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Editorial

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Dear readers,

When we started planning this issue of Danube News in January 2020, we assumed that it would be prepared as “business as usual”. As you all know, our world was turned upside down in February or at the latest in March 2020. In order to prevent the spread of the SARS-CoV-2 virus, we all had to move to home workplaces, adapt to various restrictions of daily life and at the same time still take over the daily work tasks and often the care of children at home or of elderly relatives.

Under these circumstances, we are especially pleased that Danube News 41 will be published in time and in the same quality as you are used to. In this issue, Tobias Epple and his colleagues provide insights into the effects of fragmentation and subsequent fish pass construction on nase in the Iller, a Bavarian tributary of the Danube. Georg Janauer concentrates on the spread of invasive plants in the Danube and possible management measures to control or restrict them. Michael Neumayer and his colleagues describe their conceptual approach and models for evaluating the effectiveness of natural and decentralised flood protection measures for streams in Bavaria. Finally, Johanna Weidendorfer analysed in her bachelor thesis the application of several macrophyte-based assessment methods for Serbian Danube backwaters.

As some of you may have read or been informed, the 43rd IAS conference will also have to be postponed. We hope to meet you at the currently scheduled date of 26–29 October 2020 at the Aueninstitut Neuburg. Please check for news at iad2020.ku.de.

We would like to thank all authors, our always supportive graphic designer and the printing shop for their efforts and contributions during this challenging time and wish all our readers health and strength for the time ahead.

The life cycle of nase *(Chondrostoma nasus)* before and after the construction of hydropower plants in the river Iller (Bavaria, Germany) and its migration behavior through fish-bypass channels

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Abstract

The middle section of the river Iller (Bavaria, Germany) is fragmented by weirs since the mid-20th century. At five hydropower plants (Illerstufe 4 – 8), fish-bypass channels have been constructed between the years 2013 and 2016. The upstream migration of the European fish species nase *(Chondrostoma nasus)* through the fish bypass channels has been studied daily with fish counting pools over 3 years and correlated with abiotic factors. The main abiotic factors that influence the migration patterns of juvenile and adult nase are water temperature and day-length. The highest numbers of migrating adult nase have been documented at water temperatures between 9.0 and 9.9° C and increasing day-lengths between 13:00 and 13:30 hours. Through a literature study, electrofishing and the fish counting pool, the life cycle of the nase has been investigated at the hydropower plant Illerstufe 6. Prior to the fragmentation, nase from the whole river Iller and probably even from the river Danube have migrated to two spawning habitats in the upper river Iller. After the fragmentation, migration has been impossible over a long time and there has been a large reduction of the nase population in the middle section of the river Iller.

After the restoration of the river continuity at the Illerstufe 6, nase are not migrating to their former spawning grounds at the upper river Iller anymore. The great majority of nase is only entering the fish-bypass channel for spawning and is leaving it again instantly after spawning downstream. After hatching, the larvae of nase are also leaving the fish-bypass channel downstream and congregate at a shallow water area in the main stream of the river Iller, which is used as their juvenile habitat. Even after the restoration of the river continuity, there is no automatic return to the same migration and spawning pattern as prior to its fragmentation.

1. Introduction

During evolution, fish adjusted to the 'four-dimensional' continuity of rivers (Ward 1989). Therefore, the continuity of rivers has a central importance for the interconnection, spread and resettlement of populations. For many fish species, complex interactions between different habitats are well-known (Jungwirth et al. 2000). Organisms of running waters are losing their possibility to migrate free through waterbodies intersected by dams, which are fragmenting rivers. The wide-spread construction of weirs and dams shows big effects on the biodiversity (Mueller et al. 2011). Thereof, especially long-distance migrating fish and gravel spawners are affected (Schiemer & Spindler 1989). Nowadays, watercourses are considered to be one of the most endangered ecosystems worldwide (Geist 2011). To counteract this situation, the European Union has passed the 'Water Framework Directive' in 2000. Besides other factors, the river continuity is considered paramount. Therefore, interruptions of the continuity must be restored by fish-bypass channels (Marmulla 2001).

Nevertheless, there are still open questions: e.g. how fish are using fish-bypass channels and whether there are abiotic factors, which affect the migration through fish-bypass channels. Another question is, whether the life cycle of river fish species is comparable to the time before the fragmentation of the river once the river is restored with fish-bypass channels. These points will be addressed by the example of a nase *(Chondrostoma nasus)* population in the middle river Iller (Bavaria, Germany).

2. General Situation

2.1 Study area

The study took place at the river Iller in southern Bavaria, Germany. The river Iller has a catchment area of 2154 km² and a mean discharge of 53.9 m³/s (GKD Bayern 2019). It flows into the river Danube near the city of Ulm *(fig. 1)*. Between Altusried and Lautrach *(fig. 2)*, five run-off river hydropower plants have been built in the first half of the 20th century. It has not been possible for fish to migrate upstream over them. Also, at the hydropower plant 'Illerstufe 6' *(coordinates: N 47.869845° E 10.181145°, fig. 2, fig. 3)* which has been built until 1951 near Legau, the river continuity has been interrupted over many decades.

Between 2012 and 2016, all five run-off-river hydropower plants in the study area have been made passable with fish-bypass channels. Most of them have been constructed

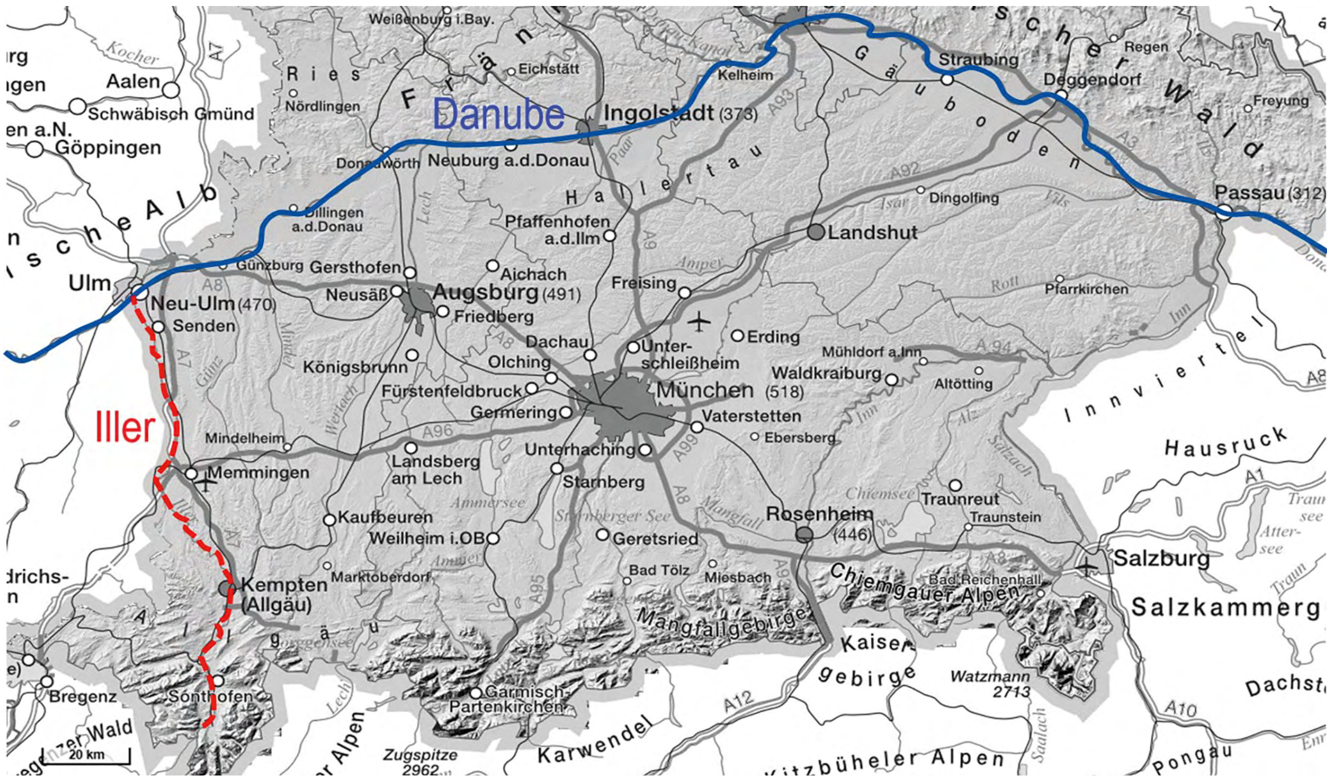

Figure 1: An overview of southern Germany, with the river Iller and the river Danube. Credit: Tobias Epple, modified from Bayerische Vermessungsverwaltung.

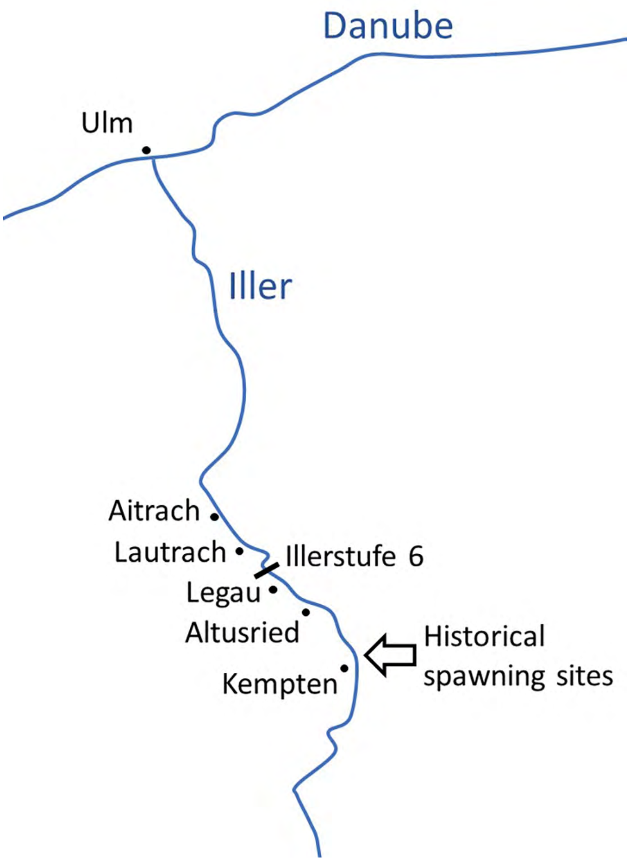

Figure 2: *Detailed map of the river Iller. 'Historical spawning sites' depicts the location of the historical spawning sites of nase (Chondrostoma nasus) described in Kreisfischereiverein (county fishing association) für Neuburg und Donau (1895) and Sarrazin (1992). The spawning site mentioned in Kreisfischereiverein für Neuburg und Donau (1895) is around 2,4 km downstream of the spawning site described in Sarrazin (1992). Credit: Tobias Epple.*

as a nature like pond pass. The length of the fish-bypass channel at the Illerstufe 6 is 473 m, its mean flow is 0.9 m³/s. During the construction of the fish-bypass channel, it was paid attention to the fact, that it is not only a pure migration corridor, but also a compensatory habitat for rheophilic fish species. Hence, there has been an aim to construct structures in the fish-bypass channel, which enable gravel spawning fish species to spawn there (Epple et al. 2018). Otherwise, also shallow and slow flowing shore areas have been integrated in the fish-bypass channel, which are suitable as larvae- and juvenile habitats. There have also been fish-bypass channels built at the other hydropower plants in the middle river Iller, so that the river continuity of the river Iller is now restored from its source until Aitrach *(fig. 2)*.

