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Pearls in Peril – Conserving and Reintroducing Freshwater Pearl Mussels

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Iain Sime MIEEM
Scottish Natural Heritage

Jackie Webley
Scottish Natural Heritage

Diane O'Leary
West Cumbria Rivers Trust

Nia Watkin
Natural Resources Wales

Lorna Wilkie
Rivers and Fisheries Trusts of Scotland

Steff Ferguson MIEEM
Rivers and Fisheries Trusts of Scotland

Flora Grigor-Taylor MIEEM
Rivers and Fisheries Trusts of Scotland

Freshwater pearl mussels *Margaritifera margaritifera* are one of the longest-lived invertebrates in the world and are critically endangered in Europe. The Pearls in Peril LIFE+ project has been working since 2012 to improve conditions for pearl mussels in 21 Special Areas for Conservation in Scotland, England and Wales. A range of techniques have been employed to restore suitable habitat, as well as reintroduce and reinforce the species in river reaches where it has become scarce.

Introduction

The Pearls in Peril (PIP) LIFE+ project is a four and a half-year initiative, led by Scottish Natural Heritage, that is raising awareness of the freshwater pearl mussel in order to secure and conserve our most important remaining populations (Figure 1). The project aims to improve riparian habitat, undertake in-stream habitat restoration, raise awareness of wildlife crime and restore some populations by moving larval pearl mussels.

Freshwater pearl mussels have a complex and long life cycle. In the summer, female pearl mussels release millions of microscopic

