Reintroduction of the dwarf bulrush (*Typha minima* Funck ex Hoppe) at the river revitalisation measure Stams-Rietz (Inn river, Austria)

Martin Schletterer[1,2*], *Christina* Kollnig[3], *Felix* Gugerli[4], and *Norbert* Müller[5]

[1]TIWAG-Tiroler Wasserkraft AG, Eduard-Wallnöfer-Platz 2, 6020 Innsbruck, Austria
[2]University of Natural Resources and Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management, Gregor-Mendel-Straße 33, 1180 Vienna, Austria
[3]Ökologisches Büro Reutte, Oberried 30, 6600 Ehenbichl, Austria
[4]Eidg. Forschungsanstalt WSL, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland
[5]Fachhochschule Erfurt, Institut für Landschaftspflege und Biotopentwicklung, Cyriakstr. 10, 99094 Erfurt, Germany

Abstract. The dwarf bulrush (*Typha minima* Funk ex Hoppe) is considered as a sensitive target species in natural alpine river landscapes. It disappeared from many rivers due to straightening, thus reintroduction efforts for species conservation have been initiated. Recently, at the Inn river between Stams and Rietz, i.e. a section of about 3 kilometres, the river bed was widened up to 75 meters and a branch as well as a back water zone were created and bank protection was removed. This measure provides potential habitats for *T. minima*, thus its reintroduction was carried out in 2023 along the banks. Plants originated from an ex-situ culture from the Botanical Garden of the University of Innsbruck, where propagation was carried out with seeds from the Lech catchment. Only 2 weeks after the reintroduction of 1500 plants, a 100-year flood occurred, which washed away many plants and only 17 remained. Thus, additional specimens (n = 37) were planted. Overall, in November 2023 a total of 54 specimens were established and genetically characterised to assess the initial genetic composition for subsequent monitoring. In June and July 2024, again high flows affected the stocks. However, at several sites the stocks were able cope with these conditions and may form a new population along the Inn river.

1 Introduction

Among flowering plants, the dwarf bulrush (*Typha minima* Funck ex Hoppe) is considered as a sensitive target species in natural alpine wild river landscapes [1, 2]. The plant, which was widespread along the major alpine rivers until the middle of the last century, experienced a dramatic decline with the decreasing hydromorphological quality due to river

* Corresponding author: martin.schletterer@tiwag.at or martin.schletterer@boku.ac.at

engineering (land use and flood protection) [3]. The species is now highly endangered throughout Europe and it is extinct along most river stretches [4,5], e.g. it disappeared from the Tyrolean Inn river in the 1990s [6].

The European Union has classified the habitat of the dwarf bulrush "7240 Alpine pioneer formations of the Caricion bicoloris-atrofuscae" as an Annex I habitat type according to the Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). As a result of revitalization measures along rivers, habitat conditions for *T. minima* have improved again regionally. However, natural recolonization of potential sites is not to be expected due to the restricted occurrences of the dwarf bulrush. Therefore, reintroducction projects have been carried out on revitalized stretches of Alpine rivers for several years. In Austria, reintroductions have so far been carried out on the Tyrolean Lech [1, 7], on the Drava [8] and on the Inn river [9, 10].

The formerly large populations of *T. minima* along the Inn river became extinct by the beginning of this century as a result of river regulation (straightening). The last evidence of the species at the Tyrolean Inn river comes from Oberpettnau (Neuner 1992 in [6]; pers comm. E. Rott).

A first reintroduction with *T. minima* was attempted at the Tyrolean Inn river in the newly created widening near Telfs in 2009 [10]. Within the WWF project "Species protection measures on the Tyrolean Inn river and backwaters", reintroduction measures have been carried out on the Tyrolean Inn river since 2018. In 2018, young shoots were planted in Milser Au, Rietzer Au, Telfs West, Oberpettnau and Flaurling [6, 9]. A monitoring campaign in 2022 revealed that the populations were developing well, especially in Pettnau. The other stocks were particularly affected by the flood in 2019. In the framework of the Interreg project INNsieme, work package 2 "Implementation of model measures to strengthen biodiversity – B2 vegetation renaturation in areas near banks", additional plantings were carried out near Hagau, Habach, Radfeld and Kundl, and additional plants were established near Serfaus, Mils, Silz and Rietz in 2022 [10]. In 2020, as part of the expansion of the HPP Kirchbichl, a planting of dwarf bulrush was carried out in a side channel and ponds [10].

