International seminar
Monitoring and restoration of freshwater (mussel) habitats

Tuesday 27th November – Thursday 29th November 2018

Clervaux, Luxembourg

Book of abstracts

Restoration of Unio crassus rivers in the luxemburgish Ardennes
LIFE11 NAT/LU/857

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LifeUNIO

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1 PREFACE

In Luxembourg, more than 80% of the wetlands and their related habitats have disappeared within the last 50 years. This is however, not only a national problem as in most highly developed countries, a similar decline of wetlands was observed. The loss of aquatic habitats often goes together with a loss of aquatic species. One of the most imperiled aquatic groups worldwide are freshwater mollusks. Freshwater mollusks are however, vital for ecosystem functions and are a bioindicator for healthy freshwater systems. The only sustainable way to ensure the survival of these flagship species is to protect or to restore their natural habitats.

Organized within the LIFE Nature Project «***Restoration of Unio crassus rivers in the Luxemburgish Ardennes LIFE11 NAT/LU/857***», the aim of the seminar is to present the latest monitoring and habitat restoration methods, as they were carried out in different countries throughout the last years.

2 ORGANIZATION AND PROJECT PARTNERS

Organisation:

natur & ëmwelt / Fondation Hëllef fir d'Natur
LIFE 11 NAT /LU/857
2, Kierchestrooss, L-9753 Heinerscheid, Luxembourg

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Project Partners:

The European Commission

Luxembourg government:
Ministry for Sustainable Development and Infrastructures
Ministry of Agriculture

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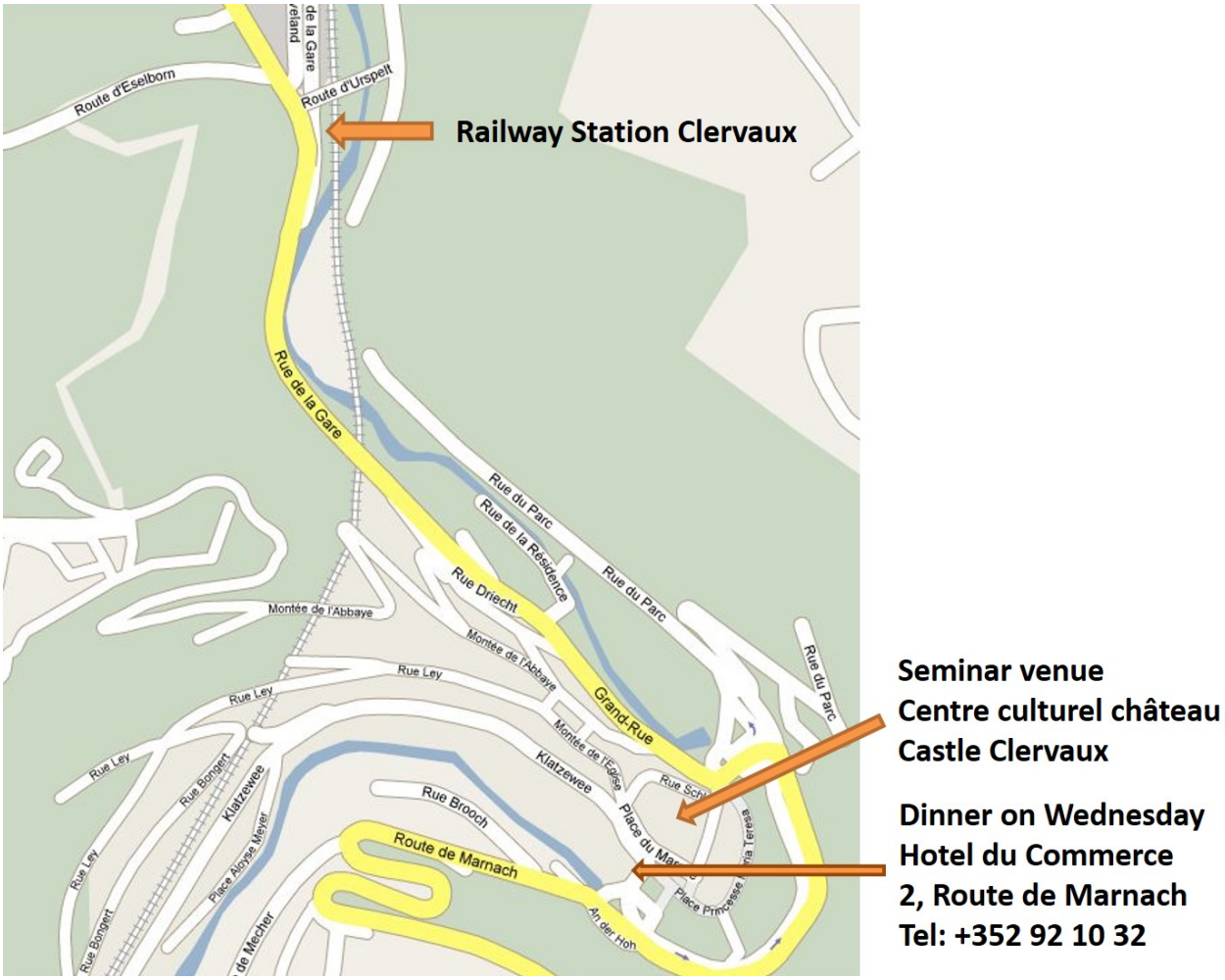
et à la Grande Région

