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Rare Color Variants in Lacertidae on the Example of *Zootoca vivipara* (Jacquin, 1787) in Ukraine

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Abstract

We used GIS modeling (DIVA-GIS, Maxent) to simulate the potential distribution of *Zootoca vivipara*. For modeling, we used a database including information from our studies and literature, comprising 190 points of lizard samples (including 7 points for melanistic lizards). It can be concluded that the distribution of *Z. vivipara* in Ukraine depends on the following environmental variables related to solar radiation and precipitation: "Radiation of wettest quarter" (BIO24; 34.2%), "Precipitation of driest week" (BIO14; 18.1%), "Lowest weekly radiation" (BIO22; 15.7%) and "Mean diurnal temperature range" (BIO2; 12.8%). For habitats where melanistic lizards were found, "Mean moisture index of coldest quarter" (BIO35; 18.9%) was also significant in addition to BIO24 (50.4%) and BIO22 (17.3%).

Keywords: melanistic lizards, *Zootoca vivipara,*GIS modeling, Ukraine.

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1. Introduction

In the literature, there are many descriptions of the rare color variants of lizards, such as morphological aberrations (anomalies) and morphs. Abnormalities in reptiles and amphibians are the result of the disturbed function of chromatophores and other elements which form the coloring [24]. For example, melanophores (black and brown), xanthophores (yellow), erythrophores (red), iridophores (iridescent, blue, silver or gold), cyanophores (blue) and leucophores (dull, whitish) are widespread [8]. Reptiles exhibit varying chromism, which is defined by partial or complete absence of different types of pigment cells. Melanism, the opposite of albinism, is the development of a dark-colored melanin pigment in the skin. The presence, absence, density and distribution of melanocytes and chromatophores within each layer determine the color of the reptile: for example, the color variants "nigra" or "platini" in *Lacerta agilis* Linnaeus, 1758 [19]. A mosaic of combined black and brown colors is described in the literature as "brown melanism" [25, 26]. Pseudo-melanism, also called abundism, is

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another variant of pigmentation, one characterized by dark spots or enlarged stripes which cover a large part of animal's body, making it look melanistic. For some reptilian species, a completely black body is normal and is maintained by natural selection, for example, *Vipera* (*Pelias*) *nikolskii* Vedmederja, Grubant et Rudaeva, 1986 (*V. berus nikolskii*). The frequency of the occurrence of rare color variants among reptiles depends on the uniqueness of their population. If the black color version is common, then the morph (or variant) is written as "var. nigra" [10] (more than 5%). Isolated cases of deviations from the normal state are called aberrations — "aber. nigra" — from the normal color (less than 5%). For example, in Ukraine such aberrations were found among melanistic *L. agilis* on Island Biruchiy [33, 39] and in the Molochnij estuary [15]; among specimens of *Lacerta viridis* (Laurenti, 1768), they were found in Mykolaiv region [23]; among *Podarcis taurica* (Pallas, [1814]) in Crimea [14]; among *Darevskia lindholmi* (Lantz et Cyrén, 1936) in Crimea [19]; and among *Darevskia dahli* (Darevsky, 1957) ("brown melanism") in the Zhytomyr region [25]. Melanistic morphs were described among *L. agilis* and *Zootoca vivipara* (Jacquin, 1787) in Russia. Singular melanistic specimens of *L. agilis* were found in Krasnodar krai [35], Western Altai [19, 39] and the Stavropol krai of Samara province [7]. Melanistic morphs have been found among *Z. vivipara* more often than in other reptile species in Russia. In Sverdlovsk province, the frequency of melanistic individuals in populations in forests was 1.15%, and in countryside it ranged from 0.95% to 1.1% [37]. Up to 5.5% of specimens were melanistic (more among the females more) in the Cherdyn district of Perm province [7]. Melanistic individuals are also reported in Leningrad province [21] and near Tomsk [20]. In Europe (the United Kingdom, Spain, Germany, Ireland, Switzerland, Poland, Slovakia, Montenegro, etc.), melanistic specimens are more common in *Z. vivipara* than in other species of the Lacertidae family [1, 10, 12, 27, 28, 38]. In the Czech Republic, up to 8% of *Z. vivipara* specimens were melanistic, and this variant of coloring is much more likely to be found among males [11]. In Denmark, 10% of lizards were melanistic [9]. Earlier in the literature, in 1805, black variant lizards (*Lacerta nigra*) were described in Wolf in Sturm (the type locality is "Schneegebirge, so genannte Wenger Alpe", in the canton of Berne, Switzerland; Schmidtler, Böhme, 2011). In July 1850, the L. nigra ("*L. Fitzingeri*") was found near Kharkov (Ukraine; [3]). Chromium is known for *Z. vivipara* (male) to be green in the UK (Bowles, 2003; [5, 37]). Rare cases of melanism in the Balkan Peninsula, near the southern range limits for this species, were described in the literature [12]. Studies of rare abnormalities (or variants) in the coloration of lizards have not been conducted in Ukraine yet. Therefore, the aim of our work is to compile information about the cases of melanistic *Z. vivipara* in Ukraine in order to identify the potential bioclimatic factors that could lead to such color manifestations.