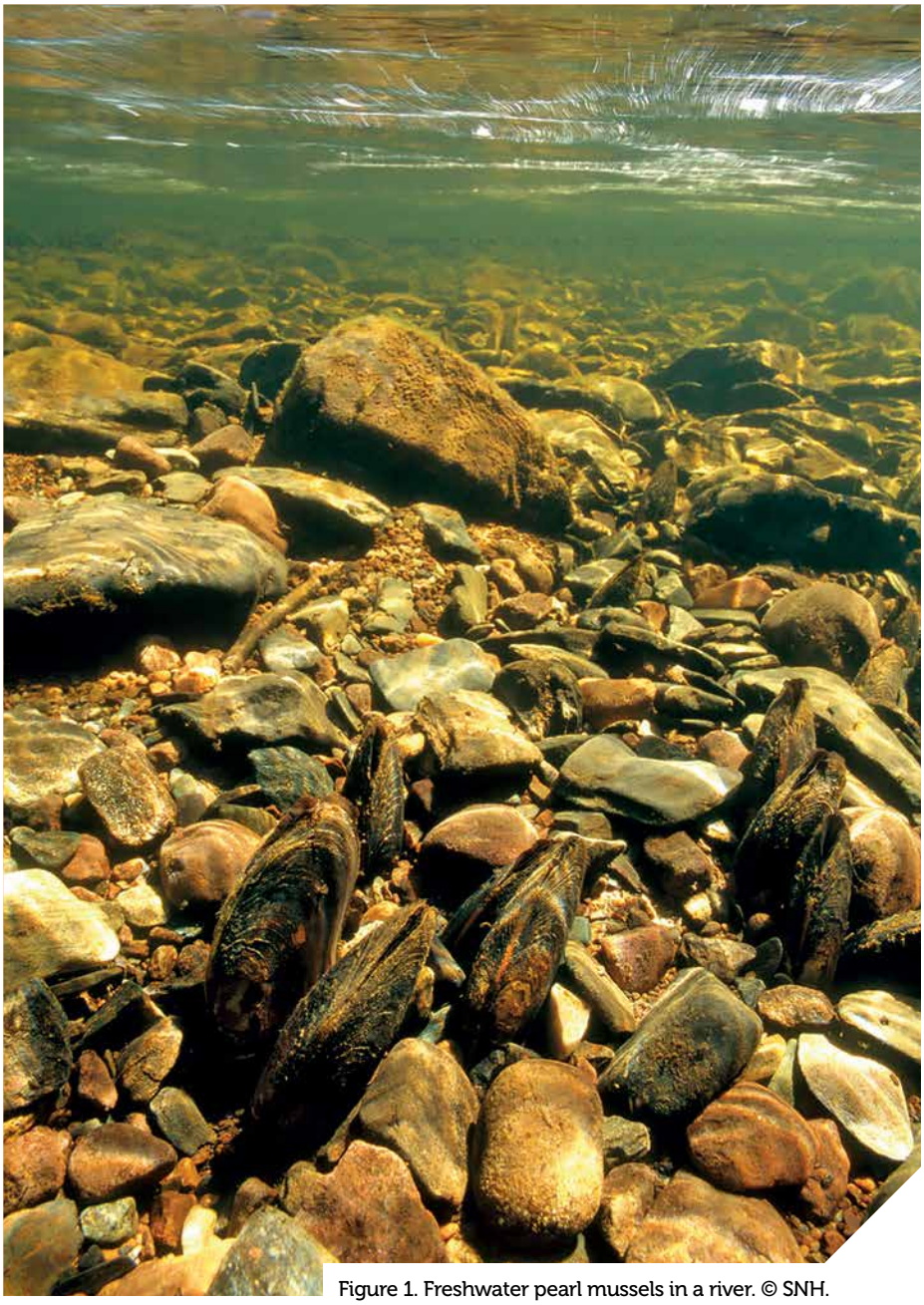

Figure 1. Freshwater pearl mussels in a river. © SNH.

larvae, called glochidia, into the water column. In order to complete the first stage of their lifecycle these glochidia must attach to the gills of a young Atlantic salmon *Salmo salar* or brown trout *S. trutta*. The glochidia may preferentially use a salmon and/or a trout as the host, depending on the preferences of particular populations. The glochidia grow harmlessly on the fish gills over the following winter. The following spring, the glochidia drop from the fish's gills and attempt to establish on a suitable clear gravel or coarse sand area of the riverbed. They can take 12-15 years to reach sexual maturity and can live for 100 years.

Due to pressures such as pearl fishing, river works and pollution, pearl mussels have declined or become absent from many rivers in Britain. In many cases, the juvenile mussels struggle to survive to adulthood, resulting in populations that are dominated by increasingly old adult animals. These aging populations often die out over time as a consequence. The species has declined globally by 61.5% and by 87% in Europe (Moorkens 2011). It is estimated that the freshwater mussel is now present in just 5% of its former range compared to the beginning of the 20th century (Mollusc Specialist Group 1996). Despite recent improvements to freshwater environments in the UK, the demanding water quality requirements of pearl mussels (Skinner *et al*. 2003) mean that problems persist for the species, with population losses continuing (Watt *et al*. 2015). This article describes a range of techniques being used to help restore several of our struggling pearl mussel populations.

Artificial encystment

The Pearls in Peril project includes work to help reintroduce and reinforce pearl mussel populations in areas where very few individuals were left but where negative impacts have been, or are being, addressed. A range of translocation techniques can be used, including moving adult mussels, rearing juveniles in captivity, and infecting wild or hatchery reared fish. The success of these techniques has recently been reviewed by Killeen and Moorkens (2016). Within the PIP project, techniques first developed in Germany (Altmüller and Dettmer 2000) have been adapted to devise a protocol for artificially encysting wild fish in the UK.

Figure 2. Well developed glochidia under the microscope. © Freshwater Biological Association.

The first step was to determine when gravid female pearl mussels were about to release their glochidia. Starting in July, and working under a protected species licence from Natural England or Scottish Natural Heritage, a small number of pearl mussels were examined to determine if there was development of any glochidia. The pearl mussel shells were opened using specially designed tongs and the mussel's gills were either examined directly by eye or an otoscope was inserted to allow the surveyor to identify if glochidia were present, evidenced by a pale creamy, brown colour on the mussel's gills. A small sample of glochidia was collected from inside the swollen gills using a syringe and needle. Trained staff carried out the work carefully to ensure no harm came to the pearl mussels.

Five stages of glochidial development have been identified (Scheder *et al*. 2011) allowing the best date for undertaking artificial encystment to be estimated as the glochidia progress through these stages. Only a very small number of pearl mussels need to be checked at any one time as the individuals in a population in a particular river tend to release their glochidia at the same time (Degerman *et al*. 2009).

