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Short Communication

Characterisation of natural streams using community indices and basal resources of macroinvertebrates in the upper Euphrates Basin

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ABSTRACT

The characterisation of natural stream conditions is the first important step to analyse ecological quality of streams in the Euphrates basin. We found that the community indices correspond to very good ecological conditions in five natural streams of that region. The macroinvertebrates composition differed significantly between September and May. Number of taxa and Shannon index were significantly higher in autumn than in spring. FPOM and biofilm were the most relevant basal resources of benthic invertebrates.

Turkey still lacks a suitable method for the assessment of ecological quality of streams (Kalyoncu and Zeybek, 2011). The complex and diverse geographical structures (Kazanci, 2011), lack of knowledge about water organisms and the low level of public concern regarding the protection of aquatic ecosystems hinder the development of Turkish water quality assessment. European indices are therefore often used to evaluate the ecological quality of freshwaters (e.g. Kalyoncu and Zeybek, 2009; Kazanci et al., 2010). These indices, however, are not adequately parameterized for this geographical region and require extensive ecological information about the macroinvertebrate taxa used as indicators. Although many faunistic studies have compiled detailed taxa lists and collected information about the distribution of species throughout Turkey (e.g. Kalkman et al., 2003; Kazanci, 2001; Kiyak, 2000), autecological information with specific reference to Turkey is often lacking. Therefore, we assessed and compared the macroinvertebrate community structure and important community indices in two seasons in undisturbed tributaries of the Euphrates (Eastern Turkey). To characterise the relevant basal resources for the benthic invertebrates, we used stable isotope analyses (SIA) and determined the abundance of functional feeding types.

We surveyed the macroinvertebrate community in five streams without visible anthropogenic use (settlements, agriculture, livestock farming; Corine, 2017) in the catchment areas which were located in the Upper Euphrates Basin near the cities of Erzincan and Tunceli in Eastern Turkey (Supplementary material 1). In each stream, we sampled one site (50 m length) in two seasons (spring, autumn). Sampling sites, which were located between epirithral and metarhithral zones at 1000 m above sea level (Supplementary material 2). The streams showed similar environmental conditions and had low nutrient concentrations (Supplementary material 2).

The benthic community was collected with a multi-habitat-sampling method (net area: 0.0625 m^2, 1 mm mesh; Hering et al., 2004) in autumn (September) 2013 and spring (May) 2014. Twenty subsamples were taken from each stream site with a total sampling area of 1.25 m^2. All macroinvertebrates were identified to the lowest feasible taxonomic level and counted. To estimate the composition of functional feeding groups (FG's), the taxa abundance of one feeding type relative to the total taxa density is given. The classification to feeding types was based on Schmedtje and Colling (1996), whereas a taxon was classified to the most represented feeding group, indicated by more than 50%. If a taxon represented different feeding types to similar parts, its abundance was assigned to the "combined FG's". To describe the community structure different indices were calculated from the data (e.g. EPT-Abundance (%), German Saprobian Index (GSI), Rithron Feeding Type Index (RETI); Table 1).

These indices were compared between the two seasons using paired *t*-test and Wilcoxon test. Differences of the benthic community composition were visualised using non-metric multi-dimensional scaling (nMDS) based on the Bray-Curtis distances of the abundance data (square root transformed) and analysed with a one-factorial analysis of similarities (Anosim). A similarity percentage analysis (Simper) was performed to identify the taxa that contributed most to the differences between seasons. All multivariate analyses were performed with the software Primer 6.

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Table 1
Community Indices (means ± sd) of the five streams in autumn and spring and the results of paired *t*-test or wilcoxon test (marked with *). Significant p values are bold typed. Number of EPTCOB: taxa number of Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Odonata, Bivalvia. For the taxa that were most important for the seasonal differences in the benthic community, the abundances in individuals m^{-2} of benthic taxa (means ± sd, n = 5) and their contribution to the difference [%] are given. In addition, the mean abundance (± sd) of different functional feeding groups (FG's) to the total invertebrate abundance is given.

Community Indices	Autumn	Spring	Statistic results	
Total Number of Individuals	1496 (± 1124)	660 (± 517)	t = 1867.0	p = 0.135
Total Number of Taxa	39 (± 6)	27 (± 10)	t = 2.89	**p = 0.045**
Number of EPT-Taxa	17 (± 2)	13 (± 4)	t = 1.82	p = 0.142
Number of EPTCOB	27 (± 5)	19 (± 7)	t = 2.16	p = 0.097
EPT [Taxa %]	44 (± 4)	49 (± 10)	t = −1.75	p = 0.155
EPT [Abundance %]	64 (± 12)	78 (± 18)	t = −1.41	p = 0.233
Odonota [Abundance]	2.66 (± 3)	0.74 (± 1)	V = 12*	p = 0.313
Ephemeroptera [Abundance]	32 (± 21)	62 (± 13)	t = −3.48	**p = 0.025**
EPT/Diptera [Abundance]	3.39 (± 1)	21 (± 33)	t = −1.19	p = 0.302
EPT/Diptera [Taxa]	1.87 (± 0.23)	3.29 (± 3.23)	t = −1.19	p = 0.302
Shannon-Index [H]	2.67 (± 0.30)	2.18 (± 0.37)	t = 3.96	**p = 0.017**
Pielues Eveness [J']	0.73 (± 0.08)	0.67 (± 0.06)	t = 2.06	p = 0.108
German Saprobian Index	1.61 (± 0.09)	1.78 (± 0.16)	t = −2.2087	p = 0.092
BMWP score	156 (± 15.65)	112.20 (± 26.33)	V = 14*	p = 0.125
Average Score Per Taxon	7.18 (± 0.12)	6.79 (± 0.30)	t = 1.8994	p = 0.130
RETI	0.59 (± 0.11)	0.60 (± 1.14)	t = 20.26	p = 0.849

