

First observation of facultative paedomorphosis in the Danube crested newt (*Triturus dobrogicus* Kiritzescu, 1903) and the occurrence of facultative paedomorphosis in two newt species from soda pans of the Danube-Tisza Interfluve (Kiskunság National Park, Hungary)

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Abstract. The first observation of paedomorphosis in *Triturus dobrogicus* and the occurrence of facultative paedomorphosis in two newt species (*T. dobrogicus* and *Lissotriton vulgaris*) from soda pans of the Danube-Tisza Interfluve, Hungary are reported in this paper. Facultative paedomorphosis in soda pans occurred in 2010, a year with extremely high precipitation. The favorable environmental conditions created enabled newt populations to extend their aquatic life stage in otherwise unsuitable (too saline), though fish-free habitats. As such, soda pans may provide a suitable aquatic environment for local newt populations in rainy years, and facultative paedomorphosis may be an important adaptation allowing early reproduction in the following year possible in an environment that frequently dries out.

Key words: paedomorphosis, *Triturus dobrogicus*, *Lissotriton vulgaris*, soda pans, Hungary.

Induced by the changing environment and genetic factors (Semlitsch 1987, Semlitsch et al. 1990, Whiteman 1994, Denoël et al. 2005b) paedomorphosis (neoteny sensu lato, Dubois 1985) is common in urodeles (Amphibia: Caudata). It is known in about 60 urodele species from nine families around the world (Denoël et al. 2005b, Kaya et al. 2008). It has been described in 17 European urodele species under natural conditions so far. In most cases it is a rare phenomenon but in five species (*Pleurodeles waltl*, *Lissotriton helveticus*, *Lissotriton vulgaris*, *Mesotriton alpestris*, *Triturus carnifex*) over 130 paedomorphic populations have been found (Ceacero et al. 2010, Covaciu-Marcov et al. 2011, Denoël & Andreone 2003, Denoël 2007, Denoël et al. 2009, Gabrion et al. 1977, 1978, Henle 1983). Before this article was published, five species from the *Triturus* genus (*T. cristatus*, *T. carnifex*, *T. marmoratus*, *T. pygmaeus*, *T. macedonicus*) were known to have paedomorphic individuals (Caetano-Castanet 1993, Ceacero et al. 2010, Covaciu-Marcov & Cicort-Lucaciu 2009, Cyrén 1945, Denoël et al. 2009b, Dolmen 1978, Fasola & Canova 1992, Fuentes et al. 2011, Kalezić et al. 1994, Piazzini et al. 2005, Zeller 1899). In our paper, we present the first observation of facultative paedomorphosis in a sixth species from the genus, the Danube crested newt (*Triturus dobrogicus*). We also provide the first description of paedomorphic

newt species that developed in soda pans with high conductivity in 2010.

A survey was undertaken to monitor aquatic macroinvertebrates in five soda pans (Kelemen-szék, Zab-szék, Büdös-szék, Böddi-szék and Fehér-szék) in the Danube-Tisza Interfluve (Kiskunság National Park, Hungary) by using the 'monolith' method, a sampling method for the quantitative collection of aquatic macroinvertebrates.

During that survey, a fully-grown and fully developed, facultative paedomorphic female Danube crested newt (*Triturus dobrogicus*) with characteristic adult morphology (head size and shape, colouration of the belly, back and tail) was caught in the northern part of Zab-szék (N 46°50'32.74", E 19°10'33.15") on 30th July, 2010 (Fig. 1.). It had an estimated total length of over 120 mm. *Triturus dobrogicus* is a typical newt species of the Great Hungarian Plain (Puky et al. 2005). In addition to the paedomorphic specimen, a metamorphic female *T. dobrogicus* was also found nearby in the same lake (N 46°49'48.52", E 19°10'52.05"). During the autumn survey of the same area a facultative paedomorphic female smooth newt (*Lissotriton vulgaris*) was also found at another site, a freshwater spillage near Kelemen-szék soda pan (N 46°47'59.81", E 19°10'19.56") on 5th October, 2010. Its total and snout-vent length were 65 and 35 mm, respectively and its weight was 1.3 grams. Because

