Oecologia
Montana 2013,
22, 1-4

Ecomorphology of *Lissotriton montandoni* from the Eastern and Western Carpathians

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Abstract. We compared the morphological plasticity of *Lissotriton montandoni* between the West and Eastern Carpathians, Slovakia. The animals from High Tatra Moutains (the West Carpathians) are bigger than animals from Poloniny National Park (The Eastern Carpathians). The samples from the Tatras originate from higher elevations and cooler climate. Newts (both males and females) which coexist with Alpine Newt in the same habitat (basin) were bigger than newts which were living in the basin as only newt species. The females of newts were generally larger than males.

Key words: Carpatian newt, ecomorphology, habitat, Carpathians

Introduction

The Carpathian newt *Lissotriton montandoni* is an endemic newt species found only in the Tatra mountains (Poland, Slovakia) and some other regions of Carpathians (Cogalniceanu 1997).

Compared to other newt species, it is relatively little known. At the time of reproduction it shows a strong sexual dimorphism and it is also easy to observe or catch. We assume that the morphological variability of newts is related to different ecological factors. The main purpose of our study was to detect which factors influence the morphology of Carpathian newt and how. The field surveys were conducted on spring 2013 on two locations in Slovakia (Belianské Tatras and Poloniny). Other objectives were:

1. Confirm morphological differences - size and shape, between sexes.
2. Find out if and how the type of breeding habitat influences the morphology of *L. montandoni*.
3. Find out and compare morphological differences between populations from the Eastern and Western Carpathians.
4. Find out if the presence of other newt species (e.g. *Triturus alpestris*, *Triturus vulgaris*...) in the same habitat affects morphology of individuals of *Lissotriton montandoni*.

Material and Methods

Finding and capturing the individuals

For the purpose of study of *Lissotriton montandoni* morphology, we searched stagnant and light-flowing waters on two locations - Belianské Tatras (surrounding enviroment of Tatranská Javorina and Tatranská Kotlina) and National park Poloniny (wider surrounding of Nová Sedlica). Search for the habitats took place also on some other locations but with negative results (surrounding of lakes in the central parts of High Tatras). After a succesful search of an aquatic habitat, we photo-documented. It, recorded GPS coordinates and measured its size and depth. We also described the nature of the habitat - natural or artificial (man-made) and searched for other amphibians (especially newt) species. We marked those habitats with acronym of their locality and serial number (e.g. BT1, BT2, P1).

Then capture and measurements of individuals of *Lissotriton montandoni was conducted.* A capture was done by hand and in some cases of a deeper water ponds we used a net.

Measurement was carried out directly in the field. Only mature adults were used for measuring. For measure of the body proportions we used a sliding scale. We put the individual on a pad, stacked it and performed measurements. We always measured 3 sizes: length 1 (distance from snout to rear edge of the cloaca), length 2 (distance from rear edge of cloaca to end of tail), head width (measured at the widest part of the head - which is also in line with the corner of mouth).

Furthermore we measured the weight of the individuals. Weighting was carried out with a spring scale Pesola designed to measure small vertebrates. We put the individual into a plastic bag and weighed it. From the result, we substracted the weight of the plastic bag and got the final weight of the subject.

In addition we identified and recorded the sex of the individual. The subject, after measuring was placed into a bag filled with water to prevent recapturing and re-measuring. After all individuals were measured, we released them back to their habitat.

Statistical processing of data

All data were processed with STATISTICA software ver. 8. The basic data matrix (see enclosure) of a morphological and enviromental data of *L. montandoni* was standardized, due to a possible eccentricity of some measurements. From the standardized matrix the correlation matrix was calculated, which gave a basis for calculating the principal components. Methodology was used to identify and determine the influence of possible factors on the morphology (size and shape) of individuals.

The calculated vectors (eigenvalues) showed us a correlation between individual measured values. They also determine potentially independent factors which influence the variability of data.

For the individual measurements the so-called factor score was then calculated. Factor score was compared for different groups (e.g. males and females) with analysis of variance (ANOVA) at the level of significant validity $p < 0.05$. The results were identified for multiple groups.

Results

In April and May (2013) 55 adult individuals of the Carpathian newt were captured and measured. Size and shape of these individuals were analysed with these measurements:

- length 1 - Body length (distance from snout to rear edge of the cloaca)
- length 2 - Tail length (from rear edge of cloaca to the end of tail)
- head width (the widest part of the head)
- weight

On these data sets of 4 variables the principal component analysis was computed. The structure and percentual variance of principal components are showed in Table 1.

The first principal component (PC1) reflects the size of the newt (including body length, tail length, head width and weight). All 4 variables are co-varied. This factor is widespread within 76 % of the measured individuals.