The downstream area of the hydropower plant Illerstufe 6 is free flowing over a length of round 1.5 km and starts to merge into the head of the reservoir of the next hydropower plant then. There is no gravel over wide areas in the downstream water section. The riverbed is mainly flat rock *(fig. 3)*. This leads to a lack of suitable spawning grounds for gravel spawners. Therefore, gravel has been added between 2017 and 2018 in the downstream area of the Illerstufe 6 *(fig. 3;* Epple et al. 2019; Stojakowits et al. 2019).

2.2. The nase *(Chondrostoma nasus)*

The nase *(Chondrostoma nasus)* is a schooling fish of the *Leuciscidae* family and populates the mid-courses of middle-European rivers *(fig. 4)*. It reaches a size up to 60 cm and a weight of 2.5 kg. In spring, nase migrate up to 100 km upstream to their spawning grounds (Penaz 1996). The

Figure 3: *The hydropower plant 'Illerstufe 6' near Legau. The fish-bypass channel at the left shoreline is clearly visible. There have been bed load additions at the right shoreline and shore levelling at the left shoreline. At the midstream of the main riverbed, flat rock is visible as light ground. Credit: Olav König.*

Figure 4: The nase (Chondrostoma nasus) is a common fish in middle Europe. In spring it migrates up to 100 km upstream to their spawning grounds. Credit: Patrick Türk/Landesfischereiverband Bayern e.V.

spawning itself takes place between mid-March and late April at water temperatures from 9.6 to 10.8° C (Huber & Kirchhofer 1998; Melcher & Schmutz 2010). Suitable spawning habitats are shallow, fast flowing and gravelly stream areas (Keckeis 2001). The larvae and juveniles have different habitat requirements than the adult nase and need shallow and slow flowing habitats along the river shore (Keckeis et al. 1997).

3. Material & Methods

At the inlet area of all five fish-bypass channels of the project area, a fish counting pool has been installed, in which all fish that are migrating upstream through the fish-bypass channels are registered in species and size daily from 15.08.2016 to 15.08.2019 (Epple et al. 2019). The fish-counting pools have a size of 4.6 m x 2.0 m, the bar racks at the inlet and outlet have a bar rack distance of 15 mm. Due to a fish trap, fish cannot leave the counting pools anymore after they have swum in. The numbers of nase in the counting pools have been matched with water temperature and daylength.

The historical situation of nase in the river Iller has been reconstructed through a literature study, as well as historical spawning sites. The present population of nase and its spawning and migrating situation at the Illerstufe 6 has been established with electrical fishing, a fish counting pool in the fish-bypass channel and optical observations of spawning processes.

Electro-fishing has been realized in the downstream water area of the Illerstufe 6 once in spring 2017, autumn 2017 and autumn 2018 on a length of over 1.5 km. At every fishing day, both shorelines have been fished once against the flow and the midstream once with the flow. All caught nase have been measured to the nearest cm. The fish-bypass channel around Illerstufe 6 has been fished electrically in spring 2017 and spring 2018 upstream against the flow. During the spawning season, the fish-bypass channel has been searched daily visually for spawning nase in 2016, 2017 and 2018.

4. Results

The majority of the nase that have been documented in the fish-counting pools had a total length from 47 to 54 cm and are assigned to the age group of adults. Furthermore, numerous juvenile nase with a total length between 5 and 20 cm have been registered in the fish-counting pools. In contrast, nase with a total length between 20 and 46 cm have only been documented sporadically, with few individuals *(fig. 5)*.

Adult nase have been primarily recorded at water temperatures between 8.0 and 12.9° C in the fish-counting pools, with a peak at water temperatures between 9.0 and 9.9° C. At water temperatures below 5.9 and over 17.0° C, no adult nase have been registered in the fish-counting pools. Juvenile nase show a different migrating behavior subject to the water temperature, in contrasts to the adults there are two peaks at very warm water temperatures from 21.0 to 21.9° C and above 23.0° C *(fig. 6)*.

Depending on the daylength, the number of adult nase in the fish-counting pools shows a strong peak at increasing daylengths from 12:30 to 13:59 hours. Beside this daylength, only a few adult nase have been documented in the fish-counting pools. The relation of the mean daily number of juvenile nase to the daylength is not as closely

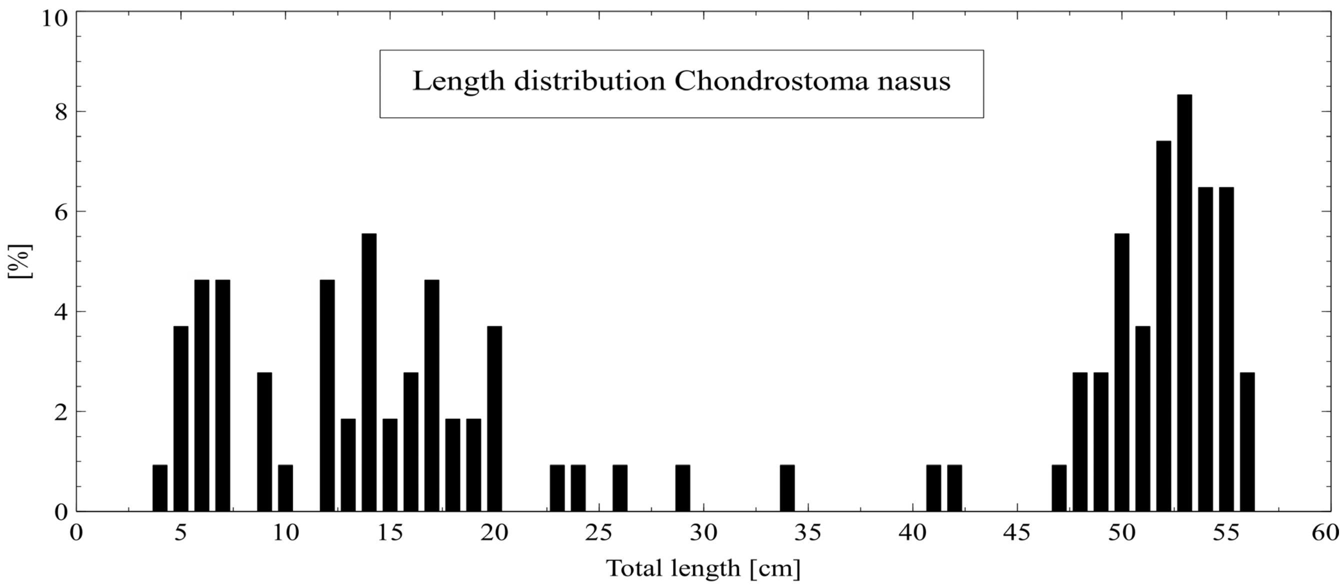

Figure 5: *The length distribution of nase (Chondrostoma nasus) recorded in the fish counting pools of the five fish-bypass channels in the study area. Credit: Tobias Epple*

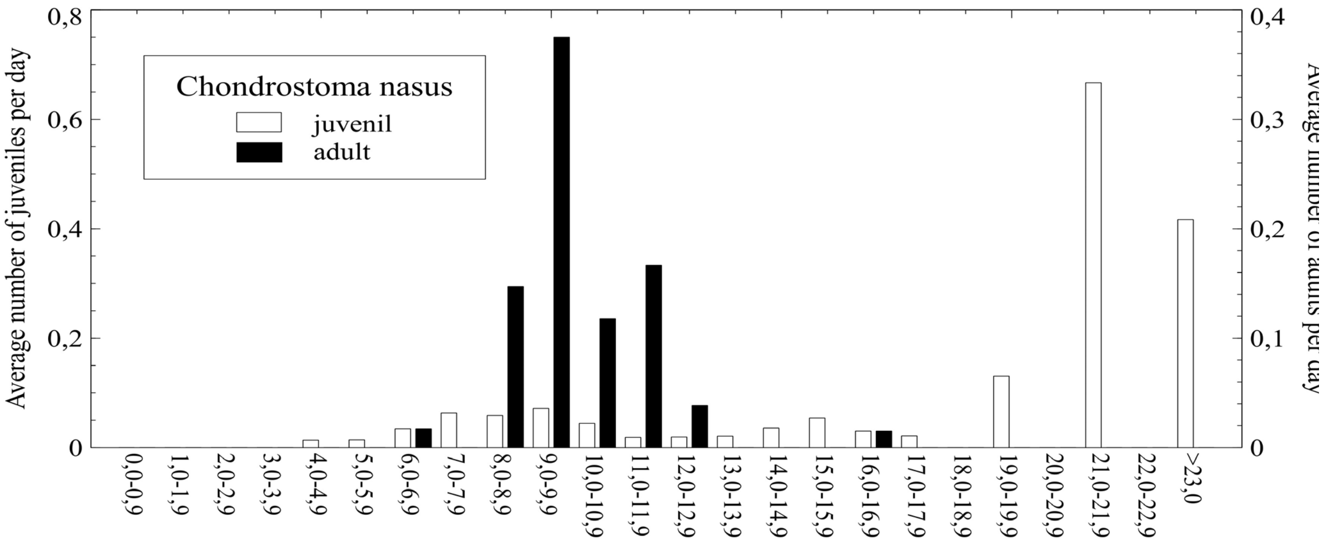

Figure 6: *The average daily numbers of juvenile and adult nase (Chondrostoma nasus) recorded in the fish counting pools of the five fish-bypass channels in the study area, in relation to the water temperature. Credit: Tobias Epple*

