THE FRESHWATER PEARL MUSSEL (*MARGARITIFERA MARGARITIFERA* LINNÉ, 1758) IN UPPER AUSTRIA – A SPECIES THREATENED WITH EXTINCTION AND CURRENT MEASURES FOR ITS SUSTAINED PROTECTION

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The freshwater pearl mussel (*Margaritifera margaritifera* Linné, 1758) is one of the most threatened species in Austria. Once having occurred in the northern parts of Upper and Lower Austria in enormous densities, there are only some isolated scattered beds left nowadays, the largest ones not exceeding a few hundred mussels. Most populations lack juveniles, as the natural reproduction obviously does not work any more due to several reasons. The most important impairments comprise habitat loss for adults and juveniles, loss of appropriate host fish for the parasitic larvae, water pollution, climate change and, for the main part, the high fine sediment loads of the Austrian watercourses.

Key words: freshwater pearl mussel, *Margaritifera margaritifera*, threatened species, habitat loss, reproduction, conservation, habitat restoration, Upper Austria.

INTRODUCTION

The freshwater pearl mussel (Fig. 1) once was extremely common and abundant in Northern and Central Europe. Its European distribution area reaches from northern Russia to the North of Spain, including Great Britain and Ireland, whereas the mussel has always been totally lacking in the South-East of England as well as southwards of the Alpine-Carpathian mountain range (Kerney, 1975). That is because it obligatorily avoids limestone. Hence, it can only be found in running waters with a granitic catchment area and it has, thus, always been restricted to the foothills of the Bohemian massif in Upper and Lower Austria (Gumpinger *et al*., 2002), where that unique species has at all times played an important economic and cultural role. Clerical and secular dignitaries used freshwater pearls for the ornamentation of their status symbols, most artfully and prominently shown in tunicles embroidered with pearls (Gumpinger, 2001), or in the Austrian Emperor's crown. Once having occurred in Upper and Lower Austria in enormous densities in almost any stretch of running water, the abundance of the freshwater pearl mussel has decreased drastically in these regions during the past two centuries (Moog *et al*., 1993).

Stocks have declined drastically, many of the former populations have totally vanished meanwhile. Considering that in 1800, since the first reliable counts are available, no major negative impacts occurred, those counts can be used as a reference value of 100 per cent. Compared to that, Moog *et al*. (1993) state that in the early 1990s stocks comprised only 2–3 per cent compared to the initial values. Things have not changed to better since then. When in the early 1990s the largest remaining mussel population in an Upper Austrian river called Waldaist counted some 20.000 individuals, occurring in a reach that was about 30 km long, there are not even 1.000 left nowadays, all living in one single, isolated bed (Scheder & Gumpinger, 2008). The very few remaining populations in Austria are exceptionally overaged, as the natural reproduction hardly works properly any more.

In order to prevent the freshwater pearl mussel in Austria from becoming extinct, several protection projects have been carried out throughout the past decade, unfortunately not always with the success desired.

REASONS FOR THE DECLINE

In order to understand the reasons for the proceeding decline, the mussel's life-cycle is to be regarded (Bischoff *et al*., 1986). Freshwater pearl mussels are dioecious. The female adults produce eggs that are fecundated within specially generated structures of the gills, the so-called marsupia. In those marsupia, the eggs develop into parasitic larvae, the glochidia, that are expelled into the surrounding water when ready for infection of host fish. In Austria, the only appropriate host fish species is the brown trout (*Salmo trutta* Linné, 1758) (Utermark, 1973). The glochidia attached to the gill tissue, are encapsulated and spend their first winter there, being carried around and supplied with oxygen and nutrients by their host. After about half a year, they undergo metamorphosis, drop to the stream bottom and dig themselves into the substrate, where the juvenile mussels stay for at least five years. Only then they move upwards to the surface of the stream bed and join their adult congeners.

A species that passes through so many different life stages can understandably be harmed by many different impacts. There are adverse effects on larvae, juvenile and adult mussels, all of different kind.