Glochidia were sampled approximately every two weeks and when fully developed glochidia were seen, and were actively "snapping" (the shell valves were opening and closing) under the microscope, this indicated that their release was imminent (Figure 2). At that stage the glochidia were collected, under licence, by placing a small number of adult mussels in a bucket of river water. After a few minutes, as the dissolved oxygen concentration dropped and the temperature rose, the female mussels were induced to release their glochidia into the water. After the glochidia were released the adult mussels were returned to the river unharmed.

The glochidia were then transported, if necessary, to the donor location. During transportation, the water had to be kept cool and aerated to ensure the glochidia remain viable. At the donor site, juvenile salmonids were collected using standard electrofishing techniques (e.g. Scottish Fisheries Co-ordination Centre 2007). These fish were held in an aerated holding tank into which the glochidia had been introduced. The enclosed nature of the tank maximised the potential for the glochidia to attach to the gills of the fish. In order to ensure that the fish did not receive too high a glochidial load, fish were left in the tank for only a few minutes. The fish were carefully removed using nets and returned to the river. The process was repeated throughout the day in order to maximise the number of fish carrying glochidia.

This work has taken place over two to three years at three rivers so far. At this relatively early stage (in the lifecycle of such a slow growing animal) it is not possible to confirm that the work has resulted in increased production of juvenile pearl mussels as the mussels are still microscopic when they excyst from the fish. However, fish carrying heavy glochidial loads have been recorded in areas where adult pearl mussels are scarce, perhaps indicating this work has been a success. With the right habitat conditions, evidence suggests that this approach can ultimately help populations re-establish.

Host fish surveys

An important pre-requisite is to confirm the host salmonid species before artificially encysting glochidia to wild fish (of relevance to many other reintroduction efforts for pearl mussels). Although freshwater pearl mussels can use Atlantic salmon and/or brown trout, the specific host fish species can vary between rivers. A straightforward identification of the host species can be made when the glochidia have formed small characteristic white cysts on the fish gills, which are obvious to the naked eye in spring time (Figure 3).

In order to identify the host species, junvenile salmonids were collected using standard electrofishing techniques. When doing this work during spring, care needs to be taken not to disturb any salmon or trout redds in the river. The fish were anaesthetised and the operculum was lifted with a blunt instrument so that the exposed gill filaments could be examined for the presence of encysted glochidia. Care was taken not to make contact with gill filaments or gill arches in order not to damage host fish. Only the most anterior gills were visible and, therefore, counts of glochidia were probably an underestimate.

Figure 3. Glochidia (white spots) on salmonid gills. © Jon Watt/Waterside Ecology, SNH.

Of the four rivers where host salmonid species were confirmed within the PIP project, the pearl mussels were found to be utilising brown trout in two rivers and Atlantic salmon in two rivers. This reflects recent findings elsewhere in Scotland. The reason behind the host specificity is unclear but it is thought to reflect local adaptation.

Figure 4. Clean gravel being seeded into the Afon Eden SAC. © Natural Resources Wales.

Habitat restoration

The importance of understanding host specificity has been of particular importance in some of the habitat restoration works during the PIP project. In Wales, on the Afon Eden Special Area of Conservation (SAC), surveys showed that not only are brown trout the local host fish species but that they were also the least abundant salmonid species in the catchment. To tackle this important issue the Pearls in Peril project restored 2.4 km of riverbed habitat, particularly targeting reaches that could provide spawning areas for trout. This work included placing locally sourced, clean gravels in tributaries (Figure 4) and placing large boulders with woody debris in the main river.

Elsewhere, hard bank protection works that have been contributing to poor riverbed habitat for pearl mussels have been removed. In the River Ehen SAC in Cumbria, in river reaches where boulder protection has been removed or has deteriorated, softer techniques including willow spiling has been used as an alternative. Willow spiling is a technique where live willow rods are woven between live willow uprights driven into the bank of a river. This has resulted in improved instream habitat (by controlling fine sediment erosion) and has helped to

Figure 5. Croys being dismantled on the River Dee. © River Dee Trust.

prevent the loss of valued neighbouring farmland. In addition, sections of willow spiling can be used subsequently as a local source of further willow rods. When rods are being harvested any necessary maintenance can be done, helping to ensure the river bank's longevity.

