Breg and Brigach, headstreams of the River Danube: biodiversity and historical comparison

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Abstract

Breg and Brigach are the headwaters of the River Danube, originating from the Black Forest at 1078m, and 925m, respectively. They merge near the town of Donaueschingen, creating the River Danube. Determined by geological background and the steep gradient between the springs and Donaueschingen, the two rivers are dominated by bryophytes. Altogether 47 species: 25 bryophytes and 22 vascular plants were detected during the MIDCC survey, the former covering more than half of the total length of the two headwater streams. A historical comparison of floristic changes based on data from earlier surveys is also presented.

Introduction

Breg and Brigach are the headwater streams of the Danube River, which is formed by their confluence in Donaueschingen, a major town in the Black Forest region of Baden Württemberg (Germany). Both streams originate close to the Main European Watershed between the River Rhine (to the northwest) and the River Danube (to the southeast) (Fig. 1, upper map). The celtic origin of the name 'Breg' means 'exalted, eminent'. Breg is the longer tributary and contributes a higher discharge to the young Danube. The Breg spring is the most distant point in the river system as measured from the mouth of the Danube at the Black Sea. 'Brig', celtic for Brigach, means 'bright and loud' and 'ach' means water (Fig. 1, lower map).

In the source region ample forests and pastures dominate the mountain area, but in the lower reaches of the two streams pastures, agriculture and settlements are predominant. The low hills of the Black Forest are a destination for recreation and winter sports. Colonization by humans traces back more than a thousand years. But effects of anthropogenic impact especially on water quality, were only recorded since the last century. About 29,000 people live in five small towns in

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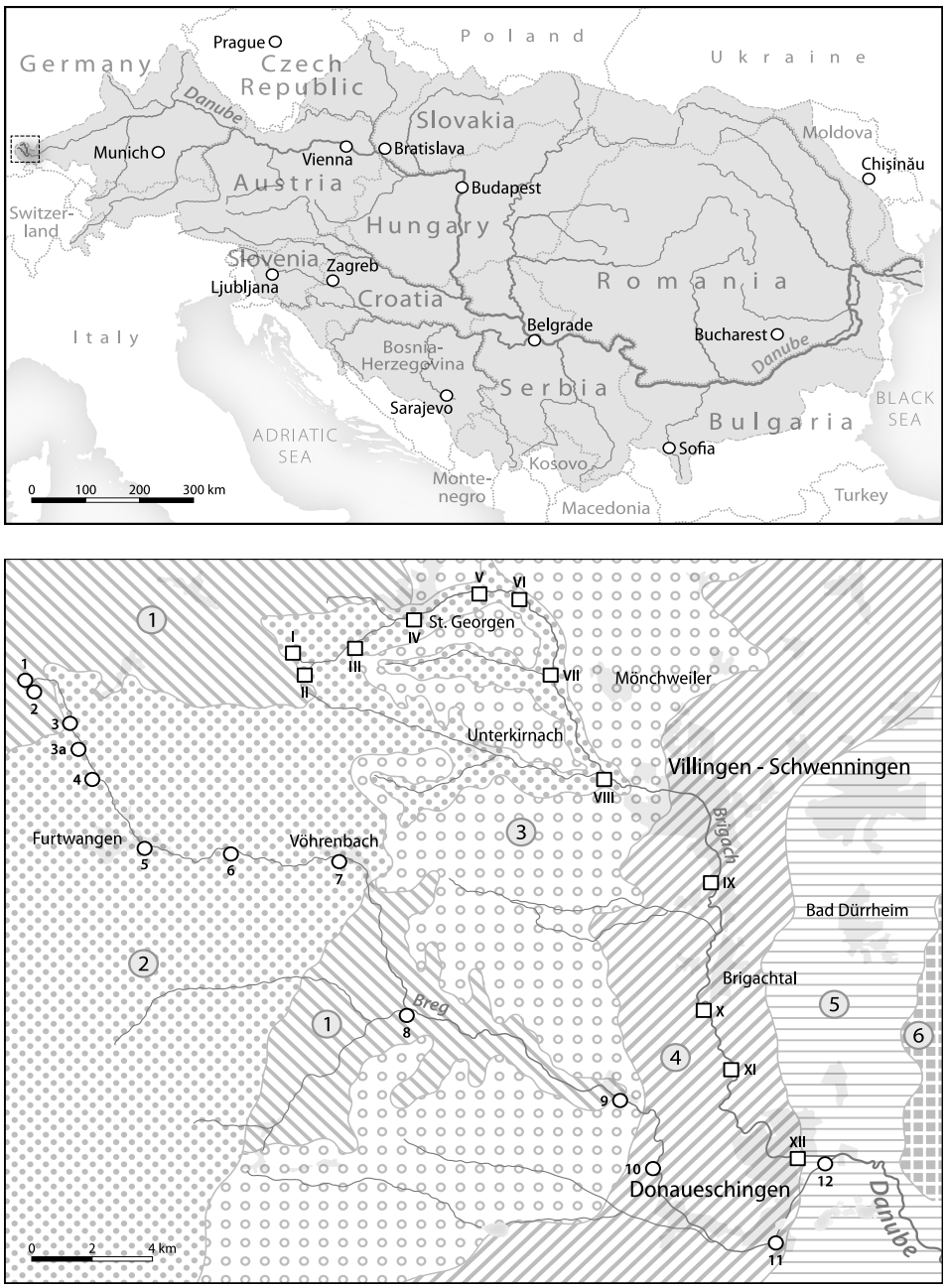