The second principal component (PC2) reflects the particular shape of the newt. The tail length varies with head width, which means there are individuals with a relatively longer tail and narrow head and also individuals with a relatively shorter tail and wider head. This factor is widespread within 13 % of the measured individuals.

The third principal component (PC3) also reflects the shape of the newt. The weight varies with the head width which means there are relatively heavy individuals with a more narrow head and relatively lightweight individuals with a wider head. This factor is widespread within 7 % of the measured individuals.

The fourth principal component (PC4) also reflects the shape of the newt. The body length varies with weight which means there are relatively lightweight individuals with a longer body and relatively heavy individuals with a shorter body. This factor is widespread only within 3 % of the measured individuals.

Morphological differences between males and females

Comparison of size (PC1) of sexes showed us that measured females were significantly bigger than males (Table 2.). No significant differences were found in shape between sexes (PC2 $F=0.08$ $p=0.77$, PC3 $F=2.5$ $p=0.11$, PC4 $F=0.43$ $p=0.52$).

Morphology of the Carpathian newt influenced by the type/origin of the habitat

33 individuals were captured in the natural habitat and 22 in man-made habitat. Factor score compared within these two groups using ANOVA showed that type of habitat does not influence the morphology of individuals (PC1 $F=0.43$ $p=0.51$ ns, PC2 $F=3.0$ $p=0.09$ ns, PC3 $F=2.6$ $p=0.1$ ns, PC4 $F=0.23$ $p=0.63$ ns).

Morphology of the Carpathian newt influenced by coexistence with the Alpine newt

39 individuals were found in habitat coexisting

Variable	**Eigenvectors of correlation matrix. Active variables only**			
	PC1 (Size)	PC2 (Shape)	PC3 (Shape2)	PC4 (Shape 3)
body length	-0.542602	-0.043494	0.192582	0.816458
tail length	-0.457035	0.775882	-0.401225	-0.167766
head width	-0.475999	-0.626177	-0.579627	-0.212977
weight	-0.519737	-0.063389	0.682615	-0.509796
variance	76%	13%	7%	3%

Table 1. Component vectors (weights) and percent of variance associated with the components indicating the size and shape of Carpathian newt.

Size (PC1)	**n**	**Mean PC1 score**	**SE**	**F**	**p**
Sex					
Females	29	-0.73	0.11	86.6	0
Males	26	0.82	0.12		

Table 2. Comparison of size of sexes of the Carpathian newt (a negative PC1 score implies bigger size).

Size (PC1)	**n**	**Mean PC1 score**	**SE**	**F**	**p**
T. alpestris					
yes	39	-0.32	0.14	18.4	0.007
no	16	0.77	0.21		

Table 3. Comparison of size of Carpathian newt depending on presence of *T.alpestris* (a negative PC1 score implies bigger size).

with other newt species (*Triturus alpestris*) and 16 individuals occupied habitat alone. ANOVA analysis showed that there are differences in size within these two groups - individuals, which coexist with *Triturus alpestris,* are bigger than individuals which occupy habitat alone (Table 3.). No significant differences were found in shape between individuals of these two groups (PC2 F=0.05 p=0.8 ns, PC3 F=0.4 p=0.5 ns PC4 F=0.6 p=0.4 ns).

Size (PC1)	n	Mean PC1 score	SE	F	p
Locality					
Tatras	36	-0.37	0.14	19.68	0
East Carpathian	19	0.71	0.14		

Table 4. Comparison of size of the Carpathian newts from various localities -Belianské Tatras and East Carpathian mountains (a negative PC1 score implies bigger size).

Morphological differences of the Carpathian newt between different locations

36 individuals were found in the Western Carpathians - Belianské Tatras and 19 individuals in the Eastern Carpathians - Poloniny. ANOVA analysis presented that there are size differences between individuals from these two localities. Newts measured in Belianské Tatras are significantly bigger than newts measured in Poloniny (Table 4.). No significant differences were found in shape between newts of these groups (PC2 F=0.35 p=0.55 ns, PC3 F=0.55 p=0.45 ns, PC4 F=0.18 p=0.66 ns).

Discussion

Within our study, the Carpathian newts were observed at altitudes ranging from 522 to 1050 m above sea level, what some authors indicate as its most frequent occurence (Dungel and Řehák 2011). It occured mainly in stagnant-water pools on the forest roads, wheel ruts from cars and heavy machinery and little lakes near the forests. Altough the size of the habitat was variable (but on average they were small), the depth mostly reached around 25 - 30 cm in the deepest point (and sometimes up to 40 cm). Various authors indicate that size and depth of the aquatic habitat affects reproduction of newt. Small water bodies may give high reproductive succes, especially in the high rainfall seasons during the reproduction period (Babik and Rafinski 2001). Newts prefer shallow water. Shallow depth of the water allows newts to devote courtship dance becauce they have to swim just a small distance to the water surface at the moments of breathing (Šusta 2002).