Despite the difficulties of measuring the benefits of restoring river and riparian habitats to a long-lived and slow-growing animal like the pearl mussel, some successes have been quantified already. Around the Afon Eden SAC, drainage ditches have been blocked and settlement ponds constructed on an 88-ha former forestry block that is being restored to a wetland. The success of these actions has been monitored in the Afon Eden by measuring the loss in redox potential in the surface layers of the riverbed near the former forest block. This technique measures the quality of the riverbed habitat for pearl mussels (Geist and Auerswald 2007). In 2013, prior to the restoration work, redox results at eight locations in the river indicated conditions were too poor to support juvenile pearl mussels. By 2015, after the works were complete, only one site remained unsuitable.

Other interventions have included the removal of redundant deflector structures that had been installed in the past as an attempt to enhance habitat. However, they have instead acted as partial impoundments, preventing the maintenance of naturally diverse river habitat. In the River Dee SAC in Grampian several such structures constructed from large boulders have been disrupted and the boulders distributed in the main river channel to restore the diverse habitat required by pearl mussels. The importance and value of good design and build in such a large river was evidenced by the fact the restored reaches survived near-unprecedented floods during early 2016.

In the upper reaches of the River South Esk SAC in Angus nearly 1 km of boulder bank protection was removed by the PIP project during 2015. Since then the river channel has widened in many places and increased the availability of salmon spawning and juvenile habitat. This area represents the current upstream limit for pearl mussels, which rely on salmon as their host. The changes will help support pearl mussel recruitment by increasing the availability of their hosts, as well as improving habitat. The work in the South Esk and River Dee has also included substantial riparian woodland creation, extending along more than 80 km of riverbank, to provide shade, reduce erosion and reinstate characteristic vegetation communities (Figure 5). In future years, as the benefits of these changes take effect, it is envisaged that pearl mussels may be translocated upstream to help reinforce the outcomes of the physical restoration work. Such restoration actions will also help to buffer the pearl mussels and their habitat against future extreme weather events, including low flows, elevated temperatures and flooding.

Further conservation translocations and actions

Future pearl mussel translocations to reinforce the outcome of habitat restoration measures will need to be carefully planned. Recent guidance and information such as the IUCN and Scottish translocation guidelines (Hollingsworth and Gaywood 2015) will be an important source of advice. In addition, reviews of past pearl mussel translocations will be important reference documents (Killeen and Moorkens 2016, Watt *et al*. 2017).

More generally, the experience of the PIP project reinforces the need to understand the habitat and ecological requirements of pearl mussels, particularly their host specificity. By working to improve the conservation of pearl mussels, and because of the pearl mussel's extremely demanding habitat requirements, river restoration actions for the species will also benefit biodiversity in general. Similarly, many of the recognised methods for restoring rivers, such as those recently published by the IUCN (Addy *et al*. 2016) will help further the conservation of pearl mussels.

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References

Addy, S., Cooksley, S., Dodd, N., Waylen, K., Stockan, J., Byg, A. and Holstead, K. (2016). *River Restoration and Biodiversity: Nature-based solutions for restoring rivers in the UK and Republic of Ireland*. CREW reference: CRW2014/10. Available at http://www.crew.ac.uk/sites/default/files/sites/default/files/publication/River%20Restoration%20and%20biodiversity_web.pdf. Accessed 9 January 2017.

Altmüller, R. and Dettmer, R. (2000). Successful species and habitat protection for the freshwater pearl mussel *(Margaritifera margaritifera)* in lower saxony (north Germany). *Natur und landschaft*, **75**: 384-388.

Degerman, E., Alexanderson, S., Bergengren, J., Henrikson, L., Johansson, B-E., Larsen, B.M. and Söderberg, H. (2009). *Restoration of Freshwater Pearl Mussel Streams*. Available at http://www.wwf.se/source.php/1257735/Restoration%20of%20FPM%20streams.pdf. Accessed 25 November 2016.

Geist, J. and Auerswald, K. (2007). Physicochemical stream bed characteristics and recruitment of the freshwater pearl mussel *(Margaritifera margaritifera). Freshwater Biology*, **52**: 2299-2316.

Hollingsworth, P.M. and Gaywood, M. (2015). New international and national guidelines for conservation translocations. *In Practice – Bulletin of the Chartered Institute of Ecology and Environmental Management*, **89**: 8-10.