Table 1. Mean water depth, mean conductivity and total annual precipitation of the Zab-szék soda pan in the summer of 1999-2001 and 2010 (water depth and conductivity were calculated from data of six to sixteen sampling sites collected four times from June to the beginning of August).

| Year | Mean water depth (cm) | Mean conductivity ($\mu\text{S}/\text{cm}$ at 25°C) | Total annual precipitation (mm) |
|------|-----------------------|--|---------------------------------|
| 1999 | 23.6 | 5,920 | 790 |
| 2000 | 19.5 | 8,900 | 405 |
| 2001 | 15.8 | 10,830 | 610 |
| 2010 | 46.7 | 3,330 | 959 |



Figure 1. Faculative paedomorphic female Danube crested newt (*Triturus dobrogicus*) caught on 30th July, 2010, at Zab-szék soda pan (Photo: Vivien Blanka Viski).

of the significant seasonal water level fluctuation, the salinity of both investigated alkali waters shows hyposaline ($3\text{-}20\text{gL}^{-1}$) and mesosaline ($>20\text{gL}^{-1}$) values. These lakes are characterized by the dominance of Na^+ , HCO_3^- , CO_3^{2-} , and Cl^- ions and a pH ranging between 9 and 10 (Schmidt 2003). Both alkali waters have volatile chemical systems consisting of four components, of which Na_2CO_3 , NaHCO_3 , $\text{Ca}(\text{HCO}_3)_2$ are in dissociation and CaCO_3 is in an undissolved condition (Boros 1999). The water level of the soda pans fluctuates greatly over the years (Table 1.). This affects the fauna that they support. During a similar monitoring survey in 1999-2001, for example, no amphibians were found in the same habitats (Lengyel & Kiss, Debrecen, pers. comm. 2012). This can be linked to salt concentration, and thus, conductivity changes of the water (Table 1.), which was within the range amphibians can tolerate only in 2010. This difference was caused by the 959 mm of annual precipitation in 2010, the highest precipitation level since 1901 in Hungary. The 100 year av-

erage is only 560 mm (OMSZ 2012). The development of paedomorphosis was described several times in waters with pH over 7 and is therefore likely to be more common than previously thought (Denoël et al. 2009a). However, the successful larval development of amphibians is an unlikely event in soda pans with high conductivity. This is because even moderate levels of salinity are sufficient to significantly reduce survival and delay the development of amphibian larvae (Chinathamby et al. 2006). Smith et al. (2007), for example, reported $6,000 \mu\text{Scm}^{-1}$ at 25 °C as a threshold for largely excluding amphibian larvae from saline wetlands in Australia with no effect below $3,000 \mu\text{Scm}^{-1}$. This is comparable to our findings. Similarly to what we found, high precipitation was also suspected to help the development of paedomorphosis in *L. vulgaris* (Ghergel et al. 2010) described from 2007 in waters with moderate salinity in Romania (Covaciu-Marcov & Cicort-Lucaciu 2007, 2009). This effect was also recognised in soda pans, such as the Zab-szék, of the Danube-Tisza Interfluve. In 2010, these pans did not dry out by late-summer as they usually do in years with low or average total precipitation (e.g. 2000 and 2001, respectively). In wet years, soda pans may have an advantage for newts over nearby permanent potential breeding sites due to the absence of fish predators. A paedomorphic life strategy (Denoël et al. 2005a) enables earlier reproduction in the following year; a vital phenomenon in an environment that frequently dries out (Denoël 2003). Thus, according to our findings, in rainy years soda pans may provide a suitable, in some respects even favourable, aquatic environment for local newt populations. In wet years, the conductivity of their water is lower than usual and faculative paedomorphosis may be an important adaptation to the changing environment under such conditions.

