BERGMANN’S RULE IS SIZE-RELATED IN EUROPEAN NEWTS (TRITURUS)

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The validity of Bergmann’s rule – which describes the intraspecific increase in body size with increasing altitude – was studied in a several populations of three European newt species. There was a positive correlation between body size and altitude for smaller-bodied Triturus vulgaris and T. alpestris species, but no relationship between body size and altitude for the much larger sized T. carnifex. Body size therefore plays a role in the application of Bergmann’s rule to European newts.

Key words: altitudinal gradient, morphology, Triturus vulgaris, Triturus alpestris, Triturus carnifex

Bergmann’s rule states that there is an intraspecific tendency toward larger body size in cooler environments (Mayr, 1956). However, tests of Bergmann’s rule have traditionally relied upon latitude or altitude as a proxy for temperature (Ashton et al., 2000). Originally restricted to mammals and birds (Mayr, 1956), it was recently claimed that Bergmann’s rule holds true for amphibians in general, but more clearly for tailed amphibians than for anurans (Ashton, 2002). Although Bergmann’s rule has been reported (Miaud et al., 1996, respectively), 19 population samples of T. alpestris (24.8±5.3 males and 25.7±5.3 females), and 22 population samples of T. carnifex (16.5 ±3.8 males and 17.5±3.4 females). Samples were collected from most of the vertical distributional range recorded for the study species (see Griffiths, 1996). The ranges were: 0-1650 m for T. vulgaris, 80-2100 m for T. alpestris, and 0-1550 m for T. carnifex.

The snout-vent length (SVL), distance from the snout to the posterior edge of the cloaca, was measured for each specimen from each population. Variation in body size within species, represented by the difference between the minimum and maximum average SVL values of the population samples studied, was as follows: T. vulgaris 30.1-43.1 mm and 30.3-44.7 mm (males and females, respectively); T. alpestris 37.7 - 48.2 mm in males and 42.5-55.0 mm in females; T. carnifex 103.7-129.7 mm in males and 117.0-146.9 mm in females.

We used simple linear regression analyses to assess the relationship between body size (average SVL values for sampled populations) and altitude for each of the Triturus species. Average SVL was significantly positively associated with altitude for T. vulgaris (r=0.44, P<0.01 for males; r=0.46, P<0.01 for females), and for T. alpestris (r=0.59, P<0.01 for males; r=0.53, P<0.05 for females; Fig. 1). However, the larger-sized T. carnifex did not show a significant relationship between SVL and altitude for males (r=0.010, P=0.96) or females (r=0.087, P=0.70; Fig. 1).

To date, the relationship between body size and the tendency of a Bergmann’s rule trend has been studied in birds and mammals. While no relationship between the tendency of a Bergmann’s rule trend and body size has been found in birds (Ashton, 2002b; Meiri & Dayan, 2003), conflicting results have emerged for mammals (Ashton et al., 2000 vs. Meiri & Dayan, 2003; Freckleton et al., 2003). Apparently, Bergmann’s rule appears to be size-related in European newts. In contrast to the much smaller T. vulgaris (this study) and T. alpestris (Miaud et al., 2000; this study), large-bodied species (T. marmoratus, Díaz-Paniagua et al., 1996 and T. carnifex, this study), do not show significant relationships between body size and altitude or latitude. Larger-bodied species may not show significant size trends because their large size makes them less sensitive

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also investigated the influence of body size on intraspecific size-altitude body size trends.

Population samples came from Slovenia, Croatia, Bosnia and Herzegovina, Serbia and Montenegro and FYR Macedonia. The studied newts came from Dr Georg Dzukic’s Herpetological Collection (Institute for Biological Research, Belgrade). Only mature newt individuals, collected during the breeding season, were studied. Due to the sexual dimorphism in newts, which is most prominent in T. alpestris (e.g. Kalezić et al., 1992), males and females have been treated separately in our study. Our data set was obtained from 39 population samples of T. vulgaris (mean no. of specimens per sample±SD: 22.0±3.84 and 22.28±3.68 for males and females, respectively), 19 population samples of T. alpestris (24.8±5.3 males and 25.7±5.3 females), and 22 population samples of T. carnifex (16.5 ±3.8 males and 17.5±3.4 females). Samples were collected from most of the vertical distributional range recorded for the study species (see Griffiths, 1996). The ranges were: 0-1650 m for T. vulgaris, 80-2100 m for T. alpestris, and 0-1550 m for T. carnifex.

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to environmental differences across populations (e.g. temperature, water availability, difference in activity period). Together with selection acting on different life-history traits correlated with body size, such factors may underlie geographical size variation in amphibians (Ashton, 2002a; Morrison & Hero, 2003).

In conclusion, smaller-bodied species of European newts (T. vulgaris and T. alpestris) increase in body size with altitude, whereas body size for the larger-sized T. carnifex does not change with size, suggesting that body size of smaller-bodied salamanders is more influenced by environmental factors. Given that all three species are broadly sympatric over much of their altitudinal ranges, they represent promising candidates for further research aimed at examining mechanisms that generate patterns of body size variation in terrestrial ectothermic vertebrates.

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