The morphological variance of the newts was significantly shown mainly in size (PC1). The size was characterized with increasing (or decreasing) size of the body, tail, head width and weight. The surveyed factors affecting the morphology of the Carpathian newt were sex, enviroment (habitat), locality and presence of the other newt species.

Lissotriton montandoni shows a high level of sexual dimorphism - phenotypic (observable) differences between male and female within one species. These differences are often relatively easy to notice. Principle of the sexual dimorphism can be understood in terms of fertility, ecology and sexual selection. The pattern of fertility assumes that females are bigger than males (Malmgren and Thollesson 1999). Altough females are generally bigger than males in absolute terms, the degree of sexual dimorphism differs among the characters (Dandová *et al.* 1998)

From a comparison of size of males (26 specimen) and females (29 specimen), it is clear that the measured females were significantly bigger than males (Table 2.). Most of the authors confirm this statement, e.g. Janiga and Mlichová (2004) stated that females are bigger than males, which is probably because of fertility of the females and also because of increased food intake. In a comparison of the shape between sexes, any significant differences were not found.

Another examined factor, which we assumed could affect morphology was habitat. The 33 individuals were found in natural habitat (small lake, dead arm of a mountain stream…) and 22 individuals in man-made habitat (wheel ruts, man-made lake…). We were interested in finding out if the Carpathian newt prefers some type of habitat and if it influences in some way the morphology of the newt. However the ANOVA results showed us that habitat does not influence size or shape. This could be due to an insufficient number of measurements or maybe we should have done more thorough measurements (e.g. length of the limbs, distance between limbs…) to find out that there are some differences in morphology. On the other hand, it is possible that individuals are selecting environmental conditions for the development of their larvae regardless of the type and quality of the habitat - they are moving to water habitats as such. Babik and Rafinski (2001), who did survey breeding sites of amphibians in the Western Carpathians, stated that nearly all their study areas were of human origin (84,2%) and that existence of *Lissotriton montandoni* in Magurski National Park (Poland) is almost entirely dependent on the presence of roadside ditches and wheel ruts. After consideration of the results, it is still uncertain if Carpathian newt prefers some type of breeding habitat or if it just selects type of habitat randomly. The type of habitat may not affect morphology of *Lissotriton montandoni.*

As some authors state (e.g. Kuzmin 1999) in many areas Carpathian newt is coexisting with *T. alpestris*, *T. cristatus* and *T. vulgaris*. Babik and Rafinski (2001) showed that *L. montandoni* and *T.alpestris* often occured together, which may indicate that they share similar requirements. During our field measurements we found out that in 4 of 7 habitats of the Carpathian newt, the Alpine newt (*Triturus montandoni*) was present. ANOVA analysis suggests differences in size between Carpathian newts coexisting with Alpine newts and Carpathian newts living in habitats without other newt species. *L. montandoni* individuals living in a diversified habitat were mostly bigger.

Habitats occupied only by Carpathian newt however smaller individuals, may indicate that this species is more flexible and it occupies habitats which lack the space or food for a larger species (or individuals). This result is in contrast with the results of Mlichová (2004) who stated that occurence of species of *T. alpestris* does not affect size or shape of *L. montandoni,* whether males or females. This disagreement may be caused by insufficient number of observations on either side.

At the final stage of this study, we compared Carpathian newt individuals from two different locations - Belianské Tatras and National park Poloniny. Males and females from the Eastern Carpathians (Poloniny) were significantly smaller than newts from the Western Carpathians (Belianské Tatras) but they did not differ in shape. Size differences may be caused by different food or temperature conditions. Lowering the temperature results in increased body size. It is a fact related to ectothermic animals. Therefore most amphibians reach bigger body size at the higher latitudes, altitudes and in cooler enviroments in general (Ashton 2002). Ray (1960) and Atkinson (1994) confirm this statement. In our study, *Lissotriton montandoni* habitats in Belianské Tatras were situated at higher altitudes (ca 1000 m a.s.l.) with cooler climate than habitats in Poloniny (ca 500 m a.s.l.). This allows to conclude that the size differences between these groups are caused by different altitude and climate.

Study of the morphology of the Carpathian newt should continue further by doing more thorough measurements of sizes, searching for more habitats, trying to find out other enviromental connections to the morphology and observing the populations (habitats) over consecutive years.

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