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Colour polymorphism in a population of the common lizard, *Zootoca vivipara* (Squamata: Lacertidae)

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Abstract. Melanistic individuals in one population of *Zootoca vivipara* in the Czech Republic were recorded. The proportion of black lizards was low (8.3%) with a significant preponderance of males ($P < 0.03$). Comparisons of heating rates, body sizes and body conditions did not confirm a supposed advantage of melanistic lizards. Therefore, the occurrence of black phase seems to be primarily dependent on habitat characteristics (vegetation cover, substrate colour), which may reduce the cost of conspicuousness. Cryptic coloration may be especially important for gravid females, which have decreased mobility. Therefore, insufficient crypsis of black females may be the main factor causing their low proportion in the population.

Key words: melanism, heating rates, body condition

Introduction

Different colour morphs occur in many populations of squamate reptiles. The most frequent colour deviation seems to be melanism, which typically occurs with relatively high frequency at higher elevations and latitudes and on islands (e.g. Luiselli 1992, Forsman 1995b). It is generally believed that the frequency of melanism in a particular population is the result of two opposite selective forces: a thermoregulatory advantage and a higher predation risk. Black animals are supposed to heat faster, thereby decreasing the time spent basking and thus reducing potential predation risk, and saving more time for foraging and reproduction. This is especially important in areas with reduced total activity time (higher elevations, latitudes). Higher energy gains increase growth rates and the amount of fat reserves, such that melanistic individuals should be bigger and heavier. However, the thermoregulatory advantage of melanism depends on the size of an animal. Experimental results showed a thermoregulatory advantage (i.e. faster heating rates) of melanism in snakes, *Thamnophis sirtalis* (Gibson & Falls 1979) and *Vipera berus* (Forsman 1995a), but not in small lizards such as *Lacerta dugesii* or *Podarcis muralis* (Tosini et al. 1979). Although melanistic snakes have higher heating rates (Forsman 1993), no difference exists in growth rates and thus recorded mass differences may be rather a result of differential mortality (Madsen & Stille 1988, Forsman 1995a).

On the other hand, melanistic individuals may suffer important costs due to higher conspicuousness to visually-hunting predators and hence experience a higher predation risk (André & Nilson 1981). However, when black individuals are better colour-matched to the background (e.g. on lava flow) than normally coloured animals, the latter experience a higher predation risk and selection should favour melanistic individuals. During pregnancy,

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females have lower agility and are more vulnerable to predation (Van Damme et al. 1989, Sinervo et al. 1991). To reduce predation risk, pregnant females can change their behaviour by decreasing their activity and relying on crypsis (e.g. Bauwens & Thoen 1981). Thus, a higher conspicuousness to predators is expected to be more costly to melanistic females than to males (but see Forsman 1995b for contrasting results).

Zootoca vivipara inhabits a substantial part of temperate Eurasia (Dély & Böhme 1984). Melanistic specimens have been often reported from different parts of its range (e.g. Boulenger 1917, Štěpánek 1955, Petzold 1978, Szyndlar 1980, Westrin 1985, Cavin 1993), but with one exception (Cavin 1993), we have no information about the frequency of melanism in particular populations. Moreover, there are no data about advantages and disadvantages of melanism in *Z. vivipara*. To fill this gap at least partially, I tested following three predictions: 1) Melanistic lizards have no thermoregulatory advantage (higher heating rates), consequently, 2) body mass, snout-vent length and body condition do not differ between melanistic and "normally" coloured individuals, and finally 3) the sex ratio of melanistic lizards should be higher in males than in females.

Material and Methods

Zootoca vivipara is a small (snout-vent length 45-65 mm) insectivorous lizard. It is live-bearing, one clutch consists of two to eight juveniles. Maturity is reached during its third or fourth activity season (see Dély & Böhme 1984 for further information).

I recorded the presence of melanistic *Z. vivipara* at one locality near the village of Raduň (Opava District, 49°53'N 18°00'E, 250 m). This area consisted of three small dried ponds, well vegetated by grasses (*Calamagrostis* sp., *Deschampsia* sp., *Juncus* sp.) and nettles (*Urtica dioica*) up to 2 m high. Lizards were captured from May to August 1996. Every specimen was individually marked by toe clipping, its colouration (melanistic, 'normal') was recorded and two measures were taken: snout-vent length (SVL; to 0.1 mm with plastic callipers), and body mass (BM; to 0.1 g with Pesola scales). After handling, each lizard was released at the place of capture.