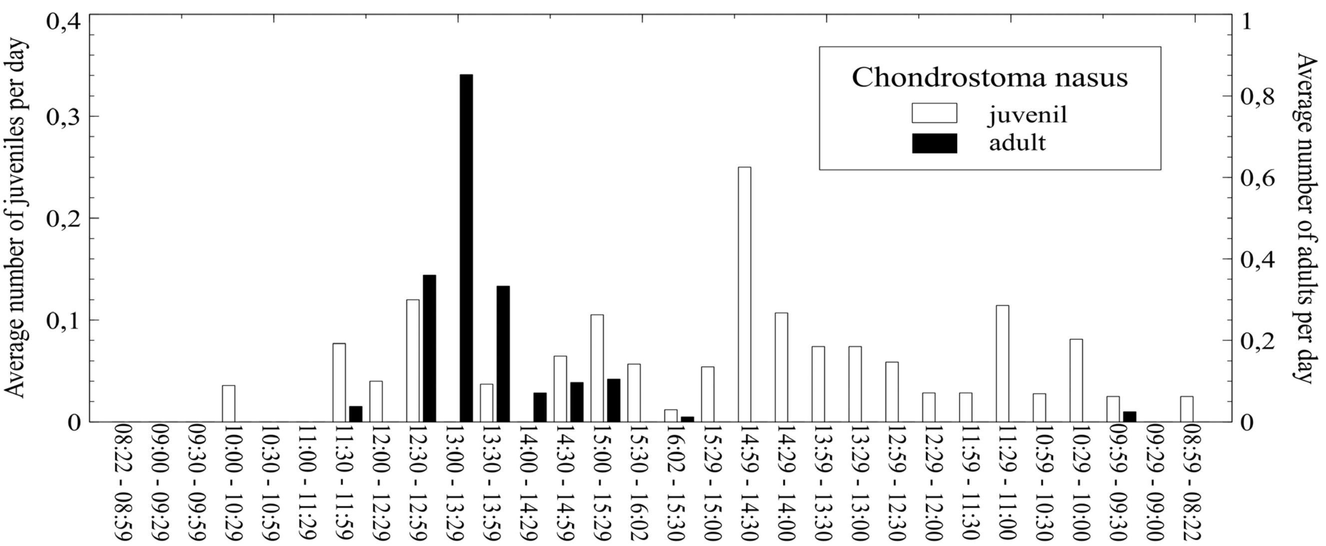

Figure 7: *The average daily numbers of juvenile and adult nase (Chondrostoma nasus) recorded in the fish counting pools of the five fish-bypass channels in the study area, in relation to the daylenght. Credit: Tobias Epple*

linked as for the adults. The highest mean daily numbers of juvenile nase have been registered at decreasing daylengths between 14:59 and 14:30 hours *(fig. 7)*.

Two sources have been identified which are describing the historical situation of nase in the river Iller before its fragmentation (Kreisfischereiverein für Schwaben und Neuburg 1895; Sarrazin 1992). The Kreisfischereiverein für Schwaben und Neuburg (1895) names a spawning site at the mouth of a creek called "Mühlbach" into the river Iller (coordinates: 47°47'02.1"N 10°17'24.3"E). Further in this text, there is no other description of the population of nase, although the fish stock of the river Iller is outlined in detail. It is described, that the barbel (Barbus barbus) and all other fish of the barbel region are frequent downstream from the city of Lautrach *(fig. 2)*. Whether this also includes nase can only be suspected.

Sarrazin (1992) documents that the river Iller has been historically well-known for its spawning migrations of thousands of nase, which have migrated until the upstream area of the city of Kempten *(fig. 1, fig. 2)*, coming from the river Danube *(fig. 1)*. An exact spawning site is not indicated. Furthermore, Sarrazin (1992) depicts that in the beginning of the 1990s some nase were still present between the hydropower plants, but that they cannot migrate anymore because of the fragmentation.

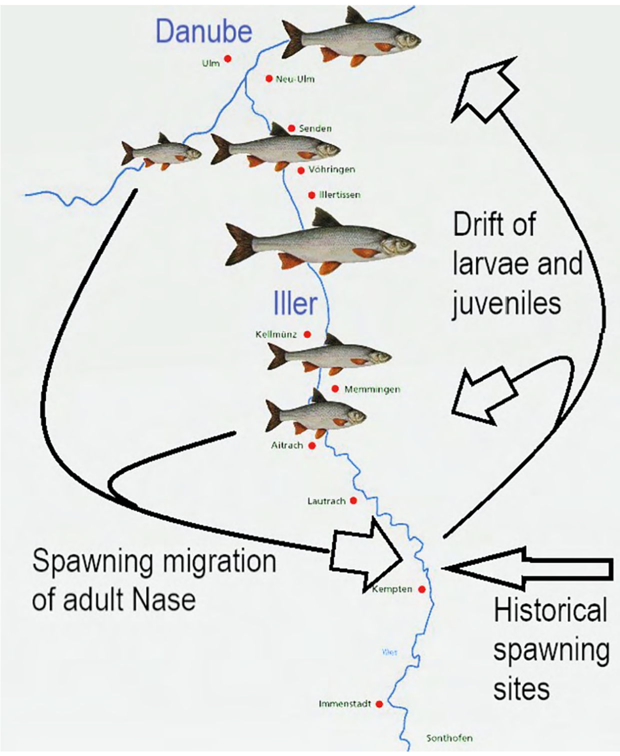

***Figure 8:** Reconstructed historical life cycle of nase (Chondrostoma nasus) in the river Iller. nase from the whole river Iller and probably even from the river Danube migrated to the historical spawning grounds in the north of the city of Kempten, to spawn there with many ten thousand individuals. Subsequently, the larvae and juveniles were drifted away from the spawning ground and spread out in the mid and lower river Iller and river Danube again. Credit: Tobias Epple, modified from www.fahrrad-tour.de, 21.12.2018.*

In Sarrazin (1992) also a spawning site at the mouth of the river Leubas into the river Iller *(fig. 2)* is mentioned. Thus, this spawning site is located around 2.4 km upstream of the spawning site that Kreisfischereiverein für Neuburg und Donau (1895) records. Sarrazin (1992) further describes, that during their spawning 10 000 to 13 000 nase are caught at the spawning site at the mouth of the river Leubas every year.

During electro-fishing in spring 2017 (26. May 2017), three nase have been caught in the downstream area of Illerstufe 6, two adults with a total length of 54 cm and 58 cm and one juvenile with a total length of 6 cm. In autumn 2017 (29. September 2017), 15 nase have been captured by electrical fishing. Three of them have been adults with a total length of 38 cm, 52 cm and 56 cm, 12 of them juveniles with a total length from 4 cm to 7 cm. In autumn 2018 (12. October 2018), 10 adult nase with a total length from 51 cm to 54 cm and 1441 juvenile nase with a total length from 6 cm to 10 cm have been caught. All juveniles have been documented in a cut-off meander around 1.5 km downstream of the Illerstufe 6 (coordinates: 47°52'26.6"N 10°10'26.5"E).

During electrical fishing in the fish-bypass channel around Illerstufe 6, no nase have been caught.

In 2016, 2017 and 2018, 100 to 150 spawning nase have been documented in the fish-bypass channel in spring. The spawning nase had an estimated total length of 35 cm to 55 cm.

In spring 2017, seven nase with a total length between 48 cm and 54 cm migrated into the fish-counting pool of the fish-bypass channel around Illerstufe 6 between 01.04.2017 and 18.08.2017. Four of them have been documented before the spawning in the fish-bypass channel and three of them after it. In spring 2018, 13 nase have migrated into the fish counting pool between 09.04.2018 and 19.04.2018. Two of them had a total length of 18 cm and 20 cm and eleven between 50 cm and 56 cm. Of the eleven sexually mature nase, nine have been documented before the spawning in the fish-bypass channel and two after it.

5. Discussion

The peaks of adult nase in the fish-counting pools are strongly related to their spawning migration. Besides the spawning migration, nearly no adult nase have been documented in the fish-counting pools. The increasing daylengths from 12:30 to 13:59 hours corresponded to the period from ca. March 26 to April 22. The peak of juvenile nase at decreasing daylength between 14:59 and 14:30 hours corresponded to the period from ca. August 01 to August 11 and fits subsequently to the peaks in high water temperatures. The motivation of this migration cannot be easily interpreted. It could be a migration to find suitable feeding grounds, as this is described by Prchalová et al. (2006) for other cyprinids.

Based on the literature study, it was possible to establish, that before the fragmentation of the river Iller, nase from the whole river Iller and probably even from the river Danube (Sarrazin 1992) migrated to the two spawning grounds in the upper river Iller *(fig 8)*. The fact that 10 000 to 13 000 nase have been caught at the mouth of the river Leubas during spawning every year, without endangering the population, obviously shows, that many thousand nase must have spawned there. This indicates a large nase population in the river Iller prior to its fragmentation. The literature study shows also that the nase have been migrating over long distances, before the fragmentation of the river Iller. The distance from the mouth of the river Iller to the Danube into the spawning ground described by Sarrazin 1992 is around 95 km.

The total length of the observed spawning nase, the nase documented in the fish counting pool and the nase caught while electrical fishing, leads to the conclusion, that the nase population at the downstream area of Illerstufe 6 is strongly overaged, due to a lack of medium sized fish between 20 and 45cm total length. It is assumed, that successful spawning of nase at the downstream area of Illerstufe 6 only took place on a very limited basis in recent years before the restauration measures, mainly because of the lack of spawning habitats. Therefore, only a small relict population of nase could persist.

It is concluded from the present results that the majority of nase at the downstream area of Illerstufe 6 is not migrating over long distances anymore, even though this would be possible again due to fish-bypass channels. Only a small part out of the 100 to 150 nase that have spawned in the fish bypass-channel migrated through the whole fish-bypass channel. The main part of nase is only entering the fish-bypass channel to spawn there and not to migrate through it *(fig. 9)*. After spawning the nase are leaving again the fish-bypass channel downstream. After hatching, the nase-larvae are drifted out of the fish-bypass channel downstream. They are growing up in a small cut-off meander around 1,5 km downstream of the Illerstufe 6 *(fig. 9)*.

From the results of electrical fishing in autumn 2018 it is assumed, that the nase population of the Illerstufe 6 is now recovering slowly. The main reason for this is seen in the presence of suitable spawning habitats in the fish bypass-channel, since there have not been suitable spawning habitats in the downstream area of Illerstufe 6 itself over a long time.