Our publication summarizes the most recent reintroduction of *T. minima* at the river revitalisation Stams – Rietz along the Inn river.

2 Study area

In winter 2021/2022 and 2022/2023, a large-scale river revitalisation was implemented at the alpine Inn river between Stams and Rietz in Tyrol (Austria). Along a length of about 3 kilometres (Fig. 1), the river was widened up to 75 meters, and a branch (A1) as well as a back water zone (A2) were created and the bank protection on the orographic left side was removed (A3). As a result, the river can develop by its own dynamics to form ecologically valuable areas such as shallow water zones as well as gravel and sand banks [11,12]. This project was implemented as a measure within the extension project of the hydropower plant Sellrain–Silz (see www.erneuerbareplus.at). This measure provides potential habitats for *T. minima*, thus a reintroduction was carried out along the banks in August and September 2023.

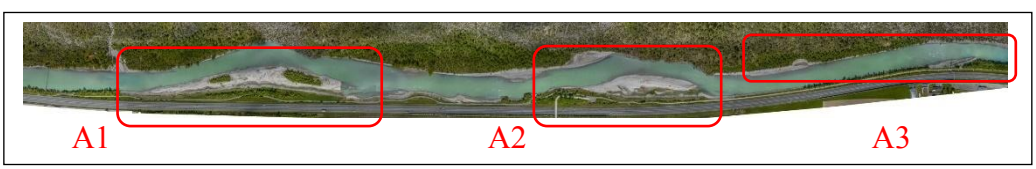

Fig. 1. Orthoimage from 27.04.2024 (droneproject.at by order of TIWAG)

3 Reintroduction

The plants originated from an ex-situ culture from the Botanical Garden of the University of Innsbruck (*T. minima* species protection program). Seed material was harvested from the Tyrolean Lech, as this is the closest remaining *T. minima* population. From the last larger source population at a gravel pit near Pinswang, reintroduction has been carried out along the Tyrolean Lech since 2003 [2]. The stock in Stuibenau has developed well since it was established in 2014, thus seeds were collected in the summer of 2022. As in previous projects, cultivation of young plants from seeds was carried out in the Botanical Garden of the University of Innsbruck (Fig. 2, see [6] for details), and 1,500 one year old plants were available by summer 2023.

Fig. 2. Ex-situ culture of *Typha minima* in the Botanical Garden of the University of Innsbruck

The reintroduction took place according to a tested method and the experience from the species protection program for *T. minima* in the Tyrolean Lechtal as well as previous reintroductions along the Inn river. At each site, 10 shoots were placed in a circle and GPS coordinates were recorded. This approach supports future monitoring (details on the method in [7]). The following table shows the numbers of young plants planted in the respective intervention areas. In September 2023, after a 100-year flood in August 2023, 37 young plants were replanted to support the affected planting.

Table 1. Numbers of *Typha minima* planted in the respective areas

Area	Initial Planting (August 2023)	Replanting (September 2023)
A1	1.470	20
A2	30	17

The side channel A1 was designed with variable widths and slopes of the embankments. At the beginning of August 2023, small areas with fine sediment were found along the channel and used for planting. The young shoots were planted both close to the waterline and further up to cope with the fluctuating water levels (between mean and flood discharge) of the Inn river. There is a risk of drying out, bush encroachment and being washed away when water levels are high. The different planting locations should ensure a gradient along the bank to allow at least some *Typha minima* plants to persist and spread. Where possible,

planting locations were chosen behind structures such as rootstock or stones to ensure some protection from runoff at higher water levels. In August 2023, 1,470 young plants were planted along the side channel A1 (Fig. 3) and 30 plants at the back water zone A2.