Owing to the scarcity of melanistic lizards, only one melanistic male and six (three males and three females) normally coloured lizards were captured for measuring their heating rates in August. Each lizard was fixed on a white plastic board (12x25 cm) by two bands of transparent adhesive tape and K-type thermocouple (0.01 inch diameter), connected to a digital microprocessor thermometer (Omega HH 21), was inserted into its cloaca. When fixed, a lizard was cooled to 19°C and then placed below a 100 W reflector lamp suspended 20 cm above the centre of the lizard's body. When lizard's body temperature (T_b) reached 20°C, I recorded the T_b at 15 s intervals until T_b equalled 35°C. All measurement were taken at an ambient room temperature of 19 ± 1°C. Heating rates (°C min^{-1}) were determined as the slopes of the linear regressions relating T_b to time elapsed (Belliure et al. 1996). Because sex and population had no significant effect on heating rates (unpublished data), data from the next three populations (18 lizards) were added for further analysis. Owing to small sample size, regression slopes and elevations were compared between the single melanistic lizard and an imaginary normally coloured lizard of the same mass (Zar 1996). The slope and intercept for the imaginary lizard were obtained from the linear regression equations of slopes and intercepts by mass of 24 normally coloured lizards.

The frequency of melanistic individuals in both sexes was compared using two-tailed Fischer's exact test. I used analysis of variance (ANOVA) to test effects of colour and month of capture on continuous variables (SVL, BM). Body condition (BM in relation to SVL) was compared using analysis of covariance (ANCOVA) with SVL as the covariate. All tests were computed with JMP 3.2 statistical software (SAS 1995).

Results

A total of 97 lizards (47 males and 50 females) were captured. Melanistic lizards composed 8% of the sample. The frequency of melanism was significantly higher in males (15%) than in females (2%, $P = 0.03$). Five melanistic males were sexually mature; the remaining lizards (two males and the female) were in their second calendar year (subadults).

Linear regression slopes and elevations of T_b by time (Fig. 1) did not differ between a melanistic male and the imaginary coloured lizard (slopes: $t = 1.11$, $df = 56$, $P > 0.05$; elevations: $t = 0.19$, $df = 57$, $P > 0.05$).

Because of the low number of melanistic females (1 specimen), SVL, BM and body condition were compared only in males. No significant differences were found for any of these characteristics between melanistic and normally coloured lizards (Tables 1 - 3).

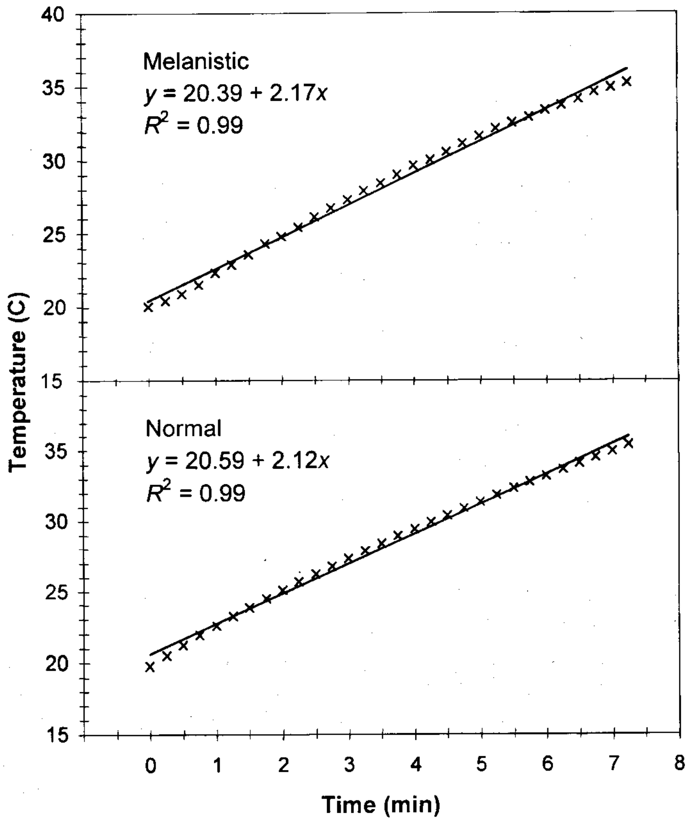

Fig. 1. Relationship of body temperature on time during heating experiment in melanistic and the imaginary normally coloured lizard of the same mass (4.4 g).