Figure 1. Location of Breg and Brigach and underlying geological units. 1 – Granite, 2 – Gneiss, 3 – Mottled Sandstone*, 4 – Shell Limestone*, 5 – Keuper*, 6 – Jurassic. *Triassic. Circles: Backhaus sites Breg. Quadrats: Backhaus sites Brigach. © 2015 by Mateja Rihtaršič

the catchment of the Breg, where Furtwangen dates back to the 12th century. Clock-making, metal processing, fine mechanics and electronic engineering dominate local industries. About 58,000 people live in the catchment of the Brigach, where history is documented since the 11th century. Today the region around the town Villingen-Schwenningen has the highest density of industries focusing on automotive supply found in Baden Württemberg.

At present more than 21,000 inhabitants are registered in the town of Donaueschingen, which was first mentioned in 889 A.D. In the park of Donaueschingen Castle a subterranean karstic source feeds a well, called the 'Source-Fountain', and ordered by the feudal family of the Fürstenberg sovereigns, who set it up in the late 19th century.

Study sites and methods

Our survey was carried out in 2003/2004, when more than 60% of the entire length of both streams was surveyed. A 5-level scale developed by Kohler et al. (1971) was used to estimate macrophyte abundance (for full methodology see Chapter 2), and 166 survey units were recorded in total. Some characteristic numbers are given in Table 1 for the two streams.

Table 1. Characterisation of the Danube headstreams Breg and Brigach (Jung, 1989)

	Breg	**Brigach**
Elevation of the springs	1,078 m a.s.l.	940 m a.s.l.
Length of streams (spring to confluence at 672 m a.s.l.)	45.9 km	40.2 km
Length as the crow flies	31.7 km	25.4 km
Vertical drop	406 m/8.8‰	268 m/6.6‰
Catchment size	291.2 km^2	195.0 km^2
Tributaries left side	14	12
Tributaries right side	22	11
pH min–pH max (Jung, 1989)	5.4–8.4	5.2–7.7
Mean Carbonate hardness	0.5–2.2	0.7–7.2

Previous investigations on parts of both streams had been carried out in 1960 (Backhaus, 1967) and in 1988 (Jung, 1989). In the MIDCC survey, an attempt was made to correctly identify these earlier sampling sites and to record possible changes as compared with the MIDCC results.

Environmental background information

Breg and Brigach are both characterized by steep gradients in their upper reach and a much lesser gradient in their lower reaches, which influences sinuosity. Though both streams (Figs 2 & 3) spring from gneiss and granite bedrock catchments in the high altitudes of the Black Forest, covering about 25 km (Breg: 55%) and 16 km (Brigach: 40%), the remaining reaches of the streams are characterised by three other geological units, which influence gradient, sinuosity, regulation measures and water chemistry (Fig. 1, and Jung, 1989). This change of abiotic parameters in both rivers is of great importance as far as variation in macrophyte species composition is concerned.

