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Unusual colour and pattern variation of *Lacerta agilis* (Squamata: Lacertidae) recorded from Central Europe

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Abstract. An unusual colour and pattern variation recorded in female of *Lacerta agilis* Linnaeus, 1758 is reported from Slovakia. The individual was examined and its coloration was compared with published data. According to these data the individual was classified as a case similar to aberration *punctato-lineata* that was so far known in eastern subspecies *L. a. exigua* Eichwald, 1831. Such classification of morphs/aberrations in high polymorphic species is, however, questionable and should be taken with caution. Possible causes of this rare colour and pattern variation are discussed.

Key words: Sand lizard, aberration, geographic variability, pattern polymorphism, Pannonian Plain.

Running title: Unusual colour and pattern variation of *Lacerta agilis*.

The colouration of animals plays an important role in predator avoidance (through crypsis, mimicry or aposematism; Sweet 1985), thermoregulation, inter- and intraspecific communication or sexual selection (e.g., Roulin & Bize 2006). One of the most colour and pattern variable species is Central European sand lizard, *Lacerta agilis* Linnaeus, 1758, with number of described subspecies, morphs and variations (Kotenko & Sviridenko 2010, Blanke & Fearnley 2015). The normal colouration of this species is brown in females and juveniles in dorsal parts and yellowish in their underside. Males are vivid green in their flanks on the side of the head and legs especially during mating season. Both sexes contain black spots on their underside and possess white and dark brown to black dorsal and flank colouration. This colouration consists of small white, black edged spots (ocelli), which are usually arranged, in one to three longitudinal rows along flanks. The diversity in pattern colouration for *L. agilis* (for review see Kotenko & Sviridenko 2010) affords the species great crypsis (camouflage). Moreover, there are many records of colour aberrations caused by lack/excess of specific types of pigment cells (erythrism, melanism, hypomelanism, flavinism, leucism; Blanke & Fearnley 2015, Moravec 2015). According to Lác (1968), so-called aberrations (morphs) *erythronota*, *immaculata*, *melanota* and *dorsalis* were recorded in Slovakia where *erythronota* is probably the most common.

During the fieldwork conducted on 19 July 2016 in the state Nature Reserve Kopáč located in suburban area of Bratislava, Slovakia (Pannonian Plain; 48.095°N, 17.162°E, 130 m elevation), we observed and captured one adult female of *L. agilis* Linnaeus, 1758 (subspecific status unknown due to mismatch between morphology and genetics in the region; Andres et al. 2014) with snout-vent length about 70 mm (Fig. 1). The locality consists of gravel-sand substrate and has a xerothermic character with habitat of *Festucion valesiacae* and *Asparago-Crataegetum* (Fig. 2). The captured individual was found during a warm summer evening (26°C, around

20:00) under an old fallen tree in a shrub environment. The individual was possibly a few weeks after oviposition and was noticeable at first sight because of its lack of pattern colouration (Fig. 1). Its ground colour was light brown in dorsal part and monochrome yellow in ventral part. However, dorsal blotches and ocelli on the flanks were markedly reduced to single white dots, partially bound by small black dots (Fig. 1). A belt of scattered small black dots extended from the head to the tail. These dots were dense in the dorsal part and rarer towards the ventral parts. Two lighter wide bands occurred at the boundary of dorsal and lateral parts of the body. Dots on limbs were not present. The typical spotted dorsal head pattern, was lighter. After photography, the individual was released at the site of capture. Three normally coloured individuals (juveniles) of *L. agilis* were also found at the locality. During the following three visits at the locality in summer 2016 no other similarly coloured individuals were observed. We have never recorded such a coloured individual, despite observing approximately 300 sand lizards during last ten years in Central Europe (see Fig. 3 for examples of colour and pattern variation of the species in Slovakia).

Is it difficult to classify any colour and pattern variation without experimental histochemical or developmental tests. How such variation is produced has not been well-studied, but it is almost certainly in most cases a result of polygenic control (i.e. where phenotypes are controlled by a large number of non-allelic genes; Nadeau 2016). This is certainly known to be the case in some Lepidoptera. In any large population, in which colour and pattern phenotypes are determined in this way, there will be a more-or-less continuous spectrum of variation with extreme forms which have arisen solely as a result of stochastic processes during recombination.