Before the fragmentation nase have done long spawning migrations through the river Iller *(fig. 8)*. After the successful restoration of the river continuity, the nase of the downstream water section of Illerstufe 6 are no longer performing long spawning migrations anymore. They migrate only a few 100 meters from the downstream water area of Illerstufe 6 to the spawning habitats of the fish-bypass channel *(fig. 9)*. The downstream area is used as an adult and feeding habitat by the sexually mature nase. The fish-bypass channel is only used as a temporary habitat by adult nase for spawning. Only a small part of the nase population uses the

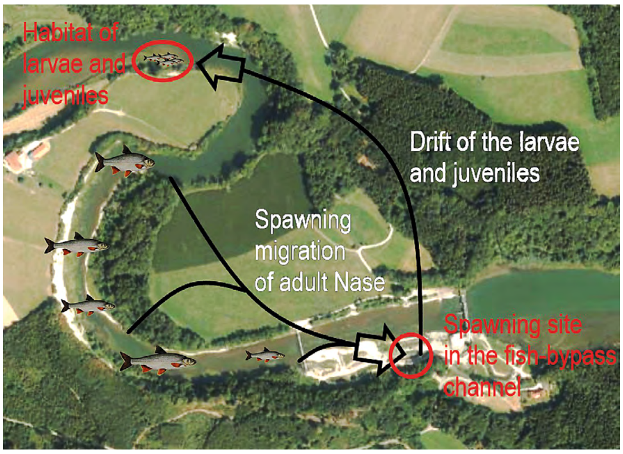

Figure 9: The life cycle of nase (Chondrostoma nasus) at the hydropower plant Illerstufe 6 in the middle river Iller after the restoration of the river continuity with a fish-bypass channel. The main part of the nase population moves in the fish-bypass channels only for spawning and leaves it after spawning downstream again. Only a small part of the nase population uses the fish-bypass channel for upstream migration. The fish-bypass channel is used by nase primarily as a spawning habitat and not as a migration corridor. After the hatching, larvae of nase drift out of the fish-bypass channel downstream and congregate at a shallow water area round 1,5 km downstream of the Illerstufe 6, which they use as their larvae and juvenile habitat.
Credit: Tobias Epple, modified from Bayerische Vermessungsverwaltung.

fish-bypass channel as a migration corridor. Nase larvae are drifted out of the fish-bypass channel downstream and are also not using the fish-bypass channel as a long-term habitat. They are congregated in a shallow water area at the main river, which they use as their juvenile habitat.

6. Conclusions

Even after the successful restoration of the river continuity, the spawning and migration behavior of nase will not be automatically be the same as before the fragmentation. The life cycle of nase can, if the relevant habitats are available, take place along relatively few river kilometers. There are complex interactions between fish-bypass channels and the main river, emphasizing why the presence of suitable key habitats is essential in both water compartments. Therefore, restauration efforts must concentrate on both areas.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Acknowledgements

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References

Bayrle, H. (2007). Süßwasserfische, Muscheln, Krebse. Heintges Lehr- und Lernsysteme GmbH, D-95615 Marktredwitz

Epple, T., Friedmann, A., & Wetzel, K. F. (2019). Illerstrategie 2020 und EU-Projekt ISOBEL schließen Lücken zwischen Forschung und Praxis. WasserWirtschaft, 2–3/2019. 68–74.

Epple, T., Wetzel, K.-F., Friedmann, A. (2018): Einbau und Pflege von Kieslaichplätzen in naturnah gebauten Fischaufstiegsanlagen. WasserWirtschaft 9/2018, 63–68.

Geist, J. (2011). Integrative freshwater ecology and biodiversity conservation. Ecological Indicators, 11(6), 1507–1516.

GKD Bayern (2019). Aktuelle Messwerte Wieblingen / Iller. https://www.gkd.bayern.de/de/fluesse/abfluss/iller_lech/wiblingen-11405000/messwerte. 13.05.2019

Huber, M., & Kirchhofer, A. (1998). Radio telemetry as a tool to study habitat use of nase *(Chondrostoma nasus* L.) in medium-sized rivers. Hydrobiologia, 371, 309–319.

Jungwirth, M., Muhar, S., & Schmutz, S. (2000). Fundamentals of fish ecological integrity and their relation to the extended serial discontinuity concept. In: Assessing the Ecological Integrity of Running Waters. Springer, Dordrecht. 85–97.

Keckeis, H. (2001). Influence of river morphology and current velocity conditions on spawning site selection of *Chondrostoma nasus* (L.). Archiv für Hydrobiologie. Supplementband. Large rivers, 12(2–4), 341–356.

Keckeis, H., Winkler, G., Flore, L., Reckendorfer, W., & Schiemer, F. (1997). Spatial and seasonal characteristics of 0+ fish nursery habitats of nase, *Chondrostoma nasus* in the River Danube, Austria. Folia Zoologica-Praha, 46, 133–150.

Kreisfischereiverein für Schwaben und Neuburg (1895). Fischbuch für Schwaben und Neuburg. 5–8

Marmulla, G. (2001). Dams, fish and fisheries: opportunities, challenges and conflict resolution (No. 419). Food & Agriculture.

Melcher, A. H., & Schmutz, S. (2010). The importance of structural features for spawning habitat of nase *Chondrostoma nasus* (L.) and barbel *Barbus barbus* (L.) in a pre-Alpine river. River Systems, 19(1), 33–42.

Mueller, M., Pander, J., & Geist, J. (2011). The effects of weirs on structural stream habitat and biological communities. Journal of Applied Ecology, 48(6), 1450–1461.

Penàz, M. (1996). *Chondrostoma nasus*-its reproduction strategy and possible reasons for a widely observed population decline-a review. In Conservation of endangered freshwater fish in Europe. Birkhäuser Basel. 279–285.

Prchalová, M., Vetesník, L., & Slavík, O. (2006). Migrations of juvenile and subadult fish through a fishpass during late summer and fall. Folia Zoologica, 55(2), 162.

Sarrazin J. (1992): Fischerei auf der Iller. – In: Kettemann, O & U. Winkler (Hrsg.): Die Iller. Geschichten am Wasser von Noth und Kraft. Druckerzeugnisse des Schwäbischen Bauernhofmuseums Illerbeuren 5, 100–110.

Schiemer, F., & Spindler, T. (1989). Endangered fish species of the Danube River in Austria. Regulated Rivers: Research & Management, 4(4), 397–407.

Stojakowits, P., Epple, T., Merkel, W., Friedmann, A., Wetzel K.-F. (2019). Wege zur Zielerreichung des guten ökologischen Potenzials am Beispiel der Iller zwischen Krugzell und Lautrach. Hydrologie & Wasserbewirtschaftung, 63, (5), 262–277.

Ward, J. V. (1989). “The 4-dimensional nature of lotic ecosystems.” Journal of the North American Benthological Society 8(1): 2–8.

Neophytes – what will be the future for present Aquatic Floodplain Vegetation?

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The river corridor environment and its aquatic plants

Floodplains are part of river corridors, which – in pre-regulation times – extended significantly in lateral dimension of the river course wherever landscape conditions had allowed. Today most river corridors are constrained by human intervention, especially by systems of levees, mainly serving flood protection. Therefore, waterbodies between the levees, still connected to, or already disconnected from the main channel, are part of the ‘active floodplain’ environment and undergo periods of high to extreme discharge, but the active floodplain area is usually much reduced as compared to historical conditions. Beyond the levees former river channels and meanders still are present in many locations, but their waterbodies are relicts, which depend on groundwater connection with the active floodplain and on precipitation. Most of these waterbodies have negligible flow, close to still conditions.

The term ‘Aquatic Macrophytes’ comprises aquatic plant species, even some bryophytes (mosses and liverworts), but usually no algae species. Aquatic plants live submersed (pondweed), with floating leaves (water lily), or free floating (duckweed), but some can live either submersed and/or in very shallow water, and/or on wet substrate, too (moneywort). All plant species which are rooted in shallow water and reach up the shore of still waters or up on river banks, with most of their structures above the water, are ‘helophytes’ (reed, cattail). Despite the fact that all these plants produce oxygen during light hours, most essentially they contribute to providing structure in the open water (hideout for young fish, cover for predatory fish), serving for food (waterfowl, invertebrates) and offering much space on the surface of their stems and leaves (algae, fungi, protozoa, invertebrates, etc.). This makes them an essential group of organisms in aquatic environments. Non-native aquatic plants, which show ‘invasive character’, can be called ‘Aquatic Neophytes’.

Neobiota – their ‘legal environment’ defined by EU-Regulation

Aspects regarding invasive species are dealt with the ‘Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 23 October 2014 on the prevention and management of the introduction and spread of invasive alien species’ (Official Journal of the European Union / L317, EU IAS 2014). Alien species of animals, plants, fungi and micro-organisms are subject of this Regulation, but only where they ‘become invasive’, show ‘adverse impact’ on native biodiversity and ecosystem functions, or on social, respectively economic, conditions. EU Member States take liability for preventing the negative effects of invasive species (for detail consult EU-Document L317).

The list of Invasive Alien Species (IAS) is under permanent development, provided that special intensive studies on invasiveness and threat to sensible environments and biota request action against these species. Prevention is the first step of impeding the access of non-native species to EU territory, followed by minimization and mitigation as the next measures on localizing and finally terminating the growth and the destructive effects of IAS. The issue of keeping track of alien animals, as well as plants, fungi and micro-organisms, shows some advantage in detecting plant species, as they do not move around like animals, and usually they are larger than most fungi, and micro-organisms in particular.

Aside from the above mentioned Regulation, other legal instruments of the European Union also take account of biota in waterbodies. Protection, sustaining and even enhancing present ecological conditions for sensitive native biota, including aquatic plant species occurring in waterbodies located in floodplains, active or beyond the levees, are part of these documents.

The EU Water Framework Directive 2000 (EU WFD 2000), amended by the Commission Directive 2014/101/EU (EU Amending Directive, 2014) explicitly state that all landscape elements depending on surface or groundwater connection with waterbodies, running and still, need to be integrated in any planning for reaching 'good status' or 'good potential' as the goals of WFD.

The focus of the conservation-aimed Council Directive 92/43/EEC (EU Habitats Directive 1992) is assuring the 'favourable conservation status' in protected areas, based on the list of habitats and species. If this status is not met at present, appropriate measures shall be taken.

Additional to balancing and compensating between the – in part – unbalanced aims of the two directives, the required tasks becomes more complicated as many countries of the temperate climate zone undergo a progressive change towards higher summer temperatures and longer lasting periods of vegetation development, as well as lower precipitation rates. This transformation provides important preconditions for non-native species from warm-temperate and subtropical regions of the globe to migrate more effectively into regions beyond the limits of their earlier areas of occurrence.

‚Aquatic Neophytes' – so what? BUT!

‚Aquatic Neophytes', the focus of this contribution, comprise different aquatic plant species which are non-native to the European Countries, with a capacity of invasive growth and capable of replacing native plant species. Many European countries already suffer from heavy infestations by non-native aquatic plants, but not in all locations these plant species are 'invasive'. This term is only used when native plants are suppressed or completely replaced by

Figure 1: An example of a dense canopy of the young Pistia stratiotes L. © georgjanauer 2020

the new species alien to the respective waterbodies and their surrounding environment and landscape. One of the reasons how alien aquatic species can keep their invasive power is the fact that in their new environments natural enemies are missing.

In Austria the distribution and abundance of terrestrial neophytes is especially critical along train dams, road margins, and river banks. However, infestation by aquatic invasive species is still at a low level in Austria as compared to other European regions (e.g. W- and S-Europe, and parts of Switzerland and Germany). Navigation canals with slow water flow, reservoirs for irrigation or other human use, but also large fishponds are environments preferred by invasive neophytes.