2. Methods

To explore this issue, we used GIS modeling of the potential distribution of *Z. vivipara* revealed in the territory of Ukraine (183 points and 7 points of melanistic findings). *Z. vivipara* var. nigra were found in regions of Ukraine like: Ivano-Frankivsk (Polonyna Bryusny; reported Zelenchuk Ya., Smirnov N., 2015; Fig. 1: №1; 47.84° N, 24.74° E), Sumy (Desnyansko-Starogutsky NNP, near the village of Ochkino according to Kotserzhinskaya, 2003; Fig. 1: №2; 52.24° N, 33.38° E), Kyiv (the village of Pluty; Fig. 1: №3; 50.16° N, 30.71° E), Cherkassy (Sytnik, 2004; Fig. 1: №4; 49.72° N, 31.49° E), Poltava - NNP "Pyryatynsky" (Udaj River, 2014; Fig. 1: №5; 50.23° N, 32.53° E), around the village of Kamyshnaya (Khorol River, 2012; Fig. 1: №6; 50.18° N, 33.72° E) and Kharkiv (NNP "Slobozhansky"; reported Biatov A.; Fig. 1: №7; 50.05° N, 35.18° E).

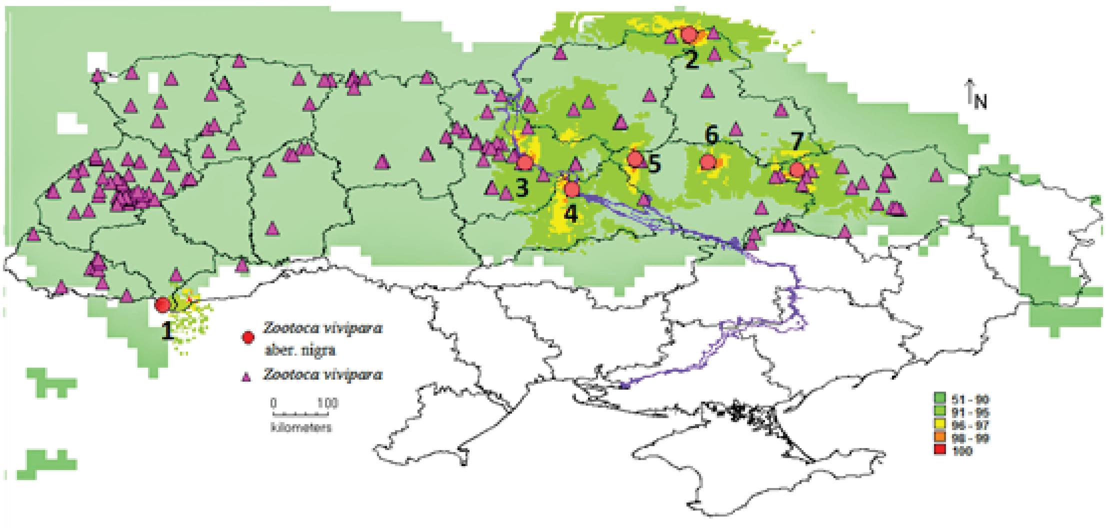

Figure 1: The results of GIS modeling of potential distribution of *Z. vivipara* (DIVA-GIS and Maxent) (No. 1-7 marking in the text).

These data were collected from the results of original research (findings, verified information) and the literature [16, 29, 40]. They were the basis for a database. Mapping, modeling and calculations were carried out using OziExplorer v.3.95.4 m, DIVA-GIS v.5.2. (19 bioclimatic factors from WorldClim database, Domain algorithm) and Maxent v. 3.3.3k. (35 bioclimatic factors) [36].