Fig. 3. Planting of *Typha minima*

A 100-year flood occurred at the end of August 2023. The cross section of the Inn river was completely filled with water, i.e. at A1 only two islands remained (Fig. 4). Thus, shortly after their reintroduction many plants were washed away, because their rhizomes were not yet well developed. Only 17 plants remained, but it is also possible that some plants survived under the sand as well. Our case study shows, that a high number of young plants along an ecological gradient at the riverbank is crucial for the establishment. After replanting some specimens, a total of 54 specimens were established in November 2023. In June and July 2024 again high flows (between HQ1 and HQ30) affected the stocks (Fig. 5). However, at several sites the stocks could cope with these conditions and may hopefully form a new population along the Inn river between Stams and Rietz.

Fig. 4. 100-year flood on 28.08.2023

Fig. 5. Example for flood dynamics at a *Typha minima* location in A1 in 2024: completely flooded (12. VII), partly flooded (19. VII) and after descending flood (31. VII), the stock is vital (8. VIII)

In November 2023, an assessment of the remaining plants was carried out and samples from all specimens found were collected for a genetic characterisation using genetic fingerprinting (microsatellite markers, details in [13, 14]). A total of 54 individuals (7-10 samples from 6 locations) were analysed, of which 52 samples were successfully genotyped. The number of genetic variants (= alleles) per marker was low (1-3 alleles per marker, 5 markers monomorphic), combining into 37 different genotypes, 11 of which occurred in more than one plant (2-4 plants of the same genotype) and 26 genotypes only occurred once. There was a maximum of 2 genetically identical samples per location; otherwise, all genotypes at a location were genetically different (but partly identical to plants from other locations). The genotypic mixing was therefore very good, despite the low genetic variation. A sample from the source population of the Lech river also showed low genetic variation, with 1-3 alleles per marker, 5 monomorphic markers and 9 different genotypes in the 10 individuals, i.e. 2 individuals had the same multilocus genotype.

4 Discussion

This reintroduction of *T. minima* aims to establish a population of this rare character species in alpine rivers at Stams (Inn river). This population may form a future source for clonal growth and for seeds to support future species conservation efforts in the region. Importantly, the genetic composition of the reintroduced, surviving shoots is rather evenly distributed among the planted locations, assuring certain redundancy, and it represents the source population from Lech river well.

Based on the recorded genetic fingerprints (multilocus genotype) of the individuals from Stams-Rietz, statistical analyses were carried out, which provide information about the genetic composition of the planted individuals. The rather low number of alleles in the existing samples in some cases led to identical multilocus genotypes, even though plants for translocation were grown from seeds in the ex-situ propagation. However, the samples from the Lech reference population had equally limited allelic diversity; even in the entire sample analyzed previously (n = 235), there were no additional alleles [14], whereas other natural populations from the Alps comprise substantially higher genetic diversity. It should be noted that the used microsatellite markers only cover a very small part of the entire genome, thus it is not possible to make a conclusive statement about the complete existing diversity. However, one can assume that there is a rather low genetic diversity in the natural population of the Lech as a whole compared with natural populations from other river catchments in the Alps (D. Csencsics, F. Gugerli, unpubl. results).

Corresponding to the low number of alleles, the observed heterozygosity as an alternative measure of genetic diversity was also rather low and slightly lower than the heterozygosity expected based on the allele frequencies (under the assumption of random mating). The latter finding is consistent with the fact that the plants used for planting (i) derive from parents who come from a small, genetically depleted population at Lech river, which (ii) may have already been excessively homozygous due to inbreeding and (iii) may even be clonal replicates. Unfortunately, the parent plants used for seed production could not be genotyped to substantiate these explanations. Nevertheless, the mean values of the two parameters (observed vs. expected heterozygosity) did not differ significantly and, therefore, are not considered problematic.

Both the composition of existing alleles as well as the multivariate and the assignment analyses clearly show that all planting locations in a locality are very similar in genetic composition, both among themselves and compared with the original Lech population, which therefore is well represented in the plantings. This means that the local (low) genetic diversity may still be preserved even if some of the locations should be washed away by a flood, as was the case in August 2023.

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