Despite limited black coloration in the pattern, our case is not represent a case of hypomelanism recorded at the species (Gvoždik 1999, Blanke & Fearnley 2015). Melanin was

visible, at least in some melanophores, though minimal in number, in the normally pigmented eyes and small black dots on the body (Fig. 1). In the past surveys, similarly coloured individuals with monochromatic colouration and small black or white dots were rather called as "morpha *virescens*" or aberration *immaculata* (Štěpánek 1949, Opatrný 1992). It is not even case of aberration *concolor* (e.g. Bischoff 1984), found particular in the Caucasus and rarely observed across Europe (Suchow 1948, Baranov et al. 1976, Blanke & Fearnley 2015, Moravec 2015). Such animals are without any patterning of the body, females are uniformly brown and males have green flanks without black colouration.

As the observed individual did not show characters typical for known aberrations of the species in the sense of Bechtel (1995), Gvoždik (1999) and Blanke & Fearnley (2015), we decided to consider our observation classified likely as *L. agilis* aberration *punctato-lineata*, despite the fact that formerly it was recorded in a small number only in eastern subspecies *L. a. exigua* (Kotenko & Sviridenko 2010) and also in Crimean mountain endemic *L. a. tauridica* (Podorozhnava, pers. comm.). However, the typical *punctato-lineata* has a pronounced pattern on the body sides, whereas it is strongly reduced in individual from Slovakia, but dorsal medial strip is missing and dorsal marginal strips are not distinguishable against the background of light dorso-lateral bands (see terminology in Kotenko & Sviridenko 2010). The individual from Kopáč is also close to aberrations *maculata* or *punctato-concolor*, characterized with typical small points on the back and body sides along the absence of typical dark pattern (Kotenko & Sviridenko 2010, Synenka & Dykyy 2015). Following Suchow (1948), these authors consider similar variations as a likely "heterozygous hybrid" between the typical form and representatives of some aberrations (morphs): *immaculata* (*punctato-concolor* in the progeny), *erythronota* (*punctata*) or *lineata* (*punctato-lineata*). However, the specimen from Slovakia is not

monotonous (back and sides are painted in different colours) and in addition, the broad light dorso-lateral bands on the sides of the vertebral band clearly expressed.

It is necessary to say that the pattern classification of aberration/morphs in *L. agilis* is not such important and probably does not reflect phylogenetic relationships (see Andres et al. 2014) of the species and we can only speculate what is behind this pattern diversity. Most likely, it could be a reason of specific environmental factors at the locality, clinal variation, very complex genetic structure of the species due to historical range fluctuations (see Yablokov et al. 1981) or selection as is suggested for *Natrix natrix* "*persa*" (back striped snakes) occurring in different phylogenetic clades (Kindler et al. 2013). But we cannot exclude stochastic processes, autosomal recessive gene mutations or hormonal changes, all of which are known to have potential to alter body pattern and coloration (Hadley & Oldman 1969, Bechtel 1995). All of this is still poorly studied in sand lizards.

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Figure 1. An unusual coloured female of *Lacerta agilis* from Slovakia. A – lateral view; B – dorsal view (photo by D. Gruľa).

Figure 2. An overview on the habitat of recorded female of *Lacerta agilis* in the state Nature Reserve Kopáč (photo by J. Christophoryová).

Figure 3. Colour and pattern variation of *Lacerta agilis* recorded in Slovakia. A – adult male from Muránska Planina, central Slovakia; B – adult male from locality Marcelová, western Slovakia; C – adult male of the *erythronota* morph, Bratislava – Železná studnička, western Slovakia; D – old adult male, Jurský Šúr, western Slovakia; E – adult female of the *erythronota* morph, Svetlice, eastern Slovakia; F – adult female, Bodíky, western Slovakia; G – adult female, Marcelová, western Slovakia; H – adult female, Terchová – Vrátna, north-western Slovakia (photos by D. Jablonski).

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