Chamber of Agriculture Luxembourg

3 MAPS

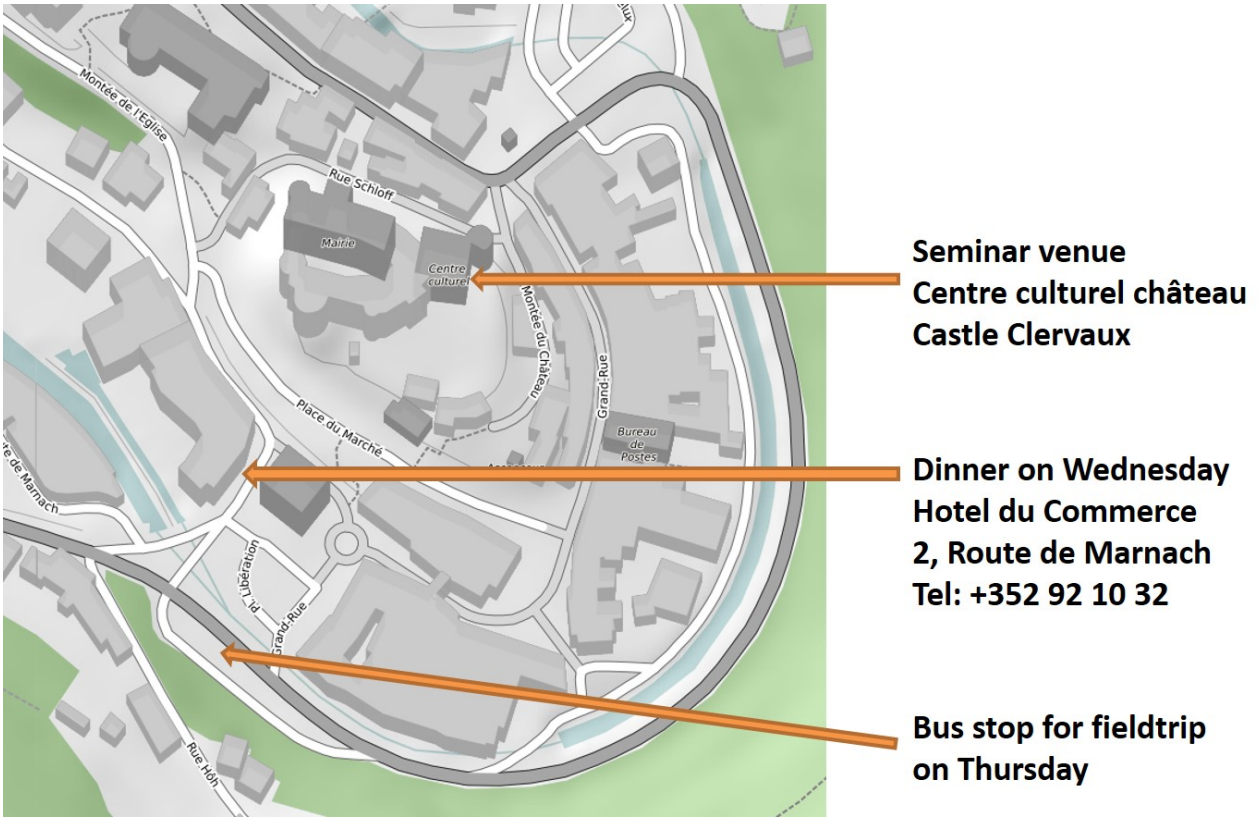
Overview of Luxembourg

Overview of Clervaux



Clervaux (Seminar venue, railway station and dinner location)

Detail of Clervaux city center



Clervaux (Seminar venue, dinner location and bus stop for fieldtrip)

4 SEMINAR PROGRAMME

Tuesday, 27 November 2018

19:15 The LIFE unio project. A summary of what was done in the last years.
(Presentation for the local population in Luxemburgish language)

20:00 Greeting words and welcome reception at the Centre Culturel Château, Castle Clervaux

Clervaux castle

Wednesday, 28 November 2018

08:00-09:00	Registration at the Centre Culturel Château, Castle Clervaux	
09:00-09:30		Opening and Greetings
Session I		
09:30-10:00	Taskinen J. et al.	*Department of Biological and Environmental Science, University of Jyväskylä, P.O. Box 35, 40014 Univ. Jyväskylä, Finland* **Decline and conservation of two Southern Finnish *Margaritifera margaritifera* populations**
10:00-10:20	Carlevaro A. & Vicentini H.	*Benthos – Büro für Gewässerökologie, Zürich; & Gewässerökologie, Zürich. Switzerland* **Monitoring and restoration of *Unio crassus* Philipson, 1788 habitats in Switzerland – an overview**
10:20-10:40	Ożgo M. et al.	*Department of Evolutionary Biology, Kazimierz Wielki University, Bydgoszcz, Poland* **Local conservation of freshwater mussels and the practical effects of species protection**
10:40-11:10	Coffee break	

11:10-11:30	Skujiene G.	*Department of Zoology, Institute of Biosciences, Life Sciences Center, Vilnius University, Vilnius, Lithuania* **Monitoring of the Thick Shelled River Mussel *Unio crassus* (Philipsson, 1788) in Lithuania**
11:30-11:50	Daill D. & Gumpinger C.	*Consultants in Aquatic Ecology and Engineering (blattfisch e.U.) – Wels, Austria* **Conservation of Freshwater Pearl Mussels (*Margaritifera margaritifera*) in Austria – Biomonitoring in the interstitial**
11:50-12:10	Denic M. et al.	*Landschaftspflegeverband Passau, Fuerstenzell, Germany* **Conservation status of two endangered freshwater mussel species in Bavaria, Germany: threats and management implications**
12:10-13:30	Lunch	
Session II		
13:30-14:00	Lorenz A.	*Department of Aquatic Ecology, Faculty of Biology, University of Duisburg-Essen, Essen, Germany* **Temporal and catchment effects on the success of restoration measures in streams**
14:00-14:20	Pichon C.	*Parc naturel régional Périgord Limousin - la Barde 24450 La Coquille- France* **Restoration of feshwater pearl mussel (*Margaritifera margaritifera*) habitat in Dronne river, France**
14:20-14:40	Olofsson P. et al.	*Environmental Assessment Section, County Administrative Board of Norrbotten, Luleå, Sweden* **Restoration of Boreal Nordic Rivers – ReBorN LIFE**
14:40-15:10	Coffee break	
15:10-15:30	Schneider J. et al.	*Institute of Hydrobiology, University of Technology Dresden, Germany* **Every small step leads to success in detail: Three years habitat characterization for reintroduction of captive-bred juvenile freshwater pearl mussels**
15:30-15:50	Schiller T. et al.	*Institute of Hydrobiology, University of Technology Dresden, Germany* **Evaluation of the success of captive-breeding activities in Saxon Vogtland, Germany: First monitoring of reintroduced juvenile river pearl mussels**
15:50-16:10	Zając K. et al.	*Institute of Nature Conservation, Polish Academy of Sciences Mickiewicza 33, 31-120 Kraków, Poland* **Monitoring of Phenology and Reproductive Effort in *Unio crassus***
16:10- 18:00	Poster Session with refreshments	
19:30	Official Seminar Dinner in Clervaux	

Thursday, 29 November 2018

08:30-09:00	Registration at the Centre Culturel Château, Castle Clervaux	
Session III		
09:00-09:30	Heumann S. et al.	*natur & ëmwelt - Fondation Hëllef fir d'natur, 2, Kierchestrooss, L-9753 Heinerscheid, Luxembourg* **Six years of monitoring and restoration during the LIFE Resto Unio Project in the Luxemburgish Ardennes**
09:30-09:50	Gallé T. et al.	*Luxembourg Institute of Science and Technology- ERIN Dept., Luxembourg* **Evaluating pesticide pressure on freshwater mussel habitats: monitoring requirements and methodological limitations**
9:50-10:10	Curley E.A.M. et al.	*School of Geographical and Earth Sciences, University of Glasgow, Glasgow, United Kingdom* **Investigating the Behavioural and Physiological Response of Endangered Freshwater Pearl Mussels to Stress Exposure**
10:10-10:40	Coffee break	
10:40-11:00	Pfister L. et al.	*Luxembourg Institute of Science and Technology., Luxembourg* **On the potential for freshwater pearl mussels to serve as a stream water stable isotope recorder**
11:00-11:20	Degelmann W. & Spisar O.	*Bund Naturschutz Auguststraße 1, 95028 Hof, Germany & Bilvalvia, Na Klotzmance 9, CZ-78901 Zabreh, Czech Republic* **Pearl mussel breeding station Hof - history and actual work**
11:20-11:40	Final Discussion & explanations about the afternoon programme	
11:40-12:45	Lunch + Poster Session	
13:00-17:00	Field trip & rearing facility 13:00 Departure of the bus in Clervaux to the border triangle (Belgium, Luxembourg, Germany) From here, a 4 km hike to the rearing facility at the mill of Kalborn will be organised. During the hike, some of the restoration measures, completed during the LIFE freshwater mussel projects in Luxembourg can be seen. Once arrived at the mill, for those interested, a tour with explanations can be given at the rearing facility. 16:30 Departure of the bus back to Clervaux Arrival in Clervaux at +/- 17:00	