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References

- Boros, E. (1999): A magyarországi szikes tavak és vizek ökológiai értékelése (Ecological state and nature conservation of sodic water bodies in Hungary). *Acta Biologica Debrecina, Supplementum Oecologica Hungarica* 9: 13–80. [in Hungarian with English summary]
- Caetano, M.H., Castanet, J. (1993): Variability and microevolutionary patterns in *Triturus marmoratus* from Portugal: age, size, longevity and individual growth. *Amphibia-Reptilia* 14: 117–129.
- Ceacero, F., Donaire-Barroso, D., García-Muñoz, E., Beltrán, J.F., Tejado, M. (2010): On the occurrence of facultative paedomorphosis in the three newt species of Southern Iberian Peninsula (Amphibia, Salamandridae). *Amphibia-Reptilia* 31(4): 571–575.
- Çevik, İ.E., Atatür, M.K., Arıkan, H., Akyurtlaklı, N. (1997): Occurrence of neotenic *Triturus vulgaris* (Urodela: Salamandridae) larvae in western Anatolia. *Israel Journal of Zoology* 43: 301–304.
- Chinathamy, K., Reina, R.D., Bailey, P.C.E., Lees, B.K. (2006): Effects of salinity on the survival, growth and development of tadpoles of the brown tree frog, *Litoria ewingii*. *Australian Journal of Zoology* 54 (2): 97–105.
- Covaci-Marcov, S.D., Cicort-Lucaciu, A.Ş. (2007): Notes on the presence of facultative paedomorphosis in the smooth newt *Lissotriton vulgaris* (Linnaeus, 1758) in western Romania. *North-Western Journal of Zoology* 3: 53–57.
- Covaci-Marcov, S.D., Cicort-Lucaciu, A.S. (2009): Big and nonmethamorphic *Triturus cristatus* larvae from north-western Romania. *Bihorean Biologist* 3: 87–89.
- Covaci-Marcov, S.D., Sas, L., Cicort-Lucaciu, A.Ş., Bogdan, H.V. (2011): *Lissotriton vulgaris* paedomorphs in south-western Romania: consequence of a human modified habitat? *Acta Herpetologica* 6(1): 15–18.
- Cyrén, O. (1945): Fynd av större vattenödlan vid Stensele. *Fauna Och Flora* 40: 238.
- Denoël, M. (2003). How do paedomorphic newts cope with lake drying? *Ecography* 26: 405–410.
- Denoël, M. (2007): Priority areas of intraspecific diversity: Larzac, a global hotspot for facultative paedomorphosis in amphibians. *Animal Conservation* 10: 110–116.
- Denoël, M., Andreone, F. (2003): Trophic habits and aquatic microhabitat use in gilled immature, paedomorphic and metamorphic Alpine newts (*Triturus alpestris apuanus*) in a pond in central Italy. *Belgian Journal of Zoology* 133: 95–102.
- Denoël, M., Duguet, R., Džukić, G., Kalezić, M.L., Mazzotti, S. (2001): Biogeography and ecology of paedomorphosis in *Triturus alpestris* (Amphibia, Caudata). *Journal of Biogeography* 28: 1271–1280.
- Denoël, M., Džukić, G., Kalezić, M. (2005a): Effect of widespread fish introductions on paedomorphic newts in Europe. *Conservation Biology* 19: 162–170.
- Denoël, M., Ficetola, G.F., Čirović, R., Radović, D., Džukić, G., Kalezić, M.L., Vukov, T.D. (2009a). A multi-scale approach to facultative paedomorphosis of European newts in the Montenegrin karst: distribution pattern, environmental variables and conservation. *Biological Conservation* 142: 509–517.
- Denoël, M., Ivanović, A., Džukić, G., Kalezić, M.L. (2009b): Sexual size dimorphism in the evolutionary context of facultative paedomorphosis: insights from European newts. *BMC Evolutionary Biology* 9: 278.
- Denoël, M., Joly, P., Whiteman, H.H. (2005b): Evolutionary ecology of facultative paedomorphosis in newts and salamanders. *Biological Reviews* 80: 663–671.
