Journal of
Molluscan Studies

The Malacological Society of London

Journal of Molluscan Studies (2017) **83**: 240–242. doi:10.1093/mollus/eyx007

RESEARCH NOTE

Successful reintroduction of the endangered black nerite, *Theodoxus prevostianus* (Pfeiffer, 1828) (Gastropoda: Neritidae) in Hungary

Zoltán Fehér[1,2], Gábor Majoros[3], Sándor Ötvös[4], Bálint Bajomi[5] and Péter Sólymos[6]

[1]*Central Research Laboratory and 3rd Zoology Department, Natural History Museum Vienna, 7 Burgring, A-1010 Vienna, Austria;*
[2]*Department of Zoology, Hungarian Natural History Museum, 13 Baross utca, H-1088 Budapest, Hungary;*
[3]*Department of Parasitology and Zoology, University of Veterinary Medicine, 2 István utca, H-1078 Budapest, Hungary;*
[4]*98 Szent István király út, H-3421 Mezőnyárád, Hungary;*
[5]*Doctoral School of Environmental Sciences, ELTE University, 1/a Pázmány Péter sétány, H-1117 Budapest, Hungary; and*
[6]*Department of Biological Sciences, CW 405, Biological Sciences Building, University of Alberta, Edmonton, Alberta, Canada T6G 2E9*

Correspondence: Z. Fehér; e-mail: zoltan.feher@nhm-wien.ac.at

Freshwater molluscs, particularly narrow-range endemics restricted to a single spring or short stream reaches, are highly susceptible to habitat loss and degradation. For this reason, the modern extinction rate of freshwater molluscs is one of the highest among animal taxa (Régnier, Fontaine & Bouchet, 2009; Johnson *et al.*, 2013) and a high percentage of extant species is threatened by extinction (Cuttelod, Seddon & Neubert, 2011; Johnson *et al.*, 2013). To prevent extinctions of species and populations, translocation and reintroduction is of increasing importance in species conservation (Armstrong & Seddon, 2007; Ewen *et al.*, 2012). But there is significant taxonomic bias in the number of reintroduction programmes and the resulting publications, which favours vertebrates, especially birds and mammals (Fischer & Lindenmayer, 2000; Bajomi *et al.*, 2010). Among the few reported freshwater mollusc translocations and reintroductions, one can find mostly unionid mussels (e.g. Cope & Waller, 1995; Peredo *et al.*, 2005; Layzer & Scott, 2006; Tiemann *et al.*, 2016), while gastropod reintroductions are surprisingly rare (Ahlstedt, 1991; COSEWIC, 2008) compared with their diversity and the high number of imperilled species (Lydeard *et al.*, 2004; Cuttelod *et al.*, 2011).

Here we report on the successful reintroduction of the black nerite, *Theodoxus prevostianus* (Pfeiffer, 1828), a rare and endangered freshwater gastropod. This species is distributed in the Pannonian biogeographical region of central Europe and inhabits hypothermal springs. Historically, 15–20 populations were known, but the majority have become extinct during the past 50 years (Kormos, 1905, 1906; Schréter, 1915; Wagner, 1927, 1937; Soós, 1943; Gagiu, 2004). Now, only four remaining populations are known: two in Austria (Bad Vöslau and Bad Fischau), one in Slovenia (Bušeča vas) and one in Hungary (Kács). As demonstrated by the recent extinction of the Răbăgani population in 2007 (Sîrbu & Benedek, 2009) and the almost fatal collapse in the size of the Kács population in 2010 (Fehér *et al.*, 2011), this species is classified as endangered according to the IUCN Red List criteria based on area of occupancy and population trend (Sólymos & Fehér, 2011).

The intraspecific molecular diversity and phylogenetic relationships among populations of *T. prevostianus* were investigated prior to planning and executing any conservation action regarding the species. Three diverging intraspecific mitochondrial lineages were revealed, of which one comprised the Kács population (Fehér *et al.*, 2009). This was a good reason to treat the Kács population as a distinct conservation unit and it gave a final impulse to the decision to establish one or more refuge populations at new locations. There was already a reported case of a benign introduction of this species in 1909. Lajos Soós introduced some specimens from Tata to Budapest (Római-fürdő) and the newly established population existed for decades (Wagner, 1927; Soós, 1943). This case indicated the likelihood of successful establishment of the species given favourable environmental conditions at the new location.