Poster Session

Wednesday, 28 November 2018 (16:10-18:00)
Thursday, 29 November 2018 (11:40-12:45)

Posters will be on display throughout the meeting

First Author	Title
Mayon N.	**Can genetic data be used as a decision-support tool to guide restoration of fish connectivity in salmonid streams? The example of the Sûre river catchment (Belgium, Wallonia)**
Vaessen Q.	**Caracterisation of *Unio crassus* Microhabitats in the Sûre River**
Motte G.	**Actions in progress for the conservation of the thick-shelled river mussel (*Unio crassus*) in Belgium (Life BNIP)**
Pichon C.	**Translocation of freshwater pearl mussels *Margaritifera margaritifera* before habitat rehabilitation project : feedback on the Dronne River**
Sehlheim H.	**15-year experience of saving the last freshwater pearl mussel population in northrhine-westfalia, Germany**
Frisch M.	**Water purification performances of freshwater mussels**
Schloemer S.	**New insights into the invertebrate fauna of beaver dams – a comparative study conducted with a vacuum sampler**

River Our valley in autumn © Foto FAF Studio

5 ABSTRACTS (ORAL PRESENTATIONS)

Transformed weir at the mill of Kalborn

Decline and Conservation of Two Southern Finnish Margaritifera margaritifera Populations

Taskinen J.[1]*, Suonia H.[1], Pakkala J.[2], Mäenpää E.[2], Suonpää A.[3], Vähä J-P.[3], Vuorinen, E.[4], Oulasvirta P.[5] and Jakobsen, P.[6]

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The freshwater pearl mussel (*Margaritifera margaritifera*, FPM) is endangered throughout the range of its distribution in Europe. There are over 120 rivers inhabiting FPM in Finland, most of them being located in the north. Only two major FPM rivers are found from the southern Finland – River Ähtävänjoki/Essen (flowing to the Bothnian Bay, Baltic Sea) and River Mustionjoki/Svartå (flowing to the Gulf of Finland, Baltic Sea). Here we report results of monitoring of these two important FPM populations, in terms of population size and reproductive status, since 1990s, and the efforts to save these populations. Estimated numbers of FPM, investigated by SCUBA diving covering the main mussel beds have declined alarmingly throughout the study period in both rivers. The total estimated FPM population size of River Ähtävänjoki was 50.000, 10.000, 3.500 and 500 in 1987, 2003, 2010 and 2016, respectively. Reproduction of FPM was evident in River Ähtävänjoki in 1990-93, 1997-98, 2004 and 2006 as viable glochidia were obtained from the mussels. However, in 2015-16 FPM of River Ähtävänjoki did not release glochidia when kept in buckets, and no glochidia were found from salmonids caged in the river. In River Mustionjoki, also no glochidia were found to be released when mussels were monitored in buckets of river water in 2016, and no glochidia were attached to salmonids caged in the river in 2010-11 and 2016. Thus, populations are in a drastic decline and glochidia production of the mussels has stopped. Thus, actions are being undertaken in the EU Life IP project FRESHABIT (2016-2021) to prevent extinction of these populations. First task was to resume glochidia production. For this purpose, adult mussels were transported to Konnevesi Research Station (JYU) in 2016 and 'captive feeding' was started. In the beginning, the mussels were in very poor condition. After two years of rehabilitation in tanks of the station, reproductive functions of the mussels have started again. First glochidia from these critically endangered mussel populations were obtained in autumn 2018. Host salmonids were infested with these glochidia, to be able to obtain juvenile mussels in summer 2019, in order to be cultured further. This means that 1) the mussels had spawned successfully in our tanks and 2) mussels that were not any more producing glochidia in the wild started glochidia production again in our tanks. Thus, it is possible to save Margaritifera populations of River Mustionjoki and River Ähtävänjoki. This shows that captive rehabilitation is possible for *M. margaritifera* whose glochidial production has already ceased in the wild.

We acknowledge the financial support by the EU Life IP Programme, EKOenergy Environmental Fund, Ossi ja Raija Tuuliainen Foundation, WWF Finland, Suomen Luonnonsuojelun Säätiö and the Ministry of Environment Finland.

Monitoring and restoration of *Unio crassus* Philipson, 1788 habitats in Switzerland – an overview

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In Switzerland, there are 8 species of Unionidae. Of these, only *U. crassus* is present mainly in rivers. The other species (*U. tumidus*, *U. mancus*, *U. elongatulus*, *U. pictorum*, *A. anatina*, *A. exulcerata*, *A. cygnea*) are mainly present in lakes and ponds. Since the 1950s, the populations of Unionidae have been decreasing, mainly as a result of land exploitation (agriculture and river canalization / habitat destruction, water pollution).

U. crassus has a red list CR status and is protected nationally in the Ordinance on the Protection of Nature and Cultural Heritage (NCHO). The latest field observations suggest that *U. crassus* is slowly recovering in large watercourses (Rhine, Suhre). In small watercourses, the pressure remains very high and the populations stay stable or tend to decline.

The management and protection of watercourses (lakes and rivers) and the aquatic species in Switzerland is the responsibility of the regional governments (cantons). The cantons usually own the surface water. This is the cause of the significant budget differences for monitoring and restoration within the regions.

Monitoring: There is no defined standard Method in Switzerland for monitoring of *U. crassus* in rivers and lakes. The methods used to date are the result of the experience of the biologists responsible for monitoring (consultants) and are adapted to the size of the population, the length of river studied, the purpose of the mandate and budget limitations.

In the cantons of Lucerne, Schaffhausen and Zurich 3 methods are used by now: mark recapture (Suhre), statistical evaluation (Seegraben) and an adapted method of the action plan crayfish (Furtbach).

Restoration: Federal water protection legislation calls for the renaturation of rivers and lakes in order to restore their natural functions. The strategy is based on the one hand on the morphological revitalization of watercourses and on the other on the upgrading of wastewater treatment plants (focus on microcontaminants). The example of the Seegraben shows how the regeneration of a previously impacted habitat in line with the ecological requirements of *U. crassus* is particularly difficult, since the aquatic system is likely to recover long after the source of degradation has been eliminated. In a project in the canton of Zurich, the input sources into the river Furtbach are being analyzed in order to identify those that make a decisive contribution to habitat degradation (project is ongoing). With the improvement of the water quality of the Sempachersee, the population of *U. crassus* in the Suhre has started to grow again - despite or thanks to the fact that the sediment consists of 80% of Dreissena.