Killeen, I. and Moorkens, E. (2016). *The translocation of freshwater pearl mussels: a review of reasons, methods and success and a new protocol for England*. Natural England Commissioned Reports, Number 229.

Mollusc Specialist Group (1996). *Margaritifera margaritifera*. The IUCN Red List of Threatened Species 1996: e.T12799A3382532. Available at http://www.iucnredlist.org/details/12799/0. Accessed 25 November 2016.

Moorkens, E. (2011). *Margaritifera margaritifera*. The IUCN Red List of Threatened Species 2011: e.T12799A3382660. Available at http://www.iucnredlist.org/details/12799/1. Accessed 25 November 2016.

Scheder, C., Gumpinger, C. and Csar, D. (2011). Application of a five-stage field key for the larval development of the freshwater pearl mussel (*Margaritifera margaritifera* Linné, 1758) under different temperature conditions – A tool for the approximation of the optimum time for host fish infection in captive breeding. *Ferrantia*, **64**: 13-22. Available at http://flussperlmuschel.at/fileadmin/redakteure/Service/Downloads/SchederGumpingerCsar2011.pdf. Accessed 25 November 2016.

Scottish Fisheries Co-ordination Centre (2007). *Electrofishing Team Leader Training Manual*. Scottish Fisheries Co-ordination Centre & Inverness College. June 2007. Available at http://www.gov.scot/Resource/Doc/295194/0096726.pdf. Accessed 26 January 2017.

Skinner, A., Young, M. and Hastie, L. (2003). *Ecology of the freshwater pearl mussel. Conserving Natura 2000 Rivers*. Ecology series 2, English Nature, Peterborough.

Watt, J., Cosgrove, P.J. and Hastie, L.C. (2015). *A national freshwater pearl mussel (*Margaritifera margaritifera, L.*) survey of Scotland*. Scottish Natural Heritage Commissioned Report No. 901. Scottish Natural Heritage, Inverness.

Watt, J., Cosgrove, P.J. and Hastie, L. (2017). *Monitoring the success of freshwater pearl mussel reintroductions*. Scottish Natural Heritage Commissioned Report No. 956. Scottish Natural Heritage, Inverness.

About the Authors

Iain Sime manages the Freshwater and Wetlands group within Scottish Natural Heritage. He also coordinated the submission of the Pearls in Peril LIFE+ funding bid and chairs the project steering group.

Contact Iain at: Iain.sime@snh.gov.uk

Jackie Webley is the project manager for the Pearls in Peril LIFE+ project. She oversees project delivery across Scotland, England and Wales working alongside a team of Project Officers and partners. Prior to PIP, she worked as a consultant undertaking ecological surveys and assessments for a range of developments.

Contact Jackie at: Jackie.Webley@snh.gov.uk

Diane O'Leary is the Project Officer responsible for taking forward actions to improve riverine conditions for mussels in the River Ehen in England and for successfully trialling artificial encystment.

Contact Diane at:
diane@westcumbriariverstrust.org

Nia Watkin is a conservation officer with Natural Resources Wales, taking over the project officer work on PIP in Wales from Elain Gwilym in March 2016. Aside from her work with PIP, Nia works on designated sites in Meirionnydd. Prior to NRW, she worked as a countryside warden and biodiversity assistant for Denbighshire Countryside Services.

Contact Nia at:
Nia.Watkin@cyfoethnaturiolcymru.gov.uk

Lorna Wilkie is the Pearls in Peril Scotland Project Officer, and has led on several in-stream restoration projects for PIP. Before joining PIP, Lorna worked with a wide range of species and habitats including tree surveying in Edinburgh's cemeteries, and studying for a PhD in seagrass ecology in the Tay Estuary.

Contact Lorna at: Lorna@rafts.org.uk

Flora Grigor-Taylor and Steff Ferguson have job-shared the post of Agricultural Project Officer for the PIP project since 2013, in conjunction with running a small ecological and land management consultancy based in the North-East of Scotland. Their combined working experience in conservation and ecology spans over 40 years.

Contact Flora at:
flora@rafts.org.uk
or flora@landcarenortheast.co.uk

Contact Steff at:
steff@rafts.org.uk or
steff@landcarenortheast.co.uk