Figure 2. Spring of Breg. Photo: Georg A. Janauer
Figure 3. Spring of Brigach. Photo: Georg A. Janauer

Flow velocity

The Breg stream is characterised by a longer reach (32% of total length, flow > 0.7 $m.s^{-1}$) with a steeper gradient than the Brigach and fast current velocities (Fig. 4). In contrast medium fast flow (0.35–0.7 $m.s^{-1}$) characterises the major part of the Brigach.

Water quality

Prior to the implementation of the European Water Framework Directive the prime water quality metric was the Saprobic Status. Regarding our time series for aquatic plants in Breg and Brigach Table 2 provides relevant data.

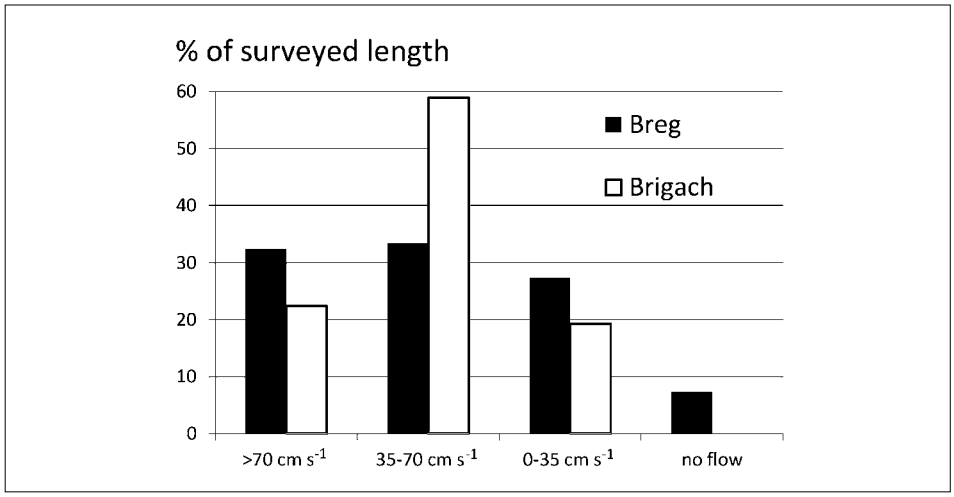

Figure 4. Flow class distribution in Breg and Brigach

Table 2. Saprobic water quality of Breg and Brigach – 1957, 1991 and 2004
Data source: Landesanstalt für Umweltschutz Baden-Württemberg (LfU, 2004).
Numbering of sites follows Backhaus (Arabic for Breg, Roman for Brigach).
I = oligosaprobic (almost no organic pollution); II = β-mesosaprobic, III = α-mesosaprobic, IV = polysaprobic (extreme organic pollution). I–II, II–III, III–IV: intermediate saprobic values

Breg

section number	**1**	**2**	**2a**	**3**	**3a**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
water quality 1957	I	I	I	II	II	II	III	II	I–II	I–II	I–II	II	II–III	III
water quality 1991	I	I	I	II	II	II	II	II	II	II	II	I–II	II	II
water quality 2004	I	I	I	I	I	I	I–II	II	II	II	I–II	I–II	II	II

Brigach

section number	I	II	IIa	IIb	III	IV	V	VI	VII	VII	IX	X	XI	XII
water quality 1957	I	I	I	I	I–II	I–II	III–IV	III	III	II	II–III	IV	IV	IV
water quality 1991	I	I	I	I	I	II	II	II	II	II	II–III	II–III	II–III	II–III
water quality 2004	I	I	I	I	I	I	I–II	II	II	II	II–III	II–III	II–III	II–III

Survey method

As in the other surveys of the MIDCC project the assessment of occurrence and abundance of the aquatic macrophyte species followed Kohler's original approach (Kohler and Janauer, 1995), which is also covered by the European Standard EN 14184 (CEN, 2003) and is used for the Joint Danube Surveys (macrophyte assessment) of the International Commission for the Protection of the Danube River (ICPDR) (Liska et al., 2008). Details are provided in Chapter 2 of this volume. Data of the present chapter cover the fully aquatic species (bryophytes and vascular plants), but not the helophytic vegetation.

