelanism in *Anguis fragilis* and erythrism in *A. fragilis* and *Lacerta agilis* (Allain et al. 2023), and “aberration punctato-lineata” in *L. agilis* , a dorsal pattern consisting of dark spots often surrounded by white or light rings (Jablonski et al. 2017). Piebaldism, also known as partial or regional albinism, is characterized by a series of non–patterned, unpigmented (white or pale) spots distributed on a pigmented background and without any change in eye color (Kornilios 2014). Such patterns are highly variable and can change depending on the sex, age, and season (e.g., Kotenko and Sviridenko 2010; Jablonski et al. 2017).

Miloš Ćetković (see Acknowledgements) encountered a single European Ratsnake (*Zamenis situla*) with black-bordered longitudinal lines and a few small reddish blotches on a gray dorsal ground color but lacking typical reddish transverse blotches or longitudinal lines and black markings on the head (Fig. 4) on a sunny day (~15 °C) in Zagora, Platamuni, Kotor (42.30416, 18.73299; elev. 67 m asl). This area is characterized by maquis, a thick scrubby evergreen underbrush of Mediterranean shores. According to Spaybroeck et al. (2016), dorsal ground color in *Z. situla* is gray, yellowish, or beige with either black-bordered reddish transverse blotches or longitudinal lines, and rows of black and sometimes red blotches on each flank; black markings on the head include Y-shaped markings on the back of the head often extending between the eyes, a black streak from the corners of the mouth extending toward the upper posterior edges of the eyes, a black bridle between the eyes, and black blotches under the eyes.

Figure 4. An unusual color pattern in a European Ratsnake (*Zamenis situla*). Photograph by Miloš Ćetković.

We were unable to find any cases in the literature of a pattern similar to that of the *Z. situla* from Zagora; consequently, we believe that such a pattern, which could be a form of partial axanthism, is rare. Only a few cases of axanthic amphibians and reptiles have been discovered in nature (Jablonski et al. 2014; Cattaneo 2015; Kolenda et al. 2017; Cavalcante and Bruni 2018; Borteiro et al. 2021; Schluckebier et al. 2022; Allain et al. 2023). An additional note of interest is that this snake was encountered during the winter (20 December 2020). Winter activity in reptiles is well documented, but it appears to be more common in lizards than in snakes and turtles (e.g., Gvozdenović Nikolić et al. 2024). However, according to Altunişik and Kara (2021), climate change is affecting winter activity in reptiles. The last several winters in Montenegro were very warm (Institute of Hydrometeorology and Seismology 2024), and climate projections showed increases in mean winter temperature of 2–2.5 °C (Dragojević 2020); consequently, an increasing frequency of observations of winter-active reptiles is not surprising — and such incidents are likely to become more common in the future.

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