Table 1. Mean ± SE, minimum and maximum values of snout-vent lengths and body masses in two colour variants of *Z. vivipara* (males only).

Character	Normal (n = 40)	Melanistic (n = 7)
Snout - vent length (mm)	50.3 ± 0.8 41.2 – 59.0	50.5 ± 2.8 40.1 – 61.2
Body mass (g)	4.0 ± 0.2 1.5 – 6.6	3.5 ± 0.5 2.0 – 5.6

Table 2. Results of analysis of variance examining an effect of colour variants and month of capture on male snout-vent length and body mass in *Z. vivipara*. Interactions were not significant.

Source	Snout-vent length			
	df	SS	F	P
Colour	1, 39	20.506	1.054	0.31
Month	2, 39	389.062	9.978	< 0.001
	Body mass			
Colour	1, 39	< 0.001	< 0.001	0.99
Month	2, 39	24.923	12.525	< 0.001

Table 3. Results of analysis of covariance examining an effect of colour variants, month of capture and snout-vent length on male body mass in *Z. vivipara*. Interactions were not significant

Source	df	SS	F	P
Colour	1, 37	0.003	0.670	0.42
Month	2, 37	0.002	0.169	0.85
SVL	1, 37	0.177	30.807	< 0.001

Discussion

Available evidence indicates that melanism provides no apparent thermoregulatory advantage to small lizards (Crisp et al. 1979, Tosini et al. 1992). The visible colour difference is caused only by different amount of melanin in epidermal layer. However, both colour variants have a well developed and thick layer of dermal melanophores, which primarily determines skin reflectivity and thereby heating rates (Mertens 1934). The results of the present study support this view, although comparisons of heating rates must be considered with caution because only a single melanistic lizard was tested. The equality of SVL, mass and body condition seems to be a logical consequence of the absence of a thermoregulatory advantage.

In the absence of a thermoregulatory advantage in the population studied, the frequency of melanism seems to be dependent only on the effect of one selective force: predation pressure. Even though I have no direct evidence of a higher predation on melanistic lizards, different frequencies of melanism in populations of *Z. vivipara* (C a v i n 1993, this study) may support this suggestion. If there would be no different predation risk and selective advantage of melanistic lizards, then melanism should occur at the similar frequencies in both populations. However, frequency of melanism in my study was seven times higher than in the population from the Swiss Alps (1.13%). I therefore suppose that a higher frequency of melanism will be maintained in populations living in habitats where the negative effect of predation on melanistic is reduced. This condition was met in my study. The polymorphic population occupied a habitat with the highest herbal vegetation and the highest tree density compared to the other five localities at altitudes ranging from 220 to 1450 m where melanism was not recorded (unpublished data). High vegetation predominantly consisted of nettles, which protected animals moving on the ground from visual detection by predators.

In accordance with the prediction, the frequency of melanistic lizards was significantly lower in females than in males. Moreover, the single melanistic female was immature suggesting that survival of adult females was really affected by predation. However, because information about frequency of melanism before selection (i.e. at birth) is lacking, any interpretation of these data must be done with caution (F o r s m a n 1995b). Contrarily to the higher frequency of melanistic males in my study area, B o u l e n g e r (1917) stated that melanism is "apparently more frequent in females than in males". However, this conclusion was based on occasional findings of single lizards from different populations and may therefore be misleading. A higher frequency of melanistic females in occasional captures may rather confirm a higher conspicuousness and vulnerability of melanistic females to a visually-oriented predator, *Homo scientificus*.

In conclusion, this study showed that frequency of melanism within populations of *Z. vivipara* was very low; although in one population, the frequency was seven times higher than in a population from the Swiss Alps (C a v i n 1993). Owing to small sample sizes, the results should be considered as preliminary. They suggest that there is no thermoregulatory, size, mass and body condition advantage of melanism in lizards. However, more data are needed to obtain definite conclusions.

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