On the basis of field observations and the results of past *U. crassus* repopulation campaigns, it can be deduced that water quality - due to its effects on the ecosystem - is a central element influencing the distribution of *U. crassus* in Swiss small rivers. The lack of financial means for major construction works (diversion of input sources) and the difficulty of restoring a habitat already impacted is a major challenge for the protection of the *U. crassus* populations in Switzerland.

Local conservation of freshwater mussels and the practical effects of species protection

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We present three cases of on-going freshwater mussel conservation and research projects in north-eastern Poland: 1. Protecting an abundant, multispecies mussel community (including *Unio crassus*) in an unprotected river threatened by the plans of so-called maintenance works 2. A field experiment in rescue relocation of mussels prior to the deepening of a river section; 3. Remediation of an environmental damage resulting in a mass mortality of freshwater mussels (predominantly *Anodonta cygnea*) and the European bitterling *Rhodeus amarus*. All these projects were initiated and are being realized because at least one of the mussel species present at the sites has a status of a protected species. We point to the (often questioned) effectiveness of this form of legal protection and to the need of increasing the conservation status of other freshwater mussel species.

Monitoring of the Thick Shelled River Mussel *Unio crassus* (Philipsson, 1788) in Lithuania

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Since the beginning of the mussel monitoring programme in 2008, *U. crassus* had been known only in 7 rivers. The research was repeated in 1990 and 2008 only on two sites of the rivers Luknelė (15 km long) and Riešė (29 km long) and it turned out that the monitoring was not suitable for the same site as the species was not found. A more detailed study along the rivers confirmed, that the species survived in Luknelė, but was absent in Riešė. The new monitoring methodologies (Balčiauskas et al., 2016) prepared by the entomologist of the Natural Research Center included also the monitoring of mollusks. This monitoring does not limit the amount of monitoring points. It only requests to collect mussels in in the following order: select a place with alive or dead mollusks, collect specimens from an area of 10 m^2 (not deeper than 0.1-0.6 m and not closer than 1 meter away) and repeat this collection 3-5 times not closer than 200 meters. Some parameters (sediment structure, quality of water, vegetation, shadow) should also be recorded locally (only visually without identification of species of plants or chemical values). Flow regulation, recreation and fish visibility during the monitoring time were included too. These factors are hardly to estimate and they vary between the researchers significantly.

In 2016, *U. crassus* has been observed in 58 rivers in Lithuania and the disadvantages of the monitoring methodology were noted. Even when freshly dead mollusks populations were found, the results of the visual assessment of the earlier mentioned factors was not different from the data in places, where the mussels were alive and abundant. For this study, we selected 236 sites in 58 rivers (not shorter than 20 km). Rivers for the study were selected according to their hydrographic regime, data about the introduction of fish or data about their abundance in scientific reports during the last 10 years. Study sites were evenly distributed across the whole of Lithuania and reached 3955,3 km of rivers length. The sites for assessment were selected using cartographic maps, not less than 3-5 places per river checking the origins and junctions and the monitoring started after the detection of alive mussels. The mollusks were collected in linear transect, where 10 study square meters were arranged per meter. A mapping method was used, to select the most similar and suitable habitat areas for mollusks in the respective river. During the monitoring *U. crassus* was found in 76% (or in 44 rivers) of all investigated rivers. The total average density of mollusks at the studied rivers 'sites, suitable for *U. crassus* (889,7 km of the rivers) was 8,7 ind./m^2. It was hard to assess any populations' trends of the species as *U. crassus* lived in short sections of the river, separated from each other at different distances from a few hundred meters to a few or a few dozen kilometers. Only 15 rivers were assessed as good for *U. crassus*.

Conservation of Freshwater Pearl Mussels (*Margaritifera margaritifera*) in Austria – Biomonitoring in the interstitial

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The freshwater pearl mussel (*Margaritifera margaritifera*) faces a dramatic decline throughout its distribution area, including Austria, where the species is considered critically endangered. As a consequence, the Austrian conservation project "Vision Flussperlmuschel" was initiated in 2011. The main objectives of this project are the rearing of juvenile mussels and the restoration of suitable habitats to establish reproductive populations.

Juvenile freshwater pearl mussels spend the first years of their life buried within the interstitial. However, the increased sediment input in the waterbodies leads to the colmatation of the substrate, which hampers the oxygen and water circulation in the interstices. As a result, remaining populations ofttimes lack recruitment and consist predominantly of adult individuals. Hence, a biomonitoring in the interstitial was started in 2016 to evaluate the availability of oxygen and nutrients at promising sites.

The survey was started using mesh cages filled with substrate. A total of 90 juvenile mussels from two different river systems were buried at a depth of 5 – 10 cm within the interstitial of the river Käfermühlbach. After an exposition of three months, the survey had to be interrupted due to a flood. At this time 68 living mussels were found, accounting for a survival rate of 75,5 %. The mussels were then transferred into hole cages, known as Buddensiek boxes, and again buried within the substrate. After an exposition of nine months, 42 living mussels were found. Strong differences in the survival rates between the two lineages were observed and all individuals showed signs of malnourishment. The results might indicate that the oxygen supply is not the limiting factor within the interstitial of the river Käfermühlbach, but rather the nutrient supply.

To further assess the degree of vertical mussel movement within the interstitial new substrate boxes were built in 2017. The first results revealed tendencies for such movements, but more extensive studies will be conducted to reinforce these observations.

The overall project is financed by the Office of the State Government of Upper Austria, Section for Environmental Protection and the European Union.

Conservation status of two endangered freshwater mussel species in Bavaria, Germany: threats and management implications

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The freshwater pearl mussel (*Margaritifera margaritifera*) and the thick shelled river mussel (*Unio crassus*) are keystone species in riverine ecosystems. Therefore, their decline has attracted growing attention and resulted in strict protection, e.g. by the European Habitats Directive, which also requires regular monitoring of the listed species. In case of the two freshwater mussels, the monitoring in Germany consists of a mapping of mussel and associated fish populations combined with an investigation of abiotic habitat parameters and potential or immediate threats. The results are used to categorize the population, habitat and threat status either as A (excellent), B (good) or C (medium-bad). In the recent monitoring period 2014-2016, 22 *Unio crassus* and 21 *Margaritifera margaritifera* streams were investigated in Bavaria, Germany. In both species, not a single population was rated as A. The amount of *Unio crassus* populations in good status was higher than of *Margaritifera margaritifera* with 53 % compared to 14 %. This difference is mainly explained by the absence of juveniles in most *Margaritifera margaritifera* streams, whereas 75 % of the *Unio crassus* populations showed at least some recruitment. Analysis of the habitat parameters suggests that reproductive failure in *Margaritifera margaritifera* populations is mainly caused by increased fine sediment introduction and nutrient levels. In contrast, *Unio crassus* seems to be more resilient towards adverse abiotic habitat conditions and still reproduces in impacted habitats, but reacts more sensitive to a decline of primary host fish populations. In addition, *Unio crassus* is more often exposed to direct threats such as river maintenance or muskrat predation, whereas *Margaritifera margaritifera* is mainly threatened indirectly e.g. by landuse changes. Conservation strategies therefore need to be species-specific and must even consider differences among populations. Consequently, in some *Unio crassus* populations, avoidance of physical destruction of mussel beds by uncoordinated river maintenance work or reduction of muskrat populations may already be sufficient to preserve functional populations, though management on different levels with consideration of host fishes and habitat conditions will be required in most cases. Yet, holistic management approaches are obligatory for successful conservation of *Margaritifera margaritifera* populations in order to reduce fine sediment and nutrient influx from the catchment as well as improve degraded stream habitats. In addition, breeding programs should supplement habitat restoration to preserve the strongly overaged populations until habitat restoration may be successfully finished. Finally, the examples of *Margaritifera margaritifera* and *Unio crassus* demonstrate that management practice cannot be directly transferred between species. Hence, before management strategies for other native freshwater mussels can be developed, the investigation of basic information on distribution, population status, ecological requirements and threats is necessary.