Abundances [Ind m^{-2}]	Autumn	Spring	Contribution
Baetis spp.	183 (± 172)	193 (± 163)	6.1 %
Leuctra spp.	68 (± 15)	2.1 (± 4.2)	5.9 %
Epeorus spp.	137 (± 205)	21 (± 36)	5.3 %
Rhithrogena sp.	118 (± 186)	5.4 (± 4)	4.5 %
Simulium spp.	94 (± 112)	12.2 (± 16)	4.0 %
Hydropsyche instabilis-gr.	110 (± 70)	34 (± 22)	3.4 %
Elmidae	78 (± 106)	12 (± 18)	3.4 %
Epeorus caucasicus	0.0 (± 0)	26 (± 23)	3.2 %
Ecdyonurus starmachi	38 (± 28)	15 (± 25)	3.1 %
Epeorus zaitzevi	0.0 (± 0)	27 (± 28)	3.0 %

Abundance of FG's [%]	Autumn	Spring
Grazers	46.6 (± 20.8)	67.0 (± 16.1)
Predators	11.3 (± 7.4)	5.6 (± 1.8)
Gatherers	9.0 (± 4.1)	15.9 (± 10.4)
Shredders	7.6 (± 5.2)	4.8 (± 4.4)
Filter feeder	5.1 (± 5.2)	3.5 (± 5.3)
Combination of FG's	14.5 (± 10.9)	1.7 (± 1.2)
Others	5.9 (± 4.8)	1.6 (± 1.3)

For stable isotope analyses (SIA), the dominant macroinvertebrates were collected with a hand net from all five streams in the autumn of 2013. Basal resources – coarse particulate organic matter (CPOM), macroalgae and moss – were picked by hand from the sediment. Macroalgae encompassed filamentous and gelatinous algae and were almost exclusively epilithic. Fine particulate organic matter (FPOM) samples were carefully collected from patches where it had accumulated using a beaker. Biofilm was scraped from stones with a brush and washed into a beaker where the deposit was extracted with a pipette after sedimentation. All isotope samples were frozen in liquid nitrogen until further processing.

After identifying the taxon, eliminating the guts from predatory taxa and cleaning the specimens in the laboratory, all samples were dried at 60 °C for at least twelve hours and then ground up. Thereafter, 0.5–1 mg of animal tissue and 3–5 mg of resources were weighed into tin capsules (5 × 9 mm) with a microbalance (precision: 0.01 mg). To prevent the high content of inorganic carbon in some resources from altering the organic carbon signatures, inorganic carbon was removed from all resource samples (Harris et al., 2001; Mazumder et al., 2010). Three replicates of each invertebrate taxon and five replicates of each resource were analysed using a Delta V™ Advantage isotope ratio mass spectrometer connected with a Flash HT elemental analyser (Thermo Finnigan, Bremen/Germany) at the Institute for Environmental Sciences (University Koblenz-Landau). The stable isotope signatures of carbon and nitrogen (X) are expressed in a δ notation relative to the international standard (carbon: Vienna Peedee Belemnite, nitrogen: N_2) in per mill units: δX [‰] = $(R_{sample}/R_{standard} - 1) * 1000$, where R is $^{13}C/^{12}C$ or $^{15}N/^{14}N$ in the sample and in the standard. The precision of the isotope values was 0.12 ‰ for carbon and 0.05 ‰ for nitrogen.

In total, 10,781 individuals and 45 taxa were observed in the five streams. Ephemeroptera, Plecoptera and Trichoptera (EPT) comprised approximately 80% of the specimens and about 50% of the total number of taxa found in each season (Table 1). The Shannon Index and the Evenness of the community indicated a high species diversity and a homogenous taxa distribution in both seasons, although the number of taxa and the Shannon Index were significantly higher in autumn than in spring (Table 1). Further, the number of EPTCOB also tended to be higher in autumn, whereas the abundance of Ephemeroptera [%] was significantly higher in spring. GSI, Biological Monitoring Working Party (BMWP) score, Average Score Per Taxon (ASPT) and RETI indicated for a very good ecological quality of the streams (Table 1).

The benthic community composition differed significantly between autumn and spring (Anosim, Global R = 0.408, p = 0.024), indicated by two distinct clusters representing the two seasons in the nMDS (Fig. 1). Although similarity between the stream sites was relatively low within one season, it was even lower for the specific sites between the two seasons represented by the high distances to each other (Fig. 1). The mean dissimilarity of the community composition between the