The reintroduction of *T. prevostianus* was planned to be a strict reintroduction in the sense of IUCN/SSC (2013), therefore the proposed recipient site was one of the historic locations of this species (Lator Spring near Sály village; 47.9820°N, 20.6318°E, *c.* 3 km in straight-line distance from the donor population). Lator spring has been utilized by the local waterworks since the 1970s and at first there were periods when its full volume was captured and the outflow stream dried out, which led to the extinction of the original population. In the following decades, despite several searches, *T. prevostianus* has not been detected at Sály. Recently, the continuous availability of water in the stream has been assured. As indicated by the low chemical oxygen demand of the water (<10 mg/l) and the composition of the macroscopic invertebrate fauna (e.g. by the presence of the narrow-range hydrobiid *Bythinella pannonica* (Frauenfeld, 1865)), habitat conditions also seem to be adequate. The first 25-m section of the outflow runs in a concrete channel; downstream the stream bed is mainly silty but there are some scattered cobbles and boulders (5–30 cm in diameter) and also some concrete structures that offer solid surfaces for attachment of *T. prevostianus*.

The reintroduction proposal was given permission in March 2010. We were only allowed to capture 200 adult specimens per year between 2010 and 2012, a total of 600 adult specimens altogether. It was clear that the amount of captured animals must not imperil the stability of the donor population (IUCN/SSC, 2013). Nevertheless, the allowed yearly quota of 200 specimens seemed overly cautious, considering the ordinary population size of 10^5–10^6 adult specimens at Kács at the time (Varga, Ötvös & Fűköh, 2007). The main problem with a small number of individuals was that nerites are dioecious, without apparent sexual dimorphism. Therefore, it was impossible to determine the sex ratio in the donor population. In an extreme situation, a skewed sex ratio combined with small number of individuals can result in the complete exclusion of one sex. Considering this risk, we preferred not to spread the permitted quantity into more than two batches (200 specimens in 2010 and 400 in 2012) and we tried to select as many specimens with unhatched egg capsules attached to their shells as possible. We carried out both translocations in late autumn, because it was known from Austrian *T. prevostianus* populations that there is increased egg-laying activity from August to February and there are two waves of increased mortality in September and in March (Piringer, 2002). Animals were hand collected and carried between wet tissue paper in a plastic cooling box. The duration of the transport was <30 min, therefore the box was neither cooled nor heated actively. The specimens were acclimatized gradually to the temperature of the recipient environment in a plastic bucket before releasing to the wild. The animals were released at two spots about 15 and 30 m from the spring's outflow. The first spot was in the concrete section and the second in the natural section of the brook. Animals were initially sheltered by small clay pots to avoid immediate drifting of withdrawn specimens caused by the strong water current in the stream.

We defined three stages of success for the reintroduction, following Seddon (1999). Short-term success was defined by the survival of the translocated population at the new location, mid-term success by the presence of locally hatched offspring, while long-term success was defined by the permanent establishment of a self-sustaining population. The follow-up monitoring was performed somewhat irregularly, on average twice a year (see Supplementary Material). Neither living specimens nor empty shells were found until August 2014, almost two years after the second translocation. At the following visit on 24 October 2015, however, numerous adult specimens were detected. One year later (15 October 2016) the population still existed and was found to occupy at least a 400–500 m section downstream from the outlet. Some of the living specimens were observed upstream from the upper release spot, demonstrating the species' ability to spread upstream. Some of the nerites were found to carry the remnants of freshly hatched egg capsules attached to their shells. We set random quadrats of 30 × 30 cm along the populated stream section to count those animals that were visible to the naked eye. Extrapolating these quadrat counts to the whole populated area, the number of adult and subadult specimens was estimated to be 5,000–20,000. These observations let us to assume that most, if not all, of the observed individuals were born and developed *in situ*, which indicated the success of the introduction in the mid-term. For the assessment of long-term success, of course, further population monitoring is necessary.