We acknowledge the financial support from the Bayerische Landesamt fuer Umwelt.

Temporal and catchment effects on the success of restoration measures in streams

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The factor time is often suggested as one of the most important factors when discussing the improvement of fish, invertebrates or macrophytes through restoration measures. This designation is based on the mere hope and desire that time heals the wounds of previously degraded and now restored stretches. Scientific studies of time series of restored sections are hitherto rare or relate only to short periods of a few years on a specific site. General conclusions on the ecological effects of restoration measures in the course of time cannot be drawn yet, but are urgently needed in the context of river basin management planning.

As a second factor, catchment parameters like anthropogenic land use or presence of source populations are said to be of crucial importance for river restoration success. In the past five years, the University of Duisburg-Essen has tried to find answers to the questions on the factor time and the factor catchment influences on river restoration ecology. Two different data sets were analyzed from restored river reaches. On the one hand, a large data set, which contained standardized samplings of fish, benthic invertebrates, macrophytes, floodplain vegetation and ground beetles of about 60 restored reaches. This data set was analyzed in relation to the time past since the restoration measures were conducted. On the other hand, 18 restored sites were sampled twice in an interval of 5 years, which allows for the exploration of the direct effect of the factor time on biological organism groups. This talk will present the main results of the project.

Restoration of freshwater pearl mussel (*Margaritifera margaritifera*) habitat in Dronne river, France

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The Dronne river shelters one of the largest freshwater pearl mussels (*Margaritifera margaritifera*) populations in France, with more than 20,000 mussels. To preserve this population, Périgord-Limousin Regional Natural Park coordinates a European LIFE + program (LIFE13 / NAT / FR000506) since 2014. In the short-term, the aim of this project is to establish optimal conditions for maintaining a population of freshwater mussels on the upper Dronne river, while the long-term goal is to enable population growth and create a viable mussel population.

Our project includes 3 main areas of work: habitat restoration, captive breeding and ecotoxicology research. For the first point, restoration works are carried out on the main barriers hindering river continuity: culverts, dams and artificial lakes. First of the objective is to help stabilize the host fish (brown trout) populations. These works not only improve survival rates for juvenile freshwater pearl mussels at this very sensitive life stage, but also help increasing population numbers by creating optimal physical breeding conditions.

Significant monitoring actions are carried out throughout the program to monitor the effectiveness of actions on the environment. The first results of the restoration works are presented here, with a focus on the successes and points of vigilance. Other phases of the LIFE program are also briefly presented.

Restoration of Boreal Nordic Rivers – ReBorN LIFE

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The rivers in the most northern part of Sweden have been used for log driving during a period of roughly 100 to 150 years. Intensive canalization, removal of stone material and blowing up large boulders have heavily modified the rivers characters and affected the biology in these rivers.

Here, we present results and achievements from a LIFE-project aiming for improvements of habitat conditions in six main drainage areas in northern Sweden. The target species in the project are the Freshwater pearl mussel (*Margaritifera margaritifera*), the Eurasian otter (*Lutra lutra*), the Atlantic salmon (*Salmo salar*) and the brown trout (*Salmo trutta*). A total of 200 km river stretch will be restored into more natural conditions, including creating 2 300 spawning beds for salmon and trout.

We acknowledge the financial support by the European Commission LIFE-Nature program, The Swedish Agency for Marine and Water Management, the County Administrative Boards of Norrbotten and Västerbotten, the municipalities of Nordmaling, Gällivare, Arvidsjaur, Boden, Jokkmokk, Luleå, Piteå and Älvsbyn, the Swedish Forestry Agency, SCA Skog AB in Västerbotten and Norrbotten and Sveaskog Förvaltnings AB in Västerbotten and Norrbotten.

Small steps leading to success in detail: Three years habitat characterisation for reintroduction of captive-bred juvenile freshwater pearl mussels

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Since the beginning of the 21st century, many efforts are being undertaken to stabilise endangered freshwater pearl mussel (*Margaritifera margaritifera*) populations by the semi-natural breeding programme in Saxony's Vogtland region, Germany. Essential protection measures and actions to improve catchment area and wastewater management have been implemented already. Based on current information suitable age structures and abundances of host fish are present in all potential reintroduction streams. Nevertheless, establishment of self-reproducing mussel populations has not been successful so far.

Within the joint project ArKoNaVera advanced concepts are being developed for reintroduction of captive-bred juvenile freshwater pearl mussels and long-term objective of establishing self-sustaining mussel populations. These activities include in particular: restoration of their natural reproduction, conservation of genetic diversity and identification of suitable mussel habitats. Furthermore, captive-bred juvenile freshwater pearl mussels of different ages and genetic lines are available for Saxony's Vogtland region. New resettlement habitats are currently needed to ensure their natural reproduction because oldest mussels are now in a reproductive age.

Extensive analyses have been conducted to narrow the search for suitable mussel habitats. In addition to physical, chemical, biological and hydrological parameters, the quality of substrate was also subject of investigation. However, bioindication tests were one main focus of the three-year habitat characterization in 7 potential reintroduction streams. Bioindication tests were realised with post-parasitic as well as semi-adult mussels and in both flowing water and hyporheic zone. Survival and growth rates are a major step forward in optimal habitat requirements for freshwater pearl mussels in certain life stages. Additionally, limiting ecological factors for the reproduction of these mussels can be narrowed further by this approach.