For one thing, wrong fish stocking strategies can harm the freshwater pearl mussel, as only the brown trout can be used as a host for the glochidia. During the past decades, though, the North American species rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) and brook charr (*Salvelinus fontinalis* Mitchill, 1814) were stocked in Austrian brooks and streams intensively, both competing successfully with the native brown trout. Whether brown trouts from fishfarms are genetically appropriate for the infection with glochidia is still to be investigated.

Habitat loss is one of the most important causes for the decline of the freshwater pearl mussel, first and foremost the loss of the aerated hyporheic interstitial. Juvenile mussels depend on that habitat, as they spend their first five years dug in the streambed. Due to the intensive agricultural land use in the catchment areas of most of the mussel streams, the interstitial becomes clogged by the washed-in fine sediments that cut off the oxygen and nutrient supply (Buddensiek & Ratzbor, 1995). Moreover, extensive straightening and regulation measures have resulted in a massive habitat loss for adult mussels as well as for host fish that are, in closing, essential for a successful reproduction.

At last, the degradation of the food quality shall be discussed at this place. In natural catchment areas, semi-deciduous alluvial forests are found along the riverside, dropping their leaves in autumn, thus contributing largely to the input of the coarse particulate organic matter on which the mussels feed. As huge areas have been either completely deforested or reforested with conifers like firs or spruces, the appropriate source of food (Hruska, 1998) was therefore lacking to a great extent.

PROTECTION PROGRAMME

Since the late 1990s, a project dealing with the maintenance of the few remaining freshwater pearl mussel populations has been carried out at the river Waldaist in Upper Austria. In a first step, the short-time maintenance of the mussel bed was aimed at, as it had been obvious that the heavy fine sediment loads and the adverse land use could not be dealt with promptly and easily. The primary objective was the infection of a preferably large number of juvenile brown trouts with glochidia that were to be gained from gravid mussels *in situ*, in order to provide an amount of juvenile mussels as great as possible and to spread the offsprings in the maximum range. While keeping up the natural reproduction by this assisted breeding, an approval was expected to take place in the catchment area. The protective scheme was, hence, planned as a bridging to maintain mussel populations as long as the currently adverse environmental conditions would have been improved sufficiently to make natural reproduction possible again.

Every summer, the gestation rate of the adult mussels from the last remaining mussel bed in the river Waldaist is controlled at regular, constantly shortening intervals. Observations usually start at the beginning of August and are carried out until glochidia ready for infection can be achieved (mostly in late August or early September). Gravid freshwater pearl mussels show a distinct alteration in their gill structure, as they carry their larvae in marsupia that can easily be detected by slightly opening the mussel with special pliers. Pregnant mussels bear apparent yellowish, filamentous agglomerates of larvae that clearly stick out of the pinkish gill tissue. If a mussel is pregnant, a small sample of its larval material is taken by means of an injection needle and observed with an outdoor microscope (enhelion-

Micron-pro) in order to determine the stage of development. The larval development proceeds gradually, but in order to estimate the level of progress, the most obvious stages were defined as follows (Scheder & Gumpinger, 2007):

- stage 1: no obvious differentiation, amorphous mass of cells;
- stage 2: first constrictions visible at the surface of the glochidium;
- stage 3: full differentiation of the shells and valves, respectively;
- stage 4: valves fully versatile, first snapping movements;
- stage 5: glochidium hatched from the egg-shell, moving around snapping freely.

As soon as 50 per cent of the glochidia have reached the fifth and last stage, the obtaining of larval material is initiated. For this purpose, several gravid mussels are taken from the bed and placed into a bucket with lukewarm water. Within a short time, they start expelling their larvae in large clots. After expulsion, the mussels are set back into the bed and the larval material is immediately transported to a local fish farmer. Since 2005, the protection programme has been carried out in cooperation with a pisciculturist who breeds a special strain of brown trouts that are genetically typical of the Upper Austrian foothills of the Bohemian Massif.

At the fish farmer's the glochidia are poured into a tank with several thousands of juvenile brown trouts. After 45 minutes, some fish are chosen randomly and their gills observed with a microscope in order to affirm that the infection has proceeded successfully. Thereupon the infected fish are carried to the river Waldaist and some of its tributaries, where they are released at several different spots in order to ensure a wide dispersion.

