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The Effect of Incubation Temperature on Deviations of Pholidosis and Malformations in Grass Snake *Natrix natrix* (L. 1758) and Sand Lizard *Lacerta agilis* (L. 1758)

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Abstract

This paper considers morphological deviations of reptiles and the influence of incubation temperature on this phenomenon. 28 types of pholidosis deviations and 5 types of malformations were observed in juvenile grass snakes. Sand lizards demonstrated 26 types of deviations and 11 types of malformations. The most common malformations in both species were spine and tail deformations. Hatchlings which were incubated at extremely high temperatures were characterized by the largest spectrum and the highest frequency of deviations and malformations. Reptiles with spine deformations had a great number of deviant ventral scales.

Keywords: deviations, malformations, pholidosis, incubation temperature, reptiles.

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1. Introduction

Examining the factors which cause one change or another in an animal's phenotype is an important task of modern research. Changes in the pholidosis untypical for reptiles are called deviations (variations, scale anomalies, scute deformities). The causes of pholidosis deviations have been debated for many years. Experimental investigations have shown that the frequency of deviations is influenced by both internal (genotype) [3, 7] and external (environment) [2, 5, 6, 8] factors, but the relations between these factors are not clear. In this research, we try to answer the question: how does incubation temperature affect pholidosis deviations and malformations in reptiles?

2. Methods

Eggs were incubated under five thermal regimes: an optimal temperature of 29°C, constant temperatures 24°C and 34°C and fluctuating temperatures with a mean of

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29°C and a fluctuation of 5°C (29-5°C, 29+5°C). The temperature was maintained by incubators. Eggs from each clutch were divided into five groups and were placed in plastic containers (250 mL) with moist vermiculite (1,5 : 1g water / vermiculite by mass). In total, 148 grass snake eggs and 142 sand lizard eggs were incubated; 134 and 76 juveniles were obtained, respectively. To evaluate the quantitative characteristics of deviations and malformations, some indices and coefficients recommended for the evaluation of amphibian morphological anomalies were used [1].

3. Results

In total, 28 types of pholidosis deviations were observed in grass snakes; the most common were deviations in the ventral, subcaudal and loreal scales and scales in the posttemporal area (Fig. 1). Juvenile sand lizards demonstrated 26 types of deviations; deviations in the ventral, parietal, supraorbital, submaxillar, occipital and frontonasal scales were more common. In general, the following groups of deviations were observed: segmentation (Fig. 1 c, g, k, o), incomplete separation (Fig. 1 h, j, l), fusion (Fig. 1 a, d, e, i), reduction (Fig. 1 f), displacement of scales (Fig. 1 m) and the presence of an additional small scale (Fig. 1 n).

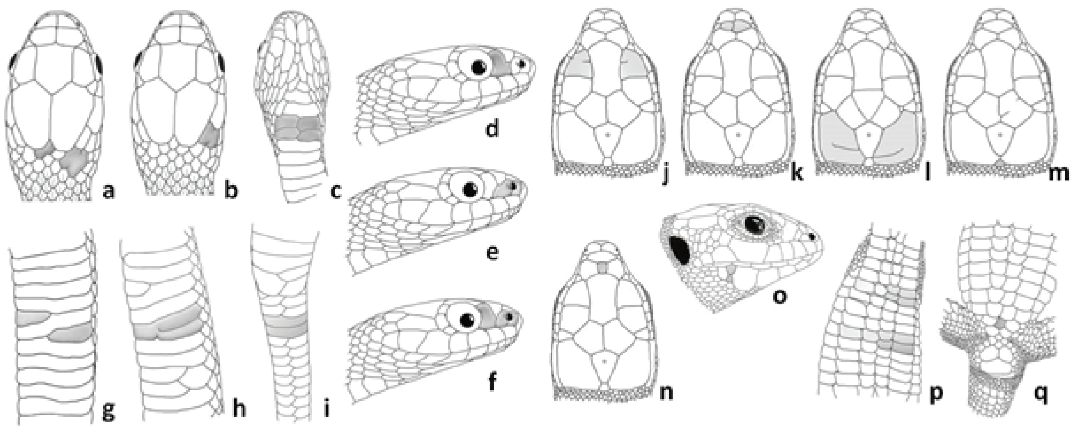

Figure 1: The most common pholidosis deviations in grass snakes and sand lizards.

