Arch. Biol. Sci., Belgrade, 67 (1), 7-10, 2015 DOI:10.2298/ABS140418003S

EVIDENCE FOR PAEDOMORPHOSIS IN MACEDONIAN CRESTED NEWT (*TRITURUS MACEDONICUS*) FROM MONTENEGRO

Maja D. Slijepčević*

Department of Evolutionary Biology, Institute for Biological Research "Siniša Stanković", University of Belgrade, Serbia

*Corresponding author: mslijepcevic@ibiss.bg.ac.rs

Abstract - One of the most interesting heterochronic processes in the European newt (genus Triturus) is paedomorphosis, a phenomenon of attaining reproductive maturity while retaining larval features. However, paedomorphosis seems to be rare in the crested newt (*Triturus cristatus* superspecies). In the locality Vrba, near the town of Tuzi (Montenegro), Dr Georg Džukić found paedomorphic Macedonian crested newt (*Triturus macedonicus*). In this paper, new evidence for this heterochronic process in the crested newt from Montenegro is reported.

Key words: Heterochronic process, Macedonian crested newt, Montenegrin karst, paedomorphosis

Received April 18, 2014; **Revised** January 27, 2015; **Accepted** January 27, 2015

INTRODUCTION

Developmental heterohronies are defined as a developmental change in the timing of events, leading to changes in the shape and size of individuals. One of the most extensively studied types of heterochronic processes in the European newt is paedomorphosis. Paedomorphosis (retention of larval traits in adult individuals) is suspected to play an important role in both micro- and macro-evolutionary processes (McKinney and McNamara, 1991). In salamanders (Caudata), paedomorphic individuals are characterized by such larval characteristic as external gills and associated hyobranchial structures, enlarged tail fins, skin often with Leydig cells, and larval texture and characteristics of larval skull that make them different from metamorphic individuals.

In some salamander species, individuals express facultative paedomorphosis in that individuals either transform into terrestrial metamorphic adults or remain in the aquatic environmental conditions experienced during larval development (Whiteman, 1994; Denoël et al., 2005). Facultative paedomorphosis occurs in several urodele species worldwide (*Ambystomatidae*, *Plethodontidae*, *Salamandridae*). There are many studies about the impact of paedomorphosis on discrete life-history polymorphism (Denoël et al., 2009), levels of genetic variability and morphological integrations (Kalezić et al., 1994), intersexual morphometric differences (Kalezić et al., 1992; Kalezić et al., 1994), cranium size-shape changes during ontogeny (Djorović and Kalezić, 2000), and sex ratio (Tucić et al., 1985; Kalezić et al., 1989).

Facultative paedomorphosis is common in European newts (family *Salamandridae*, genus *Triturus*), especially in alpine (*Ichthyosaura alpestris*) and smooth newts (*Lissotriton vulgaris*) in the Balkan area. Paedomorphosis has also been recorded in some other newt species: *Lissotriton helveticus*, *L. italicus*, *T. cristatus*, *T. macedonicus* (Wells, 2007) and *Ommatotriton ophryticus* (Baskale et al., 2011). According to Džukić (1990), the incidence of paedomorphic individuals is very high (more than 50%) in some populations of alpine and smooth newts in the Balkans, but in the crested newts (*Triturus cristatus* superspecies) facultative paedomorphosis appears to be rare; only single paedomorphic individuals were recorded. To date, there are a few recorded cases of paedomorphic crested newts in Europe. Thus, Schriber (1912) found near Gorica specimens of paedomorphic crested newt with well-developed gills but with some adult characteristics. In addition, Frazer (1983) reported paedomorphosis among crested newt individuals in England. Recently, a number of paedomorphic individuals were found in Montenegro, in which numerous larvae have prolonged growth due to overwintering (Kalezić and Džukić, 1990). These larvae usually metamorphose into immature juveniles during the following year. To date, only one population of *T. macedonicus* from the Montenegrin karst area has been found with a few sexually mature newts with larval morphology (Kalezić et al., 1994). In this paper, new evidence of paedomorphic Macedonian crested newt (*T. macedonicus*) from Montenegro will be reported. This is very important evidence because paedomorphosis is extremely rare in crested newts. Therefore, every occurrence of such individuals should be registered.

The Montenegrin karst area, a restricted part of the Dinaric Alps, is an important region where paedomorphic populations of all three species of European newts (*Lissotriton vulgaris*, *Ichthyosaura alpestris* and *Triturus macedonicus*) have been found. The karst of Montenegro is a limestone area of exposed karst, and in spite of very high precipitation (3 500 mm per year on average), the highly porous limestone base is responsible for extreme aridity during summer. In the Montenegrin karst, crested newt inhabits artificial fishless breeding sites such as ubao and lithotelma with permanent alkaline water (pH between 8 and 9) (Ćirović et al., 2008).