- Dolmen, D. (1978): De neotene salamanderne (“skrattaborrene”) ved Stensele. *Fauna og Flora* 4:171–177.
- Dubois, A. (1985): Neoteny and associated terms. *Alytes* 4 (4): 122–130.
- Fasola, M., Canova, L. (1992): Feeding habits of *Triturus vulgaris*, *T. cristatus* and *T. alpestris* (Amphibia, Urodela) in the northern Apennines (Italy). *Bollettino di Zoologia* 59: 273–280.
- Fuentes, J., García-Cardenete, L., Escoriza, E., Esteban, J.L., Benavides, J. (2011): Neotenia en *Triturus pygmaeus*. Observación en el sur de Jaén. *Boletín de la Asociación Herpetológica Española* 22: 96–98.
- Gabrion, J., Sentein, P., Gabrion, C. (1977): Les populations néoténiques de *Triturus helveticus* Raz. des Causses et du Bas-Languedoc. I. Répartition et caractéristiques. *Revue d'Ecologie* 31: 489–506.
- Gabrion, J., Sentein, P., Gabrion, C. (1978): Les populations néoténiques de *Triturus helveticus* Raz. des Causses et du Bas-Languedoc. II. Ecologie. *Revue d'Ecologie* 32: 577–610.
- Gherghel, I., Strugariu, A., Ghira, I. (2010): On the presence of paedomorphosis in *Lissotriton vulgaris* (Amphibia: Salamandridae) from Danube Delta. *Herpetologica Romanica* 4: 62–64.
- Henle, K. (1983): Eine neue neotene population des bergmolches *Triturus alpestris* (Laurenti, 1768) (Caudata: Salamandridae). *Salamandra* 19: 151–157.
- Kalezić, M.L., Cvetković, D., Djorovic, A., Džukić, G. (1994): Paedomorphosis and differences in life-history traits of two neighboring crested newt (*Triturus cristatus*) populations. *Herpetological Journal* 4: 151–158.
- Kaya, U., Sayim, F., Başkale, E., Çevik, İ.E. (2008): Paedomorphosis in the banded newt, *Triturus vittatus* (Jenyns, 1835). *Belgian Journal of Zoology* 138: 196–197.
- OMSZ (2012): Magyarország éghajlata. <http://www.met.hu/eghajlat/magyarorszag_eghajlata/eghajlati_visszatekinto/acces sed on 30. November 2012>
- Piazzini, S., Favilli, L., Manganeli, G. (2005): L'erpetofauna del sir 120 “Monte Penna, Bosco della Fonte e Monte Civitella” (Castell’Azzara-Sorano, Grosseto) (Toscana meridionale) herpetofauna of the sir. *Atti del Museo di Storia Naturale della Maremma* 21: 15–24.
- Puky, M., Schád, P., Szövényi, G. (2005): Magyarország herpetológiai atlasza. *Herpetological atlas of Hungary*. Varangy Akciócsoport Egyesület, Budapest.
- Schmidt, A. (2003): Kiskunsági szikes tavak (KNPII) összehasonlító vízkémiai vizsgálata (Comparing water chemical investigation of sodic ponds in the Kiskunság National Park (KNPII)). *Természetvédelmi Közlemények* 10: 153–162. [in Hungarian with English summary]
- Semlitsch, R.D. (1987): Paedomorphosis in *Ambystoma talpoideum*: effects of density, food and pond drying. *Ecology* 68: 994–1002.
- Semlitsch, R.D., Harris, R.N., Wilbur, H.M. (1990): Paedomorphosis in *Ambystoma talpoideum*: maintenance of population variation and alternative life-history pathways. *Evolution* 44: 1604–1613.
- Smith, M.J., Schreiber, S.G., Scroggie, M.P., Kohout, M., Ough, K., Potts, J., Lennie, R., Turnbull, D., Jin, C., Clancy, T. (2007): Associations between anuran tadpoles and salinity in a landscape mosaic of wetlands impacted by secondary salinisation. *Freshwater Biology* 52: 75–84.
- Whiteman, H.H. (1994): Evolution of facultative paedomorphosis in salamanders. *Quarterly Review of Biology* 69: 205–221.
- Zeller, V.E. (1899): Zur Neotenie der Tritonen. *Jahreshefte des Vereins für Vaterländische Naturkunde in Württemberg* 55: 23–35.