Deviations were more common in juvenile grass snakes incubated at extremely high (93% of individuals) and extremely low (85%) temperatures. The frequency of deviant hatchlings is minimal at the optimal temperature (65%). Lizards demonstrated the same: deviations were more frequent in hatchlings incubated at high (91%) and low (85%) temperatures. Other researchers have also noted an increased number of hatchlings with scale anomalies at extremely high [6], extremely low [2] and both high and low [5, 8] temperatures.

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The spectrum of deviations was affected by the incubation temperature in snakes (*H*=21,74; *df*=4; *p*=0,0002) and lizards (*H*=12,8; *df*=4; *p*=0,012). Maximal values in the population (S_{ap}=22) and individual (S_{ai}=3,3) spectra of deviations were observed in snakes exposed to high temperatures. Minimal values were observed at the optimal regime (S_{ap}=15; S_{ai}=1,2). In lizards, the maximal values in the individual and population spectra of deviations were also observed at extremely high temperatures (S_{ap}=16; S_{ai}=2,8).

Cluster analysis shows that snake samples incubated at high temperatures (34°C and 29+5°C) were distanced from those incubated at optimal and low temperatures. The lizard sample incubated at the low temperature of 24°C was distanced from the others. The spectra of deviations of all snake samples were similar (I_{cs}>50%), whereas most lizards samples differed from each other (I_{cs}<50%).

Malformations occurred in 8.4% of snakes and 24% of lizards. 5 types of malformations were observed in grass snakes: scoliosis (2.7% of individuals), kyphosis (4%), head deformation (0.4%), tail curvature (5.8%) and microphtalmia (0.4%) (Fig. 2). 11 types of malformations were found in sand lizards: scoliosis (10.5%), kyphosis (3.9%), shistosomia (1.3%), tail curvature (15.8%), incomplete tail (5.3%), olygodactyly (3.9%), polydactyly (1.3%), inflexible limb (2.6%), micrognathia (5.2%), microphtalmia (1.3%) and anophtalmia (1.3%). In both species, the most frequent were spine and tail deformations. The maximum frequency of malformations was noted at 34°C (30% of snakes and 27% of lizards). Maximum values of S_{ap} and S_{ai} were observed at 34°C in grass snakes (4 and 0.5 respectively) and at 29+5°C in sand lizards (8 and 0.9 respectively). Reptiles with spine deformations had a great number of segmented, fused, incompletely separated and asymmetric ventral scales.

It should be noted that abnormal hatchlings were siblings in many cases. Moreover, anomalies were more expressed in offspring incubated at high temperatures (they usually failed to hatch, whereas siblings from low temperatures survive). Perhaps there is a predisposition to anomalies, and extreme incubation temperatures induce deviations, malformations and sometimes death. The fact that siblings of malformed hatchlings have reduced survival rates compared to offspring from normal clutches is known for sand lizards [4].

4. Conclusion

The experimental incubation of reptile eggs showed that:

Figure 2: Malformations of grass snakes and sand lizards: a – kyphosis, b – scoliosis, c – tail curvature, d – head deformation, e – microphthalmia, f – shistosomia, g – olygodactyly, h – polydactyly, i – incomplete tail, j – micrognathia, k – anophthalmia, l – inflexible limb.

1. The studied species demonstrated several groups of deviations: segmentation, incomplete separation, fusion, reduction, displacement of scales and the presence of an additional small scale.

2. Hatchlings incubated at extremely high temperatures were characterized by the largest spectrum of deviations (individual and population) and the highest frequency of deviations.

3. Malformations were more common in hatchlings exposed to high temperatures. Juveniles with spine deformation had a great number of deviant ventral scales.

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