Natural decay and reduction of established, albeit relatively small areas with invasive aquatic species, is not very likely due to the fact that most of the neophytes referred to below, are regenerated by owners of aquariums and bio-swimming pools, who consider the density of aquatic vegetation to have turned into a nonsensical situation in these waterbodies.

In a small canal in Carinthia (Austria) *Cabomba caroliniana* is present since many decades in slightly thermal excess water of a Spa. *Elodea canadensis* (i.a. highly abundant in 1998 in the Kamp River) and *E. nuttallii* (quite rare, but challenging *E. canadensis)* in a few still and running waters, and *Egeria densa* in thermal spa outlet, were listed by UBA (2002). Additional nine invasive species were listed in several sessions (UBA 2013, 2019, 2020), but mass-development is still rare and local. Therefore no constant management of aquatic neophytes is necessary at present.

But, since cold (and freezing) winter periods are getting shorter and high temperature periods in summer increase in length, conditions for more competitive growth of a greater number of aquatic neophytes can be expected for the near future. Unless particular attention is given to recording the development of new neophyte stands, elimination in large infested areas or just containing the aquatic plants in smaller areas will be almost impossible.

But, what is the situation we can expect for floodplain waterbodies of a large river like the Danube, whose river corridor runs through the Danube National Park, an IUCN-certified nature sanctuary between Vienna and Bratislava? Most of the floodplain waterbodies are relict side channels or oxbows. During low or medium discharge they receive little or no direct flow from their upstream end. They merge with the main channel at their downstream end, where higher discharge or floods can enter causing backflow upstream. Major floods, of course, fill the whole cross section between the levees, and the high banks at the right river side. Some of the long and wider side arms have natural, as well as artificial connections to the main channel, which insure diversion of water at mean and higher discharge in general, reducing the growth of very extensive mass of aquatic neophytes.

But, all more lake-like waterbodies in the active floodplain located in greater distance to the main channel, are especially apt to become invaded by two types of invasive aquatic neophytes: some species (e.g. sub-tropical Myriophyllum species) can quickly fill waterbodies from the bottom of the water surface in less than half a summer period. This considerable increase in structural elements in the waterbody has positive and negative consequences. As shown above aquatic plant biomass provides abundant structure used as micro-habitats for many aquatic animals. Yet, during night hours the respiration of very dense plant growth reduces the oxygen concentration in the water, posing a risk for some aquatic animals, i.a. different fish species.

Another type of invasive plant species, which grow their leaves on floating 'runners' (horizontal stems) or produce buoyant petioles, develop dense and mechanically 'linked' canopies, which attenuate the intensity of light and higher temperature in the whole water body, finally terminating submersed macrophyte growth. On the other hand canopies of native species (e.g. leaves of water lilies) are habitat for amphibians, reptiles, snakes, and insects, as well as for certain bird species.

Figure 2: Young Myriophyllum aquaticum (Vell.) Verdc. and Duckweed species (Lemna sp.); after seasonal development, M. aquaticum can build extremely dense submersed plant stock, as well as aerial vegetation cover. The thin canopy of Duckweed presents no problem for M. aquaticum. © georgjanauer2020

The IAS-list refers to all types of waterbodies, including those beyond the levees, i.a. cut-off meanders, side arms, or manmade waterbodies (e.g. gravel pit lakes), as well as any other still waterbodies, slow running ditches and lowland streams. All these can easily get infested by alien invasive aquatic plants. With relevance to the EU-Regulation, right after detection of any individuals of IAS these shall be eradicated, as the first measure. The problem lies in detecting such 'first individuals', as they may grow in cover, or among different native plants. Small IAS patches or scattered groups of IAS may be recognised in early stages, and eradication can be a success. Once the infestation of the greater volume or area of waterbodies has taken place total eradication may fail. Confining IAS in certain areas and terminating further spread right there can be achieved in some cases.

But, in contrast to confining or even erasing invasive terrestrial plants the aquatic environment turns out to be a much more complicated arena. Different methods are applied against the progressive growth of terrestrial IAS, i.a. cutting, herbicide application, etc. Yet, at least in EU-Member Countries the application of any type of biocide is banned to apply in and close to waterbodies. This leads to introducing mechanical methods, or when needed, manual eradication techniques. Mechanic treatment in waterbodies needs cutting devices on boats or land-bound excavators for pulling submersed and canopy-forming plant species out of the water. 'Semi'-aquatic species can cover or even extend beyond river banks, spreading over adjacent low-land where the combination of several methods may lead to success.

The probably most adverse part regarding successful management in the water is the fragmentation of the plants when cut or pulled to the bank, which applies to running as well as still waterbodies. Almost every fragment can re-grow to a complete plant, which will later produce a large stand again. Collecting the fragments as best as possible under the conditions of the individual situation is the basis for any control measures. Hand-picking of fragments after the use of mechanical treatment (as e.g. done in Germany), has shown positive results.

The most efficient control practise would be the early proof of evidence of the start of an IAS invasion according to the EU-Regulation. When considering the length of the banks of running waters, or the length of lakeshores in general, permanent control is practically impossible, due to expense of time, labour and financial resources. However, raising the awareness of administration units responsible for all types of waterbodies is the indispensable basis for any counteractions against IAS in waterbodies. Keeping a closer eye on IAS establishment and migration is the only way of controlling the risk of losing substantial parts of the native aquatic vegetation at a limited level.

With regard to the floodplain waterbodies in the Danube National Park between Vienna and Bratislava river bed incision and related decrease of water level in the oxbows and relict channels triggered the progress of reed and other

 

Figure 3: Eichhornia crassipes (Mart.) Solms. Left: Flower and leaves of E. crassipes (Water Hyacinth) © georgjanauer2020. The lower part of the petioles/leaf stalks is widened with airspaces, providing buoyancy. Right: Solid canopy of Water Hyacinth. © Hans Hillewaert

helophytes into the former water-covered realm of the native aquatic plants. The additional threat of IAS eradicating the native aquatic vegetation should be counteracted with force by the respective public organisations. One important step is a higher frequency of surveying the floodplain water bodies to be on the spot when IAS are starting their invasion, and trying to 'confine/limit/eliminate' as described in the EU-Regulation.

References

EU WFD (2000): Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal of the European Community, L327.

EU IAS (2014): Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 23 October 2014 on the prevention and management of the introduction and spread of invasive alien species' (Official Journal of the European Union / L317)

EU Amending Directive (2014): Commission Directive 2014/101/EU of 30 October 2014 amending Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy. Official Journal of the European Union. L311.

EU Habitats Directive (1992): Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. L0043.

UBA (2002): Neobiota in Österreich, Umweltbundesamt Wien, 432pp.

UBA (2013): Aquatische Neobiota in Österreich Stand 2013. Pdf-Download: Lebensministerium. Umweltbundesamt Wien. Latest update: 2016 (https://www.umweltbundesamt.at/ms/neobiota-austria/neobiota_recht/neobiota_steckbriefe/eichhornia_crassipes; accessed 20200408, 20:36).

UBA (2019): Arten der Unionsliste – Steckbriefe; Umweltbundesamt GmbH, Spittelauer Lände 5, 1090 Wien https://www.neobiota-austria.at/ms/neobiota-austria/neobiota_recht/neobiota_steckbriefe/

UBA (2020): Neobiota-Bericht; Umweltbundesamt Wien. https://www.neobiota.austria.at/

Editorial note:

for further information on invasive alien species see details of the IAD-Expert Group IAS; see also Trichkova et al. 2017 (in Bulgar.): https://www.esenias.org/files/ESENIAS_Atlas_WEB.pdf

Analysis of the retention potential of restoration measures in Bavarian streams

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Background

The concept of restoration comprises the reestablishment of the natural state of previously anthropogenically altered ecosystems as well as the conservation of unaltered, natural ecosystems (StMUV 2014). This study focuses on examining possible restoration measures for water bodies and the surrounding floodplain ecosystems. It aims to define the possible positive effects these measures may have on the natural retention potential and thereby on flood mitigation.

Every ecosystem is defined by its location through e.g., climate, geology, tectonics, soil, and vegetation. These conditions contribute to local characteristics like run-off behavior, sediment budget, morphology, water quality, and flora and fauna, which all dynamically shape surface water bodies (Jürging 2001). During the past centuries, humans have reshaped most of the running waters in Bavaria to enable land use changes towards cultivation or even settlements. Channel straightening has eradicated many

Figure 1: Anthropogenically heavily altered (left) and barely altered, hence, quasi-natural (right) sections of the Otterbach. (left image: © Johanna Springer; right image: © René Heinrich)

water body specific characteristics and reduced the existing natural river retention. In some cases, the natural floodplains were replaced by highly water-sensitive constructions, e.g., settlements and industrial areas *(see fig. 1).*

Within this study, the retention potential of natural rivers and floodplains will be compared to the potential of the current state of streams. Therefore, one section of each of the following rivers in Bavaria was selected: Weißer Main, Roter Main, Mangfall, Glonn, and Otterbach. These sections were then analyzed with the help of the two-dimensional hydraulic model HYDRO-AS-2D.

Developing the potentially natural model scenarios

In the beginning, the hydraulic influence of anthropogenic constructions such as crossing streets or railway lines had to be reduced. Thus, a so-called structure reduced model was created, which demonstrates the current state with reduced constructional influences on the hydraulic conditions. This is the 'starting' state to which different restoration measures are compared to. Within this step, non-removable infrastructures were identified according to the restriction analysis of the Bavarian floodplains program (PAN 2016) and therefore remained in the structure reduced models.

Based on the structure reduced models, various potential natural state scenarios were created (restoration scenarios). All scenarios aim for completely (re-)naturalized conditions of the respective water bodies with non-cultivated, forested floodplains encompassing them. The methodology of the hydrodynamic two-dimensional modelling of restoration measures has been enhanced in the course of the project, resulting in a total of four different methods *(see fig. 2)*. The enumeration of these models thereby also represents their chronological order of development.