The most noteworthy lesson of our programme was the long latency of the reintroduced population. At least two years passed after the second round of translocations, during which the density of the establishing population remained below the detection threshold. The sudden increase in population size started just after that. This long latency underlines the importance of long-term follow-up monitoring in any gastropod reintroduction programme.

SUPPLEMENTARY MATERIAL

Supplementary Material is available at *Journal of Molluscan Studies* online.

ACKNOWLEDGEMENTS

The reintroduction action plan gained its final form after discussions with a wide range of hydrobiologists, malacologists and conservation colleagues. The final plan had support from the Bükk National Park Directorate and the Nature Protection and Conservation Biology Committee of the Hungarian Academy of Sciences. Permission was given by the Hungarian National Inspectorate for Environment, Nature and Water (OKTVF 14/2251-4/2010) and from the North Hungarian Inspectorate for Environment, Nature and Water (ÉMKTVF 12526-3/2010). We are grateful to Ferenc Végh for providing access to his private land at Kács. Special thanks are due to Zoltán Péter Erőss and Zita Kemencei for their assistance in the fieldwork and to Erika Bagladi and Szabolcs Mosonyi for their help in raising public awareness for the project. Z.F. was supported by the Austrian Science Fund (FWF P 26581-B25).

REFERENCES

AHLSTEDT, S.A. 1991. Reintroduction of the spiny river snail *Io fluvialis* (Say, 1825) (Gastropoda: Pleuroceridae) into the North Fork Holston River southwest Virginia and northeast Tennessee. *American Malacological Bulletin*, **8**: 139–142.

ARMSTRONG, D.P. & SEDDON, P.J. 2007. Directions in reintroduction biology. *Trends in Ecology and Evolution*, **23**: 20–25.

BAJOMI, B., PULLIN, A.S., STEWART, G.B. & TAKÁCS-SÁNTA, A. 2010. Bias and dispersal in the animal reintroduction literature. *Oryx*, **44**: 358–365.

COPE, W.G. & WALLER, D.L. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. *Regulated Rivers: Research and Management*, **11**: 147–155.

COSEWIC 2008. *COSEWIC assessment and update status report on the Banff Springs Snail,* Physella johnsoni *in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa.

CUTTELOD, A., SEDDON, M. & NEUBERT, E. 2011. *European Red List of non-marine molluscs*. Publications Office of the European Union, Luxembourg.

EWEN, J.G., ARMSTRONG, D.P., PARKER, K.A. & SEDDON, P.J. 2012. *Reintroduction biology. Integrating science and management.* Wiley-Blackwell, Oxford.

FEHÉR, Z., ZETTLER, M.L., BOZSÓ, M. & SZABÓ, K. 2009. An attempt to reveal the systematic relationship between *Theodoxus prevostianus* (C. Pfeiffer, 1828) and *Theodoxus danubialis* (C. Pfeiffer, 1828) (Mollusca, Gastropoda, Neritidae). *Mollusca*, **27**: 95–107.

FEHÉR, Z., MAJOROS, G., ÖTVÖS, S. & SÓLYMOS, P. 2011. Proposed re-introduction of the endangered Black Nerite, *Theodoxus prevostianus* (Mollusca, Neritidae) in Hungary. *Tentacle*, **19**: 36–39.

FISCHER, J. & LINDENMAYER, D.B. 2000. An assessment of the published results of animal relocations. *Biological Conservation*, **96**: 1–11.

GAGIU, A. 2004. On the extinction of the relict snail *Theodoxus prevostianus* Pfeiffer, 1828 in Răbăgani, Romania. *Nymphaea, Folia Naturae Bihariae (Oradea)*, **31**: 75–81.

IUCN/SSC 2013. *Guidelines for reintroductions and other conservation translocations. Version 1.0*. IUCN Species Survival Commission, Gland.