Evaluation of the success of captive-breeding activities in Saxony's Vogtland, Germany: First monitoring of reintroduced juvenile river pearl mussels

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In Saxony's Vogtland, Germany, freshwater pearl mussel *Margaritifera margaritifera* (FPM) declined extremely during the last decades. Only by captive breeding programs in the last 15 years the FPM population of Weiße Elster River Basin was saved from extinction. More than 5000 individuals were reared to an age of at least five years and reintroduced in 2009-2013 into the obviously most suitable brook. Since the mussels were released over a stretch of 6 km and hid in sediment completely, just a few mussels were recovered during the following years. Therefore, no evaluation of the species-protection activities was possible so far neither for long-term successes of breeding programs nor for suitability of different brook habitats for juvenile FPM. In the present study we tried to find out how many mussels survived the first years after reintroduction into natural habitats. Furthermore, we investigated habitat choice of juvenile FPM and analysed in this context environmental factors. We subdivided our study in three steps: In a first step we analysed water samples along the resettlement stretch for presence and amount of environmental DNA (eDNA) of FPM to identify sections with high abundance of mussels. Secondly, we visually searched for mussels on the surface of the brook sediment by using underwater scopes and lamps. Thirdly, the proportion of completely sediment covered mussels was analysed by digging up the whole sediment of transects up to 10 cm sediment depth. We were able to show that the strength of eDNA signals correlates with the abundance of mussels, because eDNA signal declined already after a short stretch downstream. Furthermore, we found a significant number of mussels on the sediment surface but nearly the same number of mussels was completely hidden in the sediment. From these findings, we calculated a survival of about one third of the originally reintroduced juvenile FPM.

Monitoring of Phenology and Reproductive Effort in *Unio crassus*

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Population persistence depends on number of young produced and recruiting, because they compose next generations, however, in unionids little is known about their reproductive effort, its timing and variability.

We studied timing and reproductive effort in threatened *Unio crassus*, during 5 years in 3 rivers. Eggs were lied into marsupia at earliest in the March, just after the spring thaw. The earliest date of eggs laying was usually similar in all populations, however, the rivers differed significantly in number of females reproducing at given time. Glochidia development lasted from 10 (summer) to 20 days (early spring). The marsupia inspection showed that most of the studied females raise up to 7 broods per season. Number of breeding females increased or decreased during some seasons. The content of marsupia was also variable: it could contain only small clots of glochidia as well as marsupium could be full of glochidia; glochidia load in marsupium usually decreased along time during a season. The length of reproductive period varied between seasons and between functional habitats of the river. The reproduction ultimately stopped at the beginning of August in all studied rivers and habitats.

The existing variance in reproductive output of *U. crassus* implies, that female fecundity is a sensitive life history trait in this species, which should be monitored in populations subjected to conservation actions.

Six years of Monitoring and Restoration during the LIFE Resto Unio Project in the Luxemburgish Ardennes

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The once in Luxembourg widespread mussel species *Unio crassus* can be found nowadays only in the upper course of the rivers Our and Sauer. Habitat restoration and rearing will be the only possible way to save these local populations on the long run.

This work is part of the LIFE+ nature project LIFE 11 NAT/LU/857 to restore rivers in the Luxembourgish Ardennes for the period from 2012 to 2019.

Improvement of water quality in the tributaries of Our and Sauer is the most important part of the applied restoration work. While restoration measures like the removal of fish migration obstacles were obviously a success for the fish population, it is rather difficult to prove the effect on the reduction of sediments and nutrients in the tributaries and especially in the main stream of the rivers Our and Sauer. An overview of the implemented measures and their evaluation is shown.

Mussel monitoring was done on both rivers in relation to the monitoring of the water quality. The obtained results of the monitoring and the control of marked mussels give an idea of the development of the populations.

Furthermore, the results of the monitoring of the mussels and the water quality are an important tool to show the efficiency of the measures to the concerned stakeholders and the different national administrations.

We acknowledge the financial support by the European Commission LIFE+-Nature program, Luxembourg government: Ministry for Sustainable Development and Infrastructures, Ministry of Agriculture.

Evaluating pesticide pressure on freshwater mussel habitats: monitoring requirements and methodological limitations

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Intensive agriculture is suspected to degrade mussel habitats mainly through river bed clogging from enhanced soil erosion as well as eutrophication and its consequences on oxygen regimes. Much less is known about pesticide impacts although these often coincide with the former phenomena. One approach to investigate the role of pesticides is to monitor the immission situation in longitudinal profiles featuring mussel colonies and deserted stretches. Pesticides have strong seasonal dynamics with peak concentrations in flood waves during application periods. The months with the highest occurrences are usually May to July when herbicide applications in Maize coincide with fungicide and insecticide treatments in cereals and other cultures. This study chose sampling points in the context of the presence of freshwater mussels and catchment properties expressed as agricultural intensities to investigate the impact of pesticides. The sites were continuously monitored with the help of passive samplers (POCIS; OASIS-HLB) from mid-May to the beginning of August. The approach allowed to characterize compound profiles and loads as related to land use and dominant cultures. Global ecological impact was calculated with Risk Quotients relating mixed exposure to AA-EQS of the individual compounds. Results showed that the mussel colonies were indeed the least impacted sites in the catchment. Pesticide loads from smaller catchments (1st to second order) varied strongly and the number of detected compounds increased very strongly in the higher order surface waters. Against all odds for weakly urbanized regions, waste water related compounds made a substantial contribution of ecotoxicological impact through some pharmaceuticals and biocides. This contribution also discusses issues of causality, improvements to study design and limitations to conducting evaluations in catchments with depleted autochthonous mussel populations.

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Investigating the Behavioural and Physiological Response of Endangered Freshwater Pearl Mussels to Stress Exposure

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Whilst there is encouragement to be taken from the fact that Scotland remains a stronghold for *Margaritifera margaritifera* populations, a trend of continued population decline persists. Our understanding of the environmental characteristics associated with successful *M. margaritifera* proliferation in the wild is poor. Additionally, evidence to suggest how *M. margaritifera* respond to variation in the associated parameters, is limited. The purpose of this study was to address this knowledge gap via the establishment of a non-invasive method for quantifying acute mussel stress. Experimental analysis compared the behavioural and physiological responses of *M. margaritifera* to a similar freshwater mussel, *Anadonta anatina*, across two different environmental stressors – aerial exposure and high concentrations of suspended fine particulate inorganic matter. Direct observation of behaviour using high resolution camera technology assisted researchers in establishing the presence and frequency of three sublethal endpoints: Transition Frequency, Avoidance Behaviour and Foot Extension. Variation in physiological response was recorded via analysis of oxygen consumption rates using intermittent respirometry. The presence of each of the three sublethal end-points in behaviour exhibited a significant increase in frequency in accordance with the onset of stress exposure, and steadily returned to 'normal' conditions during the post-exposure time period. Additionally, in all instances, mussels were shown to deviate from normal metabolic functioning for extended periods following stress exposure, with a similar extent of variation observed across treatment levels. Further exploration of the results at the individual level revealed variation in the reaction norms across individuals and species, with mussels appearing to display different sensitivities to the stress exposures; accentuated by the perceived alterations in behavioural and physiological traits. Attempts to discern the commonality between behavioural and physiological response highlighted the relationship between valve movement and metabolic rate. Conclusions drawn from this study, suggest further exploration of remote sensing technologies to monitor valve movement in *M. margaritifera*. If perfected - and coupled with continuous monitoring of environmental parameters - such data would enable researchers to explore factors influencing the condition of *M. margaritifera* populations across freshwater systems; thus, providing urgently required empirical data to drive future conservation strategies implemented by government (SNH, SEPA) and utilized by the hydroelectric industry (SSE).