The assisted breeding is essentially understood so far and has meanwhile become a standard tool in the protection programme.

EXTERNAL SETBACKS

Unfortunately, it has turned out that supporting the reproduction is useless without simultaneously eliminating external adverse effects. Such effects occurred in 2006 and 2007, harming the mussels directly, on the one hand, and making the infection of the host fish impossible, on the other hand, thereby putting the whole protection programme at risk.

In 2006, a so far unknown toxic substance obliterated a whole small mussel population in a tributary to the river Waldaist, a brook called Harbe Aist (Fig. 2). This was the second largest known population in the river system and one of the largest remaining ones in the whole of Upper Austria. In the regarding year, the mussels in the large bed in the river Waldaist, located some 20 km downstream of the extinguished population in the small tributary, showed a significantly lower breeding effort, only very few mussels bearing larvae at all. Apart from that, the actually pregnant mussels expelled their larvae much too soon, as a result of which no material for the infection could be gained then. It is conceivable that the presumable substance was concentrated enough to kill the mussels in the tributary, but diluted while being transported downstream, so that in the main river it just narrowed the breeding activity.

In 2007, the normal amount of female mussels was pregnant again, the population obviously being recovered from the previous year´s negative impact. The assisted breeding programme could be carried out on schedule, until only one day before the planned infection a reservoir of an upstream hydropower plant was flushed and an estimated amount of 3.000–5.000 m³ of fine sediments – sludge and sand – was mobilised. The heavy fine sediment load caused the pregnant mussels to expel their larvae at once in distress. For the second time in a row, there was no larval material available for the infection of the brown trout provided. What was even worse was the fact that the fine sediments obviously clogged the interstitial some 15 km downstream of the hydropower plant. It must be assumed that the juvenile mussels that had arisen either from natural reproduction or from the assisted breeding within the past five years will not have survived that impact. The adult mussels in the mussel bed could be rescued by means of a spontaneous salvage operation. In order to remove the silt that covered the whole bed in the form of a massive fine sediment layer (Fig. 3), a stone groyne was erected that raised and redirected the flow across the bed, thereby removing the mud quantitatively.

Due to constant careless dealings with the river, the success of the whole protection programme is at risk at the moment.

PROSPECT

It has turned out that assisted breeding alone – regarding the current circumstances – cannot be a solution to the problem, cannot save the mussel from becoming extinct. Analysing the factors that threaten the species, it becomes clear that only a major project can manage the rescue of the few remaining populations.

First and foremost, the siltation must be restrained in order to restore an appropriate habitat for juvenile mussels. As the clogging of the interstitial can be traced back to fine sediments that enter the river due to heavy agricultural land use, area drainage and missing alluvial forests, those factors must be eliminated as soon as possible. Modifying land use schemes, rewetting formerly drained areas and regenerating natural riparian vegetation in the catchment area is only possible, though, if a sufficiently large spread of land is purchased and managed from an ecological point of view. An important contribution towards the cut of siltation can be made by the erection of sand traps, as Altmüller & Dettmer (1996, 2000, 2006) have shown impressively by the example of a brook called Lutter in Northern Germany.

In a next step, regulated reaches must be restored in order to provide the adult mussels with natural habitats. Appropriate host fish must be held available by supporting autochthonous species and ceasing from stocking rainbow trouts and brook charrs.

Concludingly, all those measures (that are inevitable, though, if the unique species shall get a chance to survive) can only be implemented if enough land is acquired. It is obvious that this requires not only a complying sum of financial means, but also the support of all officials concerned with this matter. On this account, a workshop dealing with the sustained protection of the freshwater pearl mussel in Austria was held in St. Florian on November 14th, 2007. In a first step, a feasibility study is going to be appointed, comprising a detailed list of all essential projects and sub-projects that are planned as well as a cost estimate. Simultaneously, the established protection programme, dealing with assisted breeding and infection of juvenile brown trouts, will be continued, trusting that no further complications will occur from now on.

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