MATERIALS AND METHODS

On 29 May, 1996, Dr Georg Džukić found paedomorphic Macedonian crested newt (*Triturus macedonicus*) in the locality Vrba, near the town of Tuzi (10 km from Podgorica) toward the Dečić mountain (613 m a.s.l), Montenegro (42˚ 22’ N, 19˚ 20’ E). The newt was collected from a small artificial water body called an ubao, about 3 m wide, using a hand net. This ubao lies in a marshy meadow about 450 m a.s.l., in the shade of a fig tree. The major part of the surroundings belongs to karst with scanty stands of crack plant dwellers. Climatic conditions are typical for the Mediterranean region, with hot and dry summers and rainy, mild autumns and winters. The paedomorphic specimen was conserved in 70% ethanol and stored in the Herpetological Collection of the Institute for Biological Research “Siniša Stanković” in Belgrade. Morphometric measurements were taken with a dial caliper with 0.1 mm precision.

RESULTS AND DISCUSSION

The specimen was measured for the following morphometric characters: total length (L) 79.92 mm and snout-vent length (SVL) 45.61 mm, measured from the snout to the posterior edge of cloaca basis. The sex of the individual could not be determined by external secondary sexual characteristics. The paedomorphic specimen was recognized by gonad inspection after dissection. Based on the reproductive organs it was found that paedomorphic specimen was female that was not sexually mature.

In the crested newt (*T. cristatus* superspecies) its unique life-history leads to obligate metamorphosis, i.e. facultative paedomorphosis is extremely rare. In addition, very large overwintered larvae of the crested newt may sometimes be found and these tadpoles in the following year can give rise to a group of paedomorphic adults (Kalezić, 1990). The female de-

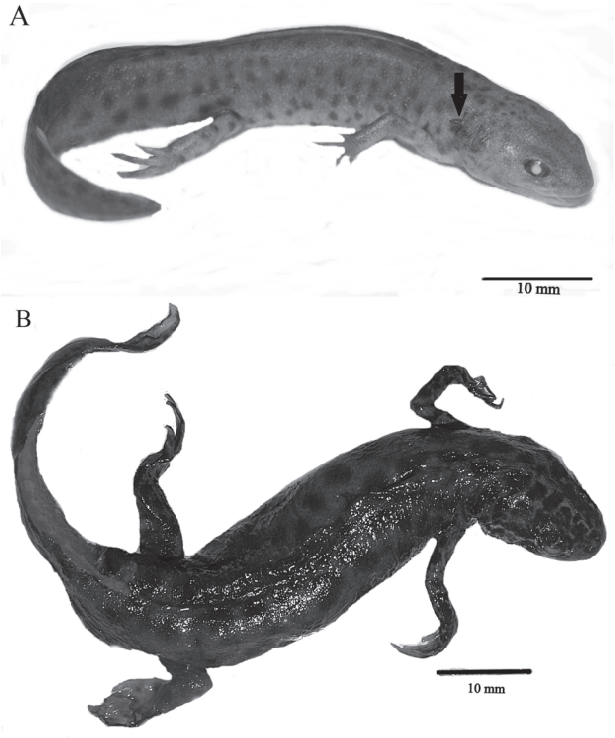

Fig. 1. A – Paedomorphic female *Triturus macedonicus* (dorsal view) with characteristic paedomorphic features; the arrow indicates small gills on the head. **B** – adult morphology (without gills on the head).

scribed here represents a paedomorphic specimen despite its small size and sexual immaturity (Figs 1 and 2). In addition, at the same locality paedomorphic males with well developed cloaca, which indicates sexual maturity and the presence of paedomorphosis, were found.

Acknowledgments - This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Grant No. 173043. I am grateful to M. Kalezić and G. Džukić for their very helpful and constructive comments.

REFERENCES

Baskale, E., Sayim, F. and *Kaya, U.* (2011). Body size and reproductive characteristics of paedomorphic and metamorphic individuals of the northern banded newt (*Ommatotriton ophryticus*). *Acta Herpetol.* **6**, 19-25.