We acknowledge the financial support from the Natural Environment Research Council (NERC), Scottish and Southern Energy (SSE) and the Scottish Alliance for Geoscience, Environment and Society (SAGES).

On the potential for freshwater pearl mussels to serve as a stream water stable isotope recorder

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Early pioneering work in the 1970s and 80s laid the foundation for using the stable isotopes of O and H ($\delta^{18}O$ & $\delta^{2}H$) in the water molecule for flow paths analysis and stream water source apportionment. Time series of precipitation and stream water isotope composition are now a standard tool for quantifying catchment transit times (TT) via mathematical convolution techniques.

While isotope records of streamflow are pivotal for improving our understanding and modelling of hydrological, ecological, biogeochemical and atmospheric processes, their full potential is hindered by short and truncated time series. Recent examples have indeed shown the considerable potential offered by multi-decadal records of $\delta^{18}O$ signals in precipitation and stream water – (i) providing evidence for climate change impacts on river systems in Austria, Germany and the UK, (ii) leading to an improved mechanistic understanding of water flow and quality controlling processes, (iii) serving for the calibration and validation of flow and transport models, or (iv) serving in climate and earth system modelling.

Access to long series of $\delta^{18}O$ and $\delta^{2}H$ in stream water (in combination with long precipitation isotope data series) is a crucial problem in hydrology and environmental sciences. Making progress on this issue is a grand challenge for unveiling potential shifts in streamflow generation processes and anticipate how flowing waters will respond to climate and land use forcings. Here we propose an innovative solution to the problem of stream isotope record limitations: the use of freshwater mollusks as long-term stream water isotope recorders.

An important characteristic of any approach for extending the current (limited) set of long streamflow isotope data series is that it has to be transposable to a wide range of settings (i.e. across continents, elevations, climate and hydrological regimes). We have done pilot work by completing a meta-analysis of mollusk shell $\delta^{18}O$ data (from 10 individual studies), spanning a latitudinal sequence of 18 sampling sites on 16 streams around the globe. We found strong links between isotope signatures in precipitation, stream water and freshwater mollusks – both stream water and mollusk signals showing a strong damping of the precipitation signal.

In order to assess the feasibility of routine analyses of freshwater mollusk shells, we have carried out a proof-of-concept investigation on the potential for SIMS to measure $\delta^{18}O$ signatures in pearl mussel shell growth bands. In what was to the best of our knowledge the first application of SIMS to freshwater pearl mussel shell analysis, we intended to reconstruct stream water $\delta^{18}O$ time series. For six successive growth bands from an empty freshwater pearl mussel shell collected in the Our River (L), we analysed 79 spots via SIMS – distributed along four parallel replicate profiles.

Average and median $\delta^{18}O$ values (-7.19 and -7.14 ‰, respectively [total range from -9 to -5‰]) obtained from an empty freshwater pearl mussel shell (exact date of death unknown) collected in the Our River (L) were similar to those found for precipitation (-7.73 ‰ and -7.25 ‰, respectively [total range from -15 to -3‰]) and stream water (-7.90 ‰ and 7.85 ‰, respectively [total range from -10 ‰ to -6.5 ‰]) sampled (from 2010 to 2015) in a creek with similar climate, land use and bedrock geology, located 40km south-east from the Kalborn Mill (Weierbach catchment). Ultimately, our proof-of-concept work demonstrated that the SIMS technique can be used for reconstructing stream water $\delta^{18}O$ seasonality and signal damping in pearl mussel shells.

Pearl mussel breeding station Hof - history and actual work

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The region Oberfranken (Germany) has six localities with Freshwater Pearl Mussel (FPM) (*Margaritifera margaritifera*) populations and four of them are at borderline localities with the Czech Republic. The population size varies between 40 000 – 50 000 individuals. The main goal of the project is to establish a breeding facility to produce young mussels for the stabilisation of the FPM population in the region and on the long run the restoration of FPM population at selected streams where they were historically present.

Owner and operator of the breeding station is the Bund Naturschutz in Bavaria. Since more than 30 years, this NGO is trying to give the FPM a real chance to survive in the river systems of North-East Frankonia. The Bund Naturschutz bought an old mill (Huschermuehle) and between March and September 2018 it was rebuild to a freshwater mussel breeding station. The new breeding facility for FPM at the Huschermuehle continues using the Czech breeding methods (established by Mr. Hruška) in combination with successful methods developed by other countries. The basic concept of the facility is to establish three breeding cycles within a year - autumn, winter and spring.

The whole project is partly financed by the Interreg Program, the Bavarian Natur conservation Fond and the Bund Naturschutz.

6 ABSTRACTS (POSTER PRESENTATIONS)

Tributary of the river Our

Can genetic data be used as a decision-support tool to guide restoration of fish connectivity in salmonid streams? The example of the Sûre river catchment (Belgium, Wallonia).

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In addition to restraining access to spawning grounds or causing migration retard, longitudinal barriers are known to be responsible for genetic risks in isolated fish populations. Therefore, the conservation of migratory spawning species like brown trout (*Salmo trutta*) implies restoration of stream connectivity. On the other hand, Belgium's rivers have been intensively stocked in past decades using domesticated trout from hatcheries. Interactions between wild and stocked brown trouts may result in the introgression of native gene pools, potentially causing fitness alterations and population decline. From this point of view, physical barriers may sometimes contribute to preserve native populations from the influence of domesticated material. Within the "MigraSûre" project, we took brown trout population genetics into account when prioritizing connectivity restoration projects. Two cases are presented where the decision of whether removing the barrier or not is justified by our willing to lower genetic threat to autochthonous populations. On the Strange River, native populations were missing upstream of an impassable barrier but were present downstream. The disappearance of native trout in the upper stretches being probably linked to a heavy oil pollution episode followed by intensive hatchery restocking. Restoring connectivity at the weir was validated since it did not threaten any remnant autochthonous population, while furthermore allowing downstream potentially better adapted native fish (35% of the population) to recolonize the upper stretches. On the Betlerbaach River system, upstream tributaries were shown to host small preserved native populations while fish living downstream of an impassable road crossing culvert displayed high hatchery introgression. Here, the decision was taken to maintain the downstream barrier and rather focus on reconnecting upstream native populations to each other to limit inbreeding and genetic drift. This was considered the more adequate solution until other conservation measures dealing with hatchery stocking are implemented.

The MigraSûre project 32-1009-002 was co-funded by the European Union (European Fund for Fisheries), Wallonia and Nature Park Haute-Sûre Forêt d'Anlier.