Figure 2: Melanistic viviparous lizard from the Poltava region.

3. Results

Viviparous lizards are widely distributed throughout the whole Eurasian forest zone. Its range extends to the north of the Arctic Circle, so it is tolerant of low temperatures. These lizards may appear very early in spring, before the snow melts away (in March, when the air temperature is around +4°C). The southern range limit runs at 48° northern latitude. In these areas, viviparous lizards live in damp locations, often near water (along rivers and in swamps and damp forests). The background coloration among these lizards is very variable - most animals are basically brown (chocolate colored), and grey or olive is less likely. In contrast to the relatively low morphological variability characteristic of this species, there is usually a high interpopulation variation in patterns [1]. Juveniles start by being black or chocolate colored, and slowly acquire a pale green ventral coloration on becoming yearlings. We recorded melanistic *Z. vivipara* (young-adults) in 7 localities (Fig. 1., Fig. 2.). In the Poltava region near the Khorol River, only one lizard specimen was black (n=15; Fig. 1: №6). Most of the finds were singular. Along River Khorol, 3-5 to 10 lizards per km were found.

GIS modeling showed that the distribution of *Z. vivipara* in Ukraine depends on the following parameters related to solar radiation and precipitation: “Radiation of wettest quarter” (BIO24; 34.2%), “Precipitation of driest week” (BIO14; 18.1%), “Lowest weekly radiation” (BIO22; 15.7%) and “Mean diurnal temperature range” (BIO2; 12.8%). For habitats where melanistic lizards were found, “Mean moisture index of coldest quarter” (BIO35; 18.9%) was also significant in addition to BIO24 (50.4%) and BIO22 (17.3%). The model presented a high fit - AUC = 0.996. Functions of coloration may be very different, for example: camouflage, UV protection, behavioral adjustments, ecology, thermobiology, etc. Melanism is thought to have thermoregulatory significance and is considered to be a result of ecological adaptation to a certain environment [4, 12, 34]. Also, some scholars have opined about the thermobiological benefits of a melanistic (dark-colored) reptile, arguing that such animals heat up faster, which allows them to be more active in adverse conditions. The skin reflectivity of melanistic wall lizards was 2% higher than that of non-melanistic ones in a short wavelength range 0.38-0.80 u [34]. There are different opinions about "the thermal melanism hypothesis (TMH)" and its specificity with regards to various regions [4]. Exploring some thermobiological features of melanistic *Z. vivipara* (heating rate, body size and habitat) in the Czech Republic, researchers could not confirm the expected benefit of melanistic color. It was suggested that the occurrence of melanistic specimens among viviparous lizards is due to the characteristics of the habitat (vegetation, background color, habitat, etc.) [11]. So, the manifestation of melanism and changes in the color and body shape in different reptilian species is also associated with a complex of factors – extreme and edge effects, height above sea level, composition of the soil (e.g., excessive quantities of substances that stimulate melanin production: manganese and iron), etc. [6, 30]. For example, lizards inhabiting more humid, dark areas are darker than species in dry open habitats [37]. Also, the light color of *Vipera* (*Pelias*) *berus* (Linnaeus, 1758) has more xerophiles and thermophiles (forest edges, southern slopes) than black snakes (river banks or swamp edges) [22].

4. Conclusion

It can be concluded that black skin color can be influenced by a complex of factors (physical, chemical, ecological, marginal, biological and climatic). In some cases, the occurrence of rare colors in lizards may be seen as an adaptation to a certain environment. Each case should be considered individually and regionally. We also observed the possible influence of climatic features on the occurrence of melanistic forms among viviparous lizards: in addition to factors associated with solar radiation and precipitation ("Radiation of wettest quarter" (BIO24; 34.2%) and "Lowest weekly radiation" (BIO22; 15.7%)), "Mean moisture index of coldest quarter" (BIO35; 18.9%) is also significant. In fact, all such specimens were discovered near the southern border of the area (Fig. 1: №1, 3-7): in similar habitats, there are live black reptile species, such as *V. nikolskii*. Therefore, we can assume that the expression of melanism is not accidental and not subject to selection. Since data on the occurrence of melanistic forms among viviparous lizards is not adequate, research should continue. However, according to preliminary data, it is important to note that in some regions where melanistic specimens are quite common (over 5%), especially among young individuals, this manifestation can be considered a variation on the normal color of the viviparous lizard of *Z. vivipara* var. nigra [10].

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