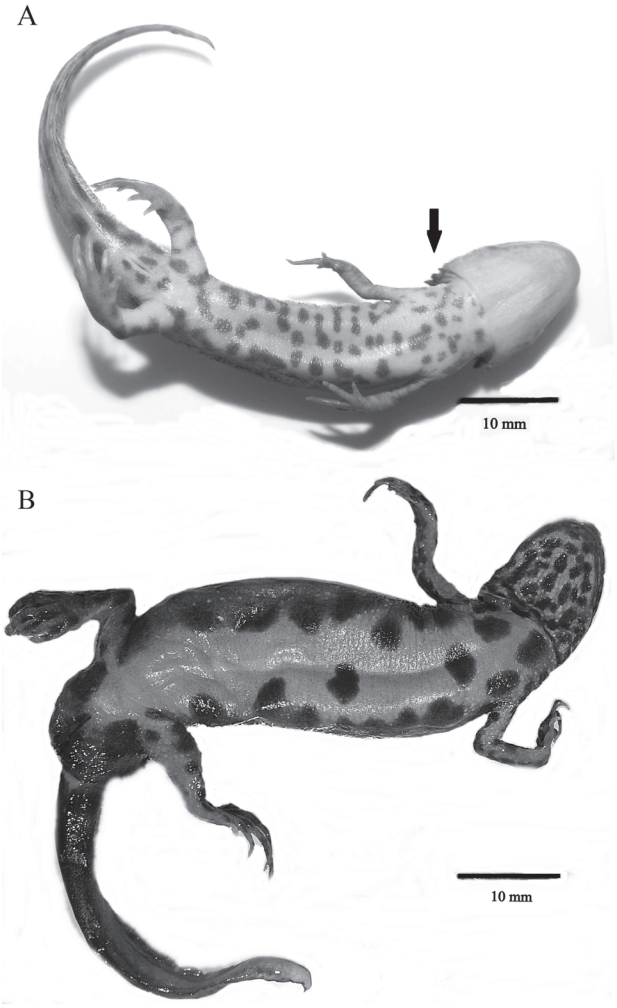

Fig. 2. A – Paedomorphic female *Triturus macedonicus* (ventral view) with a small spot on the belly; the black arrow points to small gills on the head. **B** – adult morphology (without gills on the head), with a large spot on the belly.

Ćirović, R., Vukov, T.D., Radović, D., Džukić, G. and *Kalezić, M.L.* (2008). Distribution patterns and environmental determinants of European newts in the Montenegrin karst area. *Biologia* **63**, 5-1.

Denoël, M., Whiteman, H.H. and *Joly, P.* (2005). Evolutionary ecology of facultative paedomorphosis in newts and salamanders. *Biol. Rev.* **80**, 663–671.

Denoël, M., Ivanović, A., Dzukić, G. and *Kalezić, M.L.* (2009). Sexual size dimorphism in the evolutionary context of facultative paedomorphosis: insights from European newts. *BMC Evol. Biol.* **9**, 278.

Djorović, A. and *Kalezić, M.L.* (2000). Paedogenesis in European newts (*Triturus*: Salamandridae): Cranial morphology during ontogeny. *J. Morphol.* **243**,127-139.

Džukić, G., Kalezić, M.L., Tvrtković, N. and *Djorović, A.* (1990). An overview of the occurrence of paedomorphosis in Yugoslav newt (*Triturus*, Salamandridae) populations. *BHS Bulletin* **34**,16-22.

Frazer, D. (1983). Reptiles and amphibians in Britain. Collins, London.

Kalezić, M.L., Cvetković, D., Djorović, A. and *Džukić, G.* (1994) Paedomorphosis and differences in life-history traits of two neighbouring crested newt (*Triturus carnifex*) populations. *Herpetol. J.* **4**, 151-158.

Kalezić, M.L., Crnobrnja, J., Djorović, A. and *Džukić, G.* (1992). Sexual size difference in *Triturus* newts: geographical variation in Yugoslav populations. *Alytes* **10**, 63–80.

Kalezić, M.L. and *Džukić, G.* (1990). Evidence for paedomorphosis in the crested Newt (*Triturus cristatus* complex) from Yugoslavia. *Bull. Nat. Hist. Mus. Belgrade B* **45**, 127-132.

Kalezić, M.L., Dzukić, G. and *Popadić, A.* (1989). Paedomorphosis in Yugoslav Alpine newt (*Triturus alpestris*) populations: morphometric variability and sex ratio. *Arch. Biol. Sci.* **41**, 67-79.

McKinney, M.L. and *McNamara, K.J.* (1991). Heterochrony. The evolution of ontogeny. Plenum Press, New York.

Schreiber, E. (1912). Herpetologia Europae. Gustav Fischer, Jena.

Tucić, N., Kalezić, M.L. and *Dzukić, G.* (1985). Morphometric variability in the *Triturus vulgaris* population with facultative paedomorphosis. *Zool. Anz.* **215**,102-108.

Wells, K.D. (2007). The ecology and behavior of amphibians. The University of Chicago Press, Chicago and London.

Whiteman, H.H. (1994). Evolution of facultative paedomorphosis in salamanders. *Q. Rew. Biol.* **69**, 205-221.