Within Method 1, restoration concepts include alterations of the river course, changes in the cross sections, and the presence of riparian forest. These were modeled and analyzed separately as well as in varying combinations. However, following a restoration approach where measures are conceptualized individually, the result is unsatisfacto-

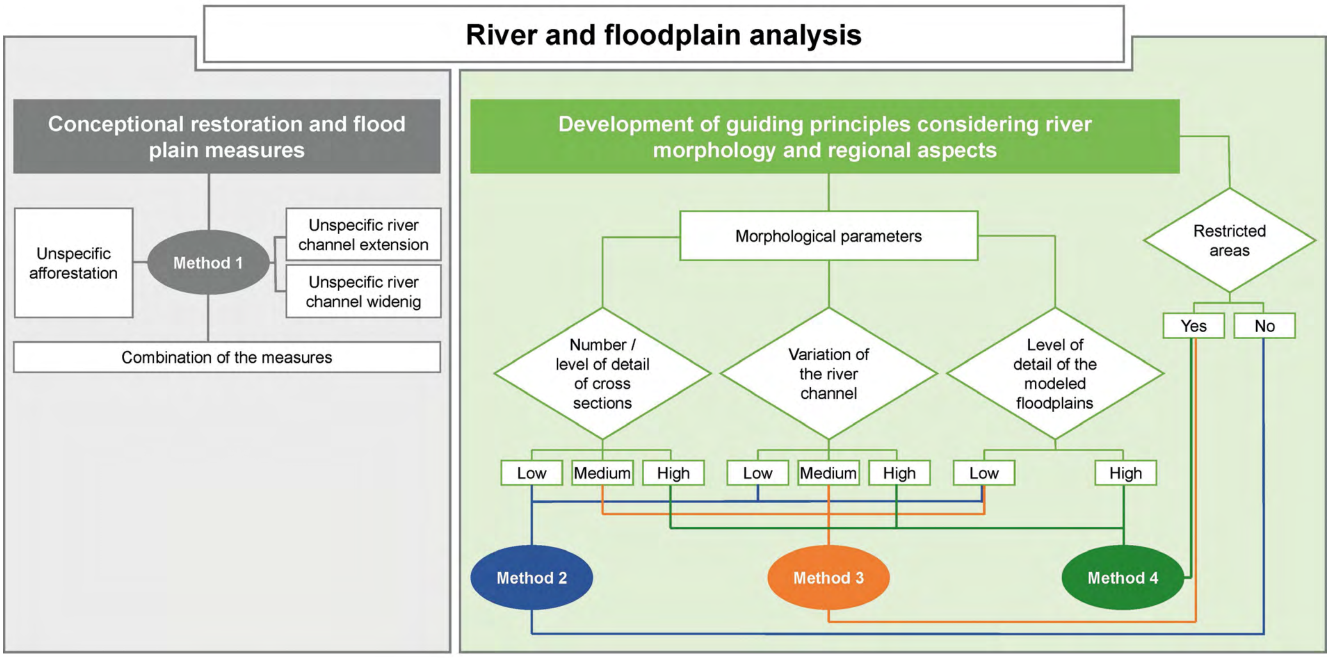

Figure 2: Different methods of modelling river and floodplain restoration measures. (Neumayer et al. 2018, modified)

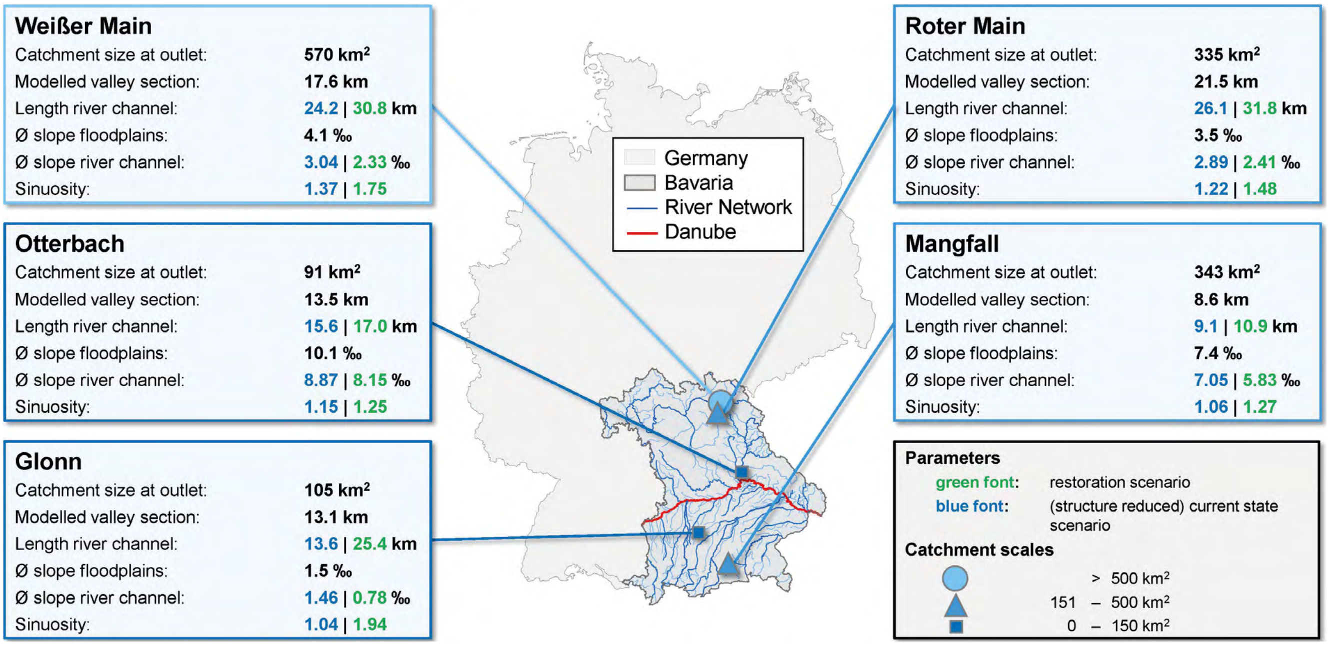

Figure 3: Overview of the most important area and model characteristics of all five investigation sections of the restoration scenarios in comparison with those of the structure reduced current state. (Neumayer et al. 2019, Bayerische Vermessungsverwaltung 2014, modified)

ry and does not represent actual natural conditions well. Because of this, Method 1 was no longer pursued.

On the contrary, Methods 2–4 regard restoration as a holistic water-body specific approach. These methods enable the derivation of specific hydromorphological conditions that represent a potential natural floodplain. The derivation of the appropriate model parameters included analysis of morphological data extracted from the streams and the floodplains as well as state-of-the-art knowledge from technical literature on surface water typology (e.g., Pottgiesser & Sommerhäuser 2008, Dahm et al. 2014, Koenzen 2005, Briem 2002).

The level of detail for the modeled floodplains and streams increases across the four methods. However, the necessary input data, the degree of parametrization, as well as the cost for preparation and computation, analogically increase.

Detailed investigations considering all of the factors mentioned above as well as the quality of the modelling results proved Method 3 to be economically most feasible.

Investigation Areas

The location as well as the values of the most important parameters are illustrated in figure 3 for the five investigated hydraulic sections. The model outlet of the induced catchment area, the center line of the valley, and the mean slope of the terrain were kept constant for the structure reduced current state model and the different restoration scenarios.

The sizes of the catchment areas at the model outlet vary between 570 km² (Weißer Main) and 91 km² (Otterbach). The restoration measures lead to an extension of the flow path in all study sections, as the water bodies were straightened by anthropogenic constructions, mostly for increasing the agricultural use in the floodplain area. Flow path extensions will therefore depend on both the current condition and the predicted sinuosity of the natural stream.

The most extensive lengthening of the flow path, both relative and absolute, could be seen for the section of the river Glonn, where the length increased by 11.8 km, which is equal to 87 % of the original length. The Otterbach river which mainly flows through U- and V-shaped valleys experienced the least change concerning the length of the flow path with an increase of 1.4 km (ca. 9 %).

The increase in the over-all flow path correlates with a more pronounced sinuosity of the path as well as a flatter bottom slope compared to the current state. The correlation between the degree of sinuosity and the flow path length can be observed very well for the river Glonn which experienced the maximum change in flow path length. The degree of sinuosity nearly doubled, changing from 1.0 to 1.9. For both investigation areas in the Main catchment, the degree of sinuosity increased by 0.3, with the Roter Main showing the smaller absolute degree of curving. This can be explained with the overall narrower profile of the valley.

For the river Mangfall as well as the Otterbach, the degree of sinuosity increased from 1.1 to 1.3. Again, the reasons for the comparably small increase in curving and in the over-all flow path length can be found in the shape of the valley and the hydromorphological characteristics of the streams.

Comparison of the resulting peak flow attenuations and translations

Five flood events of varying return periods and precipitation events were simulated for each of the investigated

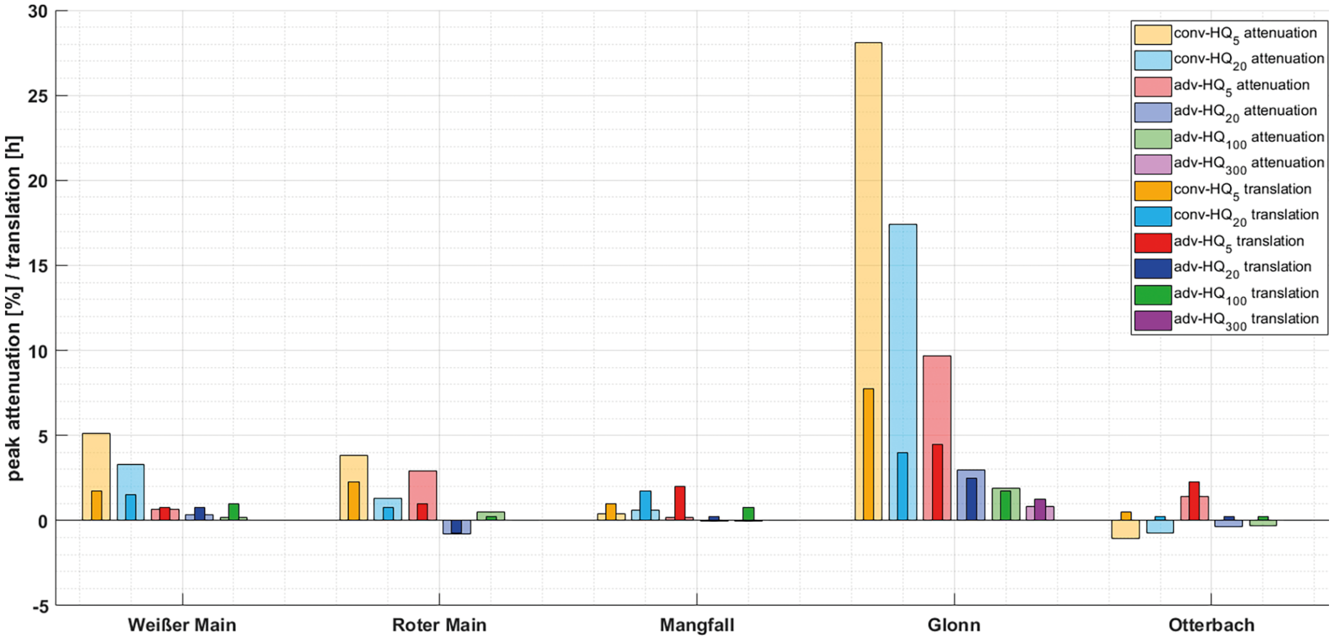

Figure 4: Cross-area representation of the peak attenuation and translation effects between the structure reduced current state and the restoration scenario at the model outlet.

river sections. The precipitation events were categorized in convective events (high intensity over a comparably short period of time; 'summer thunderstorms') and advective events (comparably low intensity over a long period of time; 'persistent rain'). For the river Glonn, an additional advective extreme precipitation event with a return period of 300 years was simulated. Figure 4 presents the attenuation and translation of the flood peak at the outflow when comparing the structure reduced current state of the catchment areas with the respective restoration scenario. A positive flood peak reduction expresses a decrease of the peak discharge for the restoration scenario. Consequently, a positive translation in the peak translates to a delayed flood peak for the restoration scenario. If the values in figure 4 are negative, the effects simulated are vice versa. Note that regardless of the catchment area or flood event, the total inundation area increases for the restoration scenarios due to the higher water levels in the floodplains and more favorable conditions for overflowing.