Data Analysis

The main matrix included 36 macrophyte taxa in 66 survey units (SU), where 25 taxa in 35 SU occurred in the Breg River and 27 taxa in 31 SU in the Brigach River. Species abundances, assessed with a 5-level ordinal scale, were converted to quantitative amounts by the function $y = x^3$, where x = values of the 5-level scale. We performed a Multi-response Permutation Procedure (MRPP) to test for differences between rivers based on within-group (Bray–Curtis) dissimilarities. Merging the SU of the different sampling periods (years 1960, 1988 and 2003), groups were defined by the total number of survey units in each river stretches. MRPP is a nonparametric multivariate test of differences between groups. The resulting 'A' statistic describes effect size or within-group homogeneity, and the p-value provides the test for group differences (McCune and Grace, 2002). Indicator Species Analysis (ISA) was also used to identify the species that characterizes each of the two rivers and assess how well species are separated between the rivers. Statistical significance of species in each river was determined by a Monte Carlo randomization test with the null hypothesis that the species have no value as indicators. The method is explained further in Dufrêne & Legendre (1997), McCune & Grace (2002) and Legendre & Legendre (2012). Despite the known weaknesses of Detrended Correspondence Analysis (DCA) ordination we chose to use this hitherto much-used technique to facilitate comparison of the floristic and quantitative structure of vegetation between the two rivers.

Macrophyte species diversity in each survey unit is expressed as Simpson's index of diversity ($1 - D$). Simpson's index is sensitive to changes in the more abundant species, and represents the probability that two statistical individuals randomly selected from a sample will belong to different species (Magurran, 2004). Variations in Simpson diversity between the Rivers Breg and Brigach are expressed by notched Box-Plots. The notched Box-Plot represents an alternative to check for equality of the medians of several data groups. Thus, non-overlapping notches provide strong evidence that the medians are significantly

different at the 5% significance level (Reimann et al., 2009). We also used the nonparametric Mann–Whitney *U*-test to assess the two-tailed hypothesis that there is no difference between the Simpson diversity among the five reaches. MRPP, ISA, DCA and calculation of the Simpson diversity indices were conducted using the PC-ORD ver. 6 program (McCune and Mefford, 2011; Addinsoft, 2012), notched Box-Plots and Mann–Whitney *U*-test was carried out with XLSTAT®-Pro (Addinsoft, 2012).

Results

Floristic composition of the macrophyte vegetation

Altogether, in both headwaters 47 species were recorded (aquatic vascular plants: 22; bryophytes: 25). Algae and helophytes were also recorded during the MIDCC survey, but this contribution focuses on the aquatic plant species. Regarding the number of survey units inhabited by vascular plants *Callitriche brutia* dominated both Breg and Brigach (55% of all SU), *Ranunculus fluitans* was co-dominant in the Brigach. In the Breg *Amblystegium riparium* co-dominated. Bryophytes showed the highest diversity in these headwaters, as compared to the other reaches of the Danube. The bryophytes exceeded the vascular species by number and abundance in many survey units.

Breg

During our survey 63% of the total length of the Breg stream was surveyed, covering 89 survey units (SU). 11 SU had no aquatic plants, whereas in 5 SU up to 11 species could be recorded.

The upstream units were generally richer in aquatic plants, whereas the occurrence of aquatic plants showed a slight decrease downstream. In the reach between the villages Hüfingen and Donaueschingen only *Spirodela polyrhiza* was detected.

In the Breg (Fig. 5) 20 bryophyte species were recorded, dominating the whole course of the stream and even producing high abundance in several sections. Particularly *Amblystegium riparium* (in 37 SU), *Fontinalis antipyretica*, *Brachythecium rivulare*, *Hygrohypnum ochraceum* and *A. fluviatile* were frequently found. Among them, *A. riparium*, *F. antipyretica*, *F. squamosa* and *H. ochraceum* occurred also in downstream stretches. *Scapania undulata* was only frequent in the upstream region.

Between Hüfingen and Donaueschingen no bryophytes were found due to the channel lining and the gravel dominated sediment. In the two terminal sections of the Breg, located just before merging with the Brigach near the eastern limits of the town Donaueschingen, *F. antipyretica* and *A. fluviatile* were recorded again.