Characterisation of *Unio crassus* Microhabitats in the Sûre River

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In the context of a remeandering project on the Sûre River led by the Parc naturel Haute-Sûre Forêt d'Anlier, we aimed to determine the requirements of the thick-shelled river mussel (*Unio crassus*) in terms of its microhabitats. To fulfill this objective, we carried out a cartography of *Unio crassus* microhabitats at 3 study sites on the Sûre. This method involves the study of features such as depth, current velocity, and substrate analysis. Monitoring of *Unio crassus* populations on the 3 sites allow us to link the individuals location to the hydromorphological characteristics identified. Study devices to characterize sediment transport, such as marked pebbles (PIT-Tags), scour chains and sediment traps, have also been installed. General trends can be identified from the results obtained. Thick-shelled river mussels of the Sûre River are mainly to be found in low velocity zones (from 0 m/s to 0.4 m/s), and in depths higher than 0.3 m for a flow close to the median flow (average of annual medians). They are located mostly at the base of the banks, and in areas of sediment deposition in convex riverbanks. *Unio crassus* individuals are generally found in a gravel-type substrate with a sandy matrix (D50 = 2.6 mm; D90 = 11.3 mm). This grain texture could be used in case of *Unio crassus* habitat restoration projects involving granulometric recharge.

We acknowledge the financial and material support of the Parc Naturel Haute-Sûre Forêt d'Anlier. We acknowledge the support of the Département d'Etude du Milieu Naturel et Agricole (DEMNA).

Actions in progress for the conservation of the thick-shelled river mussel (*Unio crassus*) in Belgium (Life BNIP)

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Unionida are among the most endangered organisms in the world (Lopes-Lima et al. 2017). In Belgium, conservation status of *Unio crassus* form the art. 17 Natura 2000 reporting, estimate that population are U1 in the continental biogeographical region and U2 in the Atlantic region (Wibail et al. 2014). Due to this poor state of conservation, Wallonia has initiated studies and inventories through the Belgian Nature Integrated Project (Life BNIP). The objective is to propose in 2021 an action plan for the protection and restoration of this species.

First, we present past and current distribution of *Unio crassus* in Wallonia. Then we will describe studies in progress about host fishes, habitat requirements and genetics of populations from different catchments. We also describe methodology used with Natura 2000 monitoring and actions of population and habitat restoration already ongoing. We end with perspective and action plan project to protect and restore *Unio crassus* population in Wallonia.

We acknowledge the financial support by Wallonia and European Commission (LIFE2014, IPE BE002 (Belgian Nature Integrated Project).

Translocation of freshwater pearl mussels *Margaritifera margaritifera* before habitat rehabilitation project: feedback on the Dronne River

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The Dronne River shelters one of the largest freshwater pearl mussels *Margaritifera margaritifera* populations in France, with more than 20,000 mussels. To preserve this population, Périgord-Limousin Regional Natural Park coordinates a European LIFE + program (LIFE13 / NAT / FR000506). A preliminary diagnosis has highlighted several impacts caused by the presence of an old dam in Saint-Saud-Lacoussière: disruption of ecological continuity, habitats loss by clogging substrate upstream of the dam, temperature elevation in summer, risk of sudden rupture. A habitat restoration project consisted of the dam removal. Before the work begins, more than 500 mussels localized just downstream were moved to a receptor site selected to optimize the success of translocation. During the collecting stage, many unidentified mussels were found in the first few centimeters of substrate. 10 % of moved mussels have been tagged and tracked for 18 months. The results of the mussel monitoring and the quality of restored habitats are presented here.

15-year experience of saving the last freshwater pearl mussel population in North Rhine-Westphalia, Germany

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The last freshwater pearl mussel population in North Rhine-Westphalia is found in the river Perlenbach near Monschau. From formerly half a million mussels around the year 1800 only 40 mussels, aged more than 60 years, were left in 2003.

In 2003, the LIFE project "Lebendige Bäche in der Eifel" was set up to restore the habitat for pearl mussel (*Margaritifera margaritifera*) and brown trout (*Salmo trutta*). Besides that, a captive breeding programme started. In 2006, the first infestation of brown trout took place. For two more years, it was possible to infest fish with glochidia until in 2009 the last five mussels died in a dry and hot summer. In 2018, there are around 200 mussels in cages aged between 11 and 9 years issued from the captive breeding programme. In around 5 years, a new cycle of reproduction of pearl mussels from the Perlenbach can be expected.

Until then some tasks will have to be done, e.g.:

- Introduction of substrate (lack of suitable grain sizes).

- Analyzing possible sections with stable substrate conditions in changing water levels.

- Improving the genetic pool with genetically related populations.

Water purification performances of freshwater mussels

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Freshwater bivalves provide immense ecosystem services due to their feeding habits. The following trial intends to demonstrate the potential impact of freshwater mussel on their environment. Furthermore, it aims to develop more detailed experiments, to prove general ecosystem services on water chemistry provided by freshwater mussels.

Observations and measurements on two identical tanks, both containing the same amount of brown trout, one containing 10 adult *Anadonta cygnea*, show the influence of freshwater mussels on different parameters such as pH, NO_2^-, NO_3^-, NH_4^+ and PO_4^{3-}. Chemical analyses are run once weekly for several months. The short period of this first trial cannot lead to scientific significant results, however several promising figures have been observed.

It is worth running further detailed experiments regarding influences of fresh water mussels on water chemistry, since the first short trial already showed a decline of several parameters such as NO_2^- and NH_4^+ in the tank containing mussels. The poster also shows tracks for continuing models to be elaborated in the future to verify the first short-term results and supply more evidence for positive effects of mussels on their environment.

In addition to the change, freshwater bivalves can produce on water chemistry; further trials should be used to observe the influence of mussels on fish condition and behaviour.

New insights into the invertebrate fauna of beaver dams – a comparative study conducted with a vacuum sampler

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Beaver dams are influential structures in streams, since they are able to create a multi-habitat-pattern, which affects stream ecosystems and their adjacent areas in many ways. These beaver generic landscapes are described and explored by many scholars. Nevertheless, we still lack data on the faunal composition of beaver dams themselves, because common water ecological sampling methods do not allow for encompassing investigations. Thus, it is hardly surprising that the present data regarding this topic is comprised of two studies worldwide (Clifford et al. 1993; Rolauffs et al. 2001). For a new approach in surveying this well-hidden species community within beaver dams, I constructed a vacuum sampler. This sampler was initially tested under field conditions in 2017, resulting in the documentation of 18 species out of 11 orders, including the first and unexpected discovery of *Dianous coerulescens* (Coleoptera) in a beaver dam. *Dianous coerulescens* is known as a species living in the splash zone of waterfalls or weirs and mill wheels as well as banks of cool and fast flowing streams with overflowed mosses and other vegetation. In order to sample beaver dams systematically, nine different areas on the dam were defined and each of them were sampled for three minutes. With this method, an investigation of eight abandoned and eight active beaver dams was conducted in spring 2018 in the Nordeifel (North Rhine-Westphalia, Germany). First results of this comparative investigation will be presented.

7 CONTACT INFORMATION OF PARTICIPANTS

Tagged *Unio crassus* on the river bottom after release

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9 RESTAURANTS AND HOTELS IN CLERVAUX

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10 NOTES