The restoration measures show larger decreases for the peak discharge in case of low-volume convective precipitation events for all catchment areas. The effects of the restoration measures decrease with an increase in return periods regardless of the characteristics of the precipitation event. The delay of the peak discharge thereby follows a similar trend as the attenuation. The maximum reduction of 28.1 % and delay of 7.75 h occurred for a convective HQ5 event in the catchment area of the Glonn river which is characterized by a relatively wide and flat foreland. This contributes to the reduction of the flood peak which is five times higher than that of the Weißer Main (catchment area 570 km²) which showed on average the second highest peak reduction at the outlet. The smallest catchment areas include the area of the Otterbach (91 km²) along with the area of the Glonn (104 km²). While the catchment sizes of the Otterbach and Glonn are fairly similar, the effects of the restoration measures on the peak discharge are not. In contrast, the peak discharge is often increased at the outlet of the Otterbach catchment. A detailed analysis showed that the inflow of the Sulzbach, which has a comparably high discharge, into the Otterbach close to the model outlet significantly reduces the positive effects of the restoration measures along the Otterbach. Prior to the estuary, reductions of the peak discharge reached up to 8.2 %.

Table 1 lists the development of the peak discharge attenuation and translation along the course of the Otterbach. It shows the large influence of the Sulzbach which joins the Otterbach between section five ('Vor Unterlichtenwald') and six ('Outflow') *(see fig. 5)*.

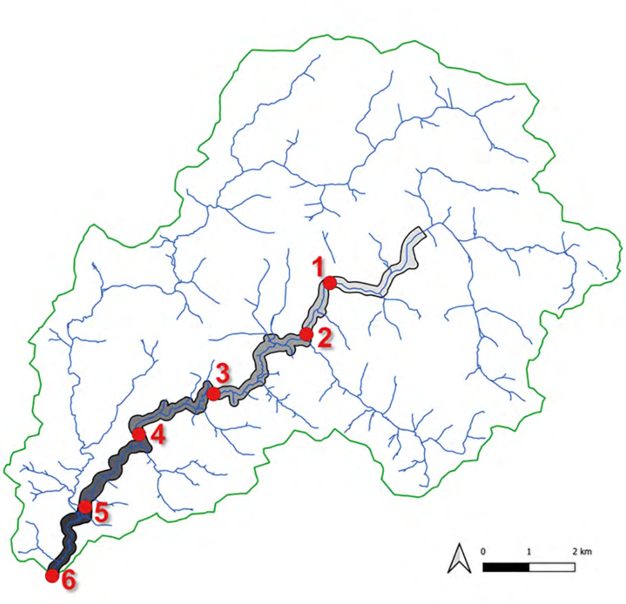

Figure 5: Locations of the control cross-sections at the Otterbach.

Flood Event	ID	Control Cross Section	Catchment Size [km²]	Peak Discharge [m³/s]		Peak Attenuation [%]	Peak Translation [h]
				IstOhne	Renat	Renat / IstOhne	Renat / IstOhne
adv HQ5	1	Steinsölden	24	5.71	5.68	0.6	0.75
	2	Vor Himmelmühlbach	26	6.12	6.06	0.9	0.75
	3	Vor Steinseige	41	10.30	9.94	3.4	0.75
	4	Vor Diebsgraben	45	11.47	11.04	3.8	0.50
	5	Vor Unterlichtenwald	50	13.20	12.60	4.5	1.00
	6	Outflow	91	18.30	18.04	1.4	2.25
adv HQ20	1	Steinsölden	24	8.36	8.32	0.4	1.00
	2	Vor Himmelmühlbach	26	8.92	8.87	0.5	0.25
	3	Vor Steinseige	41	14.01	13.86	1.1	0.25
	4	Vor Diebsgraben	45	15.32	15.23	0.6	-0.25
	5	Vor Unterlichtenwald	50	17.36	17.12	1.4	1.00
	6	Outflow	91	26.41	26.50	-0.4	0.25
adv HQ100	1	Steinsölden	24	12.18	12.10	0.6	0.00
	2	Vor Himmelmühlbach	26	12.94	12.90	0.3	0.25
	3	Vor Steinseige	41	19.55	19.47	0.4	0.25
	4	Vor Diebsgraben	45	21.24	21.11	0.6	-0.25
	5	Vor Unterlichtenwald	50	23.34	23.26	0.4	0.25
	6	Outflow	91	37.60	37.71	-0.3	0.25
conv HQ5	1	Steinsölden	24	8.89	8.80	1.0	0.25
	2	Vor Himmelmühlbach	26	8.98	8.94	0.5	0.25
	3	Vor Steinseige	41	12.30	11.69	4.9	1.50
	4	Vor Diebsgraben	45	12.63	11.86	6.0	1.50
	5	Vor Unterlichtenwald	50	13.08	12.01	8.2	1.75
	6	Outflow	91	16.87	17.05	-1.0	0.50
conv HQ20	1	Steinsölden	24	13.06	12.90	1.3	0.25
	2	Vor Himmelmühlbach	26	13.28	13.12	1.2	0.00
	3	Vor Steinseige	41	18.03	17.57	2.5	0.25
	4	Vor Diebsgraben	45	18.27	17.88	2.1	0.25
	5	Vor Unterlichtenwald	50	18.83	18.20	3.4	0.50
	6	Outflow	91	24.91	25.09	-0.7	0.25

Table 1: Peak discharges and related attenuation and translation for characteristic river sections within the hydraulic model of the Otterbach.

The least effect of the restoration measures on the peak discharge could be seen for the river Mangfall, with a maximum reduction of 0.6 % and delay of 2 h. With a catchment area size of 343 km², the Mangfall is one of to the medium sized hydraulic areas investigated. The measures along the Roter Main show similar effects to the ones along the Weißer Main; however, they are more influenced by the interaction with joining rivers, which even results in an increased peak discharge for the advective HQ20 event.

Conclusions

It could be shown that local superposition of flood waves has a significant impact on the effectiveness of the modeled restoration measures throughout all investigated areas. The situation of the estuary of the Otterbach and Sulzbach proves this particularly well. Based on this analysis, it can be assumed that both the location of the estuary as well as its relative share of the total discharge significantly contribute to the impact of the superposition effects. Whether a superposition of flood waves supports flood peak attenuation or not depends on the river network of the catchment and the characteristics of the flood event (e.g., peak timing at the confluence, ratio of the flood wave volumes). Finally, the study showed that the efficacy of restoration measures concerning flood mitigation is based on a complex interaction between location and waterbody specific factors. As the prediction of these factors is quite limited, an appropriate modelling of the area to be investigated is necessary. The results of the simulations ran for this project only show a comparably small effectiveness in flood control (except for the river Glonn). This correlates with the moderate increase in additionally activated retention volumes. The retention effect of the modeled scenario on the Glonn river, which is relatively large for small flood events, can be explained by several factors. On the one side, the anthropogenically altered river and floodplains, in combination with wide and flat forelands, positively contribute to an activation of additional retention volumes for the restoration scenario. On the other side, the wave superposition effect that occurs during the investigated flood events has positive impacts on the reduction of the peak discharge.

Besides of flood retention effects, natural surface waters and floodplains have positive synergy effects on the surrounding ecosystems as new wetland habitats can be created through improved river-floodplain interaction.

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Further Information

This article contains extracts from the conference article Neumayer et al. 2018 as well as from the journal article Neumayer et al. 2020.

References

Bayerische Vermessungsverwaltung (2014). Gewässernetz, Grundlage: ATKIS Basis-DLM25. URL: https://www.lfu.bayern.de/wasser/gewaesserverzeichnisse/fachlicher_hintergrund/index.htm.

Briem E & Mangelsdorf J (2002): Fließgewässerlandschaften in Bayern. Hg. v. Bayerisches Landesamt für Wasserwirtschaft. Wasserwirtschaftsamt Deggendorf.

Dahm V, Kupilas B, Rolauffs P, Hering D, Haase P, Kappes H, Leps M, Sundermann A, Döbbelt-Grüne S, Hartmann C, Koenzen U, Reuvers C, Zellmer U, Zins C & Wagner F (2014): Hydromorphologische Steckbriefe der deutschen Fließgewässertypen. Anhang 1 von „Strategien zur Optimierung von Fließgewässer-Renaturierungsmaßnahmen und ihrer Erfolgskontrolle". Hg. v. Umweltbundesamt. Dessau-Roßlau.

Jürging P (2001): Wasserbauliche Aspekte bei der Renaturierung von Fließgewässern, Fließgewässerdynamik und Offenlandschaften. In: Bayerisches Landesamt für Umwelt (Hg.). Fachtagung, 7–18.

Koenzen U (2005): Fluss- und Stromauen in Deutschland – Typologie und Leitbilder. Ergebnisse des F+E-Vorhabens "Typologie und Leitbildentwicklung für Flussauen in der Bundesrepublik Deutschland" des Bundesamtes für Naturschutz; FKZ: 803 82 100. Zugl.: Köln, Univ., Diss., 2005. Bonn-Bad Godesberg: Bundesamt für Naturschutz (Angewandte Landschaftsökologie, 65).

Neumayer M, Heinrich R, Rieger W & Disse M (2018): Vergleich unterschiedlicher Methoden zur Modellierung von Renaturierungs- und Auengestaltungsmaßnahmen mit zweidimensionalen hydrodynamisch-numerischen Modellen. – Forum für Hydrologie und Wasserbewirtschaftung 39.

Neumayer M, Teschemacher S & Disse M (2019): Modelling river restoration and floodplain measures in Bavaria on different scales. Poster. European Geosciences Union, Vienna.

Neumayer M, Teschemacher S, Merk F & Disse M (2020): Retentionspotenzialanalyse von Renaturierungsmaßnahmen an bayerischen Gewässern. Auenmagazin, Heft 18.