JOHNSON, P.D., BOGAN, A.E., BROWN, K.M., BURKHEAD, N.M., CORDEIRO, J.R., GARNER, J.T., HARTFIELD, P.D., LEPITZKI, D.A.W., MACKIE, G.L., PIP, E., TARPLEY, T.A., TIEMANN, J.S., WHELAN, N.V. & STRONG, E.E. 2013. Conservation status of freshwater gastropods of Canada and the United States. *Fisheries*, **38**: 247–282.

KORMOS, T. 1905. A püspökfürdői és tatai Neritinák kérdéséhez. *Állattani Közlemények*, **4**: 3–8.

KORMOS, T. 1906. Beiträge zur Molluskenfauna des kroatischen Karstes. *Nachrichtsblatt der Deutschen Malakozoologischen Gesellschaft*, **3**: 140–154.

LYDEARD, C., COWIE, R.H., PONDER, W.F., BOGAN, A.E., BOUCHET, P., CLARK, S.A., CUMMINGS, K.S., FREST, T.J., GARGOMINY, O., HERBERT, D.G., HERSHLER, R., PEREZ, K., ROTH, B., SEDDON, M., STRONG, E.E. & THOMPSON, F.G. 2004. The global decline of nonmarine mollusks. *BioScience*, **54**: 321–330.

LAYZER, J.B. & SCOTT, E.M. 2006. Restoration and colonization of freshwater mussels and fish in a southeastern United States tailwater. *River Research and Applications*, **22**: 475–491.

PEREDO, S., PARADA, E., VALDEBENITO, I. & PEREDO, M. 2005. Relocation of the freshwater mussel *Diplodon chilensis* (Hyriidae) as a strategy for its conservation and management. *Journal of Molluscan Studies*, **71**: 195–198.

PIRINGER, B. 2002. *Populationsdynamik und Verteilung von* Theodoxus prevostianus *(Neritidae: Prosobranchia) und* Esperiana daudebartii daudebartii *(Melanopsidae: Prosobranchia) im südlichen Wiener Becken*. PhD thesis, University of Vienna, Vienna.

RÉGNIER, C., FONTAINE, B. & BOUCHET, P. 2009. Not knowing, not recording, not listing: numerous unnoticed mollusk extinctions. *Conservation Biology*, **23**: 1214–1221.

SEDDON, P.J. 1999. Persistence without intervention: assessing success in wildlife reintroductions. *Trends in Ecology and Evolution*, **14**: 503.

SCHRÉTER, Z. 1915. Neue Fundorte zweier relikten Gastropoden-Arten aus Ungarn. *Állattani Közlemények*, **14**: 262–265.

SÎRBU, I. & BENEDEK, A.M. 2009. The extinction of *Theodoxus prevostianus* (C. Pfeiffer, 1828) (Mollusca: Gastropoda: Neritidae) in Romania. *Tentacle*, **17**: 19–21.

SÓLYMOS, P. & FEHÉR, Z. 2011. Theodoxus prevostianus. *IUCN Red List of threatened species 2011*: e.T165322A6004668.

SOÓS, L. 1943. *A Kárpát-medence Mollusca-faunája*. Hungarian Academy of Sciences, Budapest.

TIEMANN, J.S., DRESLIK, M.J., BAKER, S.J. & PHILLIPS, C.A. 2016. Assessment of a short-distance freshwater mussel relocation as viable tool during bridge construction projects. *Freshwater Mollusk Biology and Conservation*, **19**: 80–87.

VARGA, J., ÖTVÖS, S. & FŰKÖH, L. 2007. *Thedoxus prevostianus* C. Pfeiffer, 1828 kácsi lelőhelyei. *Malakológiai Tájékoztató*, **25**: 95–101.

WAGNER, J. 1927. A Római-fürdő környékének puhatestű faunája. *Természettudományi Közlöny (supplementum)*, **59**: 99–101.

WAGNER, J. 1937. Újabb adatok a Bükk-hegység Mollusca-faunájának ismeretéhez. *Állattani Közlemények*, **36**: 59–65.