PAN (2016): Planungsbüro für angewandten Naturschutz GmbH. Entwicklung und Anwendung einer Methodik zur Analyse der innerhalb der Auenkulisse wirkenden Restriktionen (Restriktionsanalyse). Hg. v. Bayerisches Landesamt für Umwelt, Referat 64. München.

Pottgiesser T & Sommerhäuser M (2008): Beschreibung und Bewertung der deutschen Fließgewässertypen -Steckbriefe und Anhang. Hg. v. Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA).

StMUV (2014): Hochwasserschutz: Aktionsprogramm 2020plus. München: StMUV.

The vegetation of water bodies in the floodplain of the Danube in Serbia – comparative analysis and assessment of water quality using existing evaluation methods

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Rather by chance I got the opportunity to participate in a research project between six universities from Serbia, Croatia and the Czech Republic. During the site surveys in July 2019 data on species communities occurring in 17 backwaters along the Danube were collected (fig. 1 and 2). Using the metacommunity concept influences such as environmental parameters or inter-species competition on the occurrence of individual species should be explored (see Árva et al. 2017; Alahuhta & Heino 2013). A subtask included the recording of macrophytes, about which I could write my bachelor thesis.

Evaluation of Serbian backwaters using aquatic macrophytes

Eutrophication is one of the main problems maintaining good water quality in open waters today (Laketić et al. 2013). Impacts such as structural impoverishment or the discharge of toxic substances also have far-reaching consequences for lakes and rivers (Schneider 2004). In order to implement targeted measures for the improvement of water quality a regular assessment of the status of a body of water is necessary (Stelzer 2003). The bioindication is a simple way to determine the nutrient content of a waterbody as far as possible without using chemical and physical measurements. With aquatic plants in particular, changes in the nutrient balance can be derived from growth behavior and species composition (Laketić et al. 2013). Over the past few years, many indices for the evaluation of rivers and lakes using aquatic macrophytes have been developed, ranging from a simple description of macrophyte distribution to a complete ecological evaluation of the water (Schneider 2004).

Within Serbia, which is traversed by the Danube for a length of 588 km (Takić et al. 2012), the Danube has a

Figure 1: *A part of the research team while collecting the data of one of the evaluated back-waters. Own photograph*

water quality level of III. The most important causes of this low class are urban agglomerations and industries that are concentrated along the Danube (Milanović et al. 2010). Because the water quality of a river also inevitably affects the adjacent floodplain areas and the backwaters in them, monitoring for these areas is also necessary. However, especially for the assessment of backwaters, which are smaller than lakes and subject to the natural dynamics of the floodplain during floods, there are no adequate assessment systems (Lüderitz & Remy 2009).

As part of my bachelor thesis, mapped macrophyte stocks in Serbian oxbows were assessed using various existing indices. One was the water quality class according to the WFD, despite the fact that Serbia is currently not part of the EU, calculated using two different methods referring to Schaumburg et al. (2011) and Stelzer (2003). A second method was the Lake Macrophyte Nutrient Index adapted for Serbia to assess the water status of lakes referring to Laketic et al. (2013). Since several bioindication methods were used, which were not developed in or for Serbia, the aim was to check whether good results can be achieved by transferring them to this region, which method is best and whether improvements need to be made.

The 17 bodies of water investigated as part of this research work are located within floodplain landscapes along the Danube in the northern Serbian province of Vojvodina near Novi Sad and extend over the river kilometers km 1,400 to km 1,250 (Ramsar Convention 2012, 2007). The sampled backwaters are with three exceptions within the Nature Reserves 'Koviljsko-Petrovaradinski Rit', 'Gornje Podunavlje', 'Begečka Jama' and 'Karadjordjevo'.

Comparison of the different indication methods

On the basis of the three indices used to determine just the nutrient load, it was not possible to clearly differentiate between the study sites. A more precise assessment was only possible when the recorded water parameters, the mapped hydromorphological parameters and the properties of the specific macrophytes were taken into account. When calculating the water quality class – with the method of Schaumburg et al. (2011) as well as the somewhat different calculation method according to Stelzer (2003) – the assessments of some water bodies are to be regarded as not certain, since the proportion of the species not taken into account there exceeds 25 %. While this is primarily due to the missing assessment of the behavior of *Azolla filiculoides* in the calculation according to the PHYLIB method, the species table in Stelzer (2003) lacks the necessary scope to be able to transfer the calculation safely to another data set. Only 54 species are listed here, of which 18 were mapped in the course of this work. Without considering the helophytes excluded from the analysis, data on 12 species is missing, which is $^{2}/_{3}$ of the data set.

In a large-scale comparison of several indices to assess the condition of lakes and rivers in Europe, Schneider (2007) concluded that the greatest differences between the results lie in the assessed species composition instead of the index values themselves. When an index is used in a country other than that of its origin, important local indicators may be neglected, which may result in an insufficient proportion of indicative species. It is therefore recommended to adapt the list of indicator types to local conditions (Schneider 2007).

When calculating the water quality, it should also be noted that the used indices have only been developed for lakes with a size of 0.5 km² or more (Schaumburg et al. 2011; Stelzer 2003). In the course of the WFD, the existing procedures are not mature enough for the assessment of oxbows (Lüderitz & Remy 2009). Apart from that Serbia is currently not an EU member state, which is why the provisions of the WFD does not apply to this country. The implementation methods are also not adapted to this region and can potentially lead to sources of error. But since Serbia is surrounded by other EU countries, to which these requirements should also apply, the question is whether there are such large deviations that an application would have to be questioned. Instead of making a distinction based on purely political criteria, Serbia should be considered as part of a united Europe. In order to prepare for a possible membership in the EU, it is essential for Serbia to meet the necessary standards with regard to the WFD before they become mandatory (Takić et al. 2012).

In the overall picture, none of the indices used can be seen as sufficient to reproduce the actual condition of a backwater in Serbia accurately using a single calculation. Only a combination of all of them allows a good assessment. It is therefore necessary to adapt the survey methods for macrophytes and environmental variables on a Europe-wide scale and to extend the results of the various indices to include environmental parameters (Penning et al. 2008). And also with regard to the limited procedures for a macrophyte-based assessment of backwaters, a further adaptation of the existing bioindications to all types of water is a high priority.

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Figure 2: One of the evaluated backwaters within the 'Koviljsko-Petrovaradinski Rit' Nature Reserve with good water quality. Own photograph

ic plants, with which I have never had any contact before, as well as with questions about the evaluation and analysis of the data. Communication during the field work was not always so easy due to the mix of different nationalities and languages, but that was precisely why the collaboration with the many researchers was a great asset for me and I was able to get to know a wide range of working methods related to water.

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References

Alahuhta J, Heino J (2013): Spatial extent, regional specificity and metacommunity structuring in lake macrophytes. J. Biogeogr. 40/8, 1572–1582

Árva D, Tóth M, Mozsár A, Specziár A (2017): The roles of environment, site position, and seasonality in taxonomic and functional organization of chironomid assemblages in a heterogeneous wetland, Kis-Balaton (Hungary). Hydrobiologia 787/1, 353–373

Laketić D, Radulović S, Živković M, Jurca T, Alford M (2013): Lake Macrophyte Nutrient Index of standing waters in Serbia (LIMNIS). Ecological Indicators 25, 200–204

Lüderitz V, Remy D (2009): Einleitung - Entstehung und Entwicklung von Altwässern. In: Lüderitz V, Langheinrich U, Kunz C (Eds): Flussaltwässer. Ökologie und Sanierung. Wiesbaden: Vieweg+Teubner, 13–18

Milanović A, Kovačević-Majkić J, Milivojević M (2010): Water Quality Analysis of Danube River in Serbia - Pollution and Protection Problems. Bulletin of the Serbian Geographical Society, Tome XC 2, 47–68

Penning WE, Dudley B, Mjelde M, Hellsten S, Hanganu J, Kolada A, van den Berg M, Poikane S, Phillips G, Willby N, Ecke F (2008): Using aquatic macrophyte community indices to define the ecological status of European lakes. Aquatic Ecology 2008/42, 253–264

Ramsar Convention (2007): Information Sheet on Ramsar Wetlands (RIS) – 2006–2008 version. Gornje Podunavlje

Ramsar Convention (2012): The Nomination of the "Koviljsko-Petrovaradinski Rit" Area for a Ramsar Site. Ramsar Site no. 2028

Schaumburg J, Schranz C, Stelzer D, Vogel A (2011): PHYLIB – Verfahrensanleitung für die ökologische Bewertung von Seen zur Umsetzung der EG-Wasserrahmenrichtlinie: Makrophyten und Phytobenthos. Bayerisches Landesamt für Umwelt

Schneider S (2004): Indikatoreigenschaften und Ökologie aquatischer Makrophyten in stehenden und fließenden Gewässern. Habilitationsschrift. Technische Universität München, Wissenschaftszentrum Weihenstephan, Limnologische Station Iffeldorf

Schneider S (2007): Macrophyte trophic indicator values from a European perspective. Limnologica 37/4, 281–289

Stelzer D. (2003): Makrophyten als Bioindikation zur leitbildbezogenen Seenbewertung. Ein Beitrag zur Umsetzung der Wasserrahmenrichtlinie in Deutschland. Dissertation. Fakultät Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt der Technischen Universität München

Takić L, Mladenović-Ranisavljević I, Nikolić V, Nikolić L, Vuković M, Živković N (2012): The Assessment of the Danube Water Quality in Serbia. Advances technologies 1/1, 58–66

News and Notes

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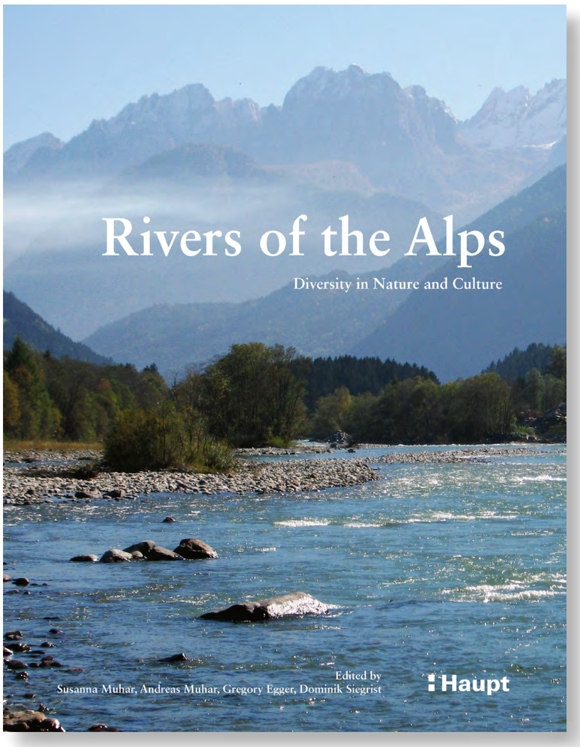

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Hydrological catchment of the River Danube

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