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ECOLOGICAL QUALITY ASSESSMENT OF THE GIDRA RIVER BY MEANS OF MAYFLIES (EPHEMEROPTERA) AND STONEFLIES (PLECOPTERA)

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Abstract: In the years 2007–2008 we assessed the ecological state in the Gidra river basin (the Malé Karpaty Mts). We assessed metrics on the basis of mayflies and stoneflies using software ASTERICS and compared them with those calculated from 1998–1999 data. The influence of selected environmental and microbiological factors was also evaluated. Two sample sites in the most natural tributary (the Kamenný potok) showed good ecological quality; in the middle reaches, site 3 (with the highest species diversity) scored very good ecological quality, whilst site 4 had average ecological quality. This does not represent a significant change compared to results from almost ten years before our research. Site 5 in the lower reach showed bad ecological quality and had declined by two classes compared to 1998–1999. We consider that the marked increase in microbial values has badly affected the ecological quality in the lower reaches.

Key words: Ephemeroptera, Plecoptera, Gidra, Slovakia, ecological quality.

INTRODUCTION

The continual increase of pollution and associated decrease in ecological quality of running waters led to creation of the European Water Framework Directive 2000/60/EC. One of its main aims is the prevention of further decline in ecological quality of aquatic ecosystems and the achievement of good ecological state of waters by December 2015 (Punčochář 2002). Ephemeroptera and Plecoptera are important ecological indicators of water quality (Rosenberg & Resh 1993). The study of mayflies and stoneflies in relation to environmental factors was the aim of several projects originating from the Malé Karpaty Mts (Krno 1984, 1986, Krno & Hullová 1988, Deván 1995). Krno et al. (1994b) and Bulánková et al. (2000) studied selected taxa of macrozoobenthos of the Gidra river basin including mayflies and stoneflies. The most detailed research of mayflies and stoneflies of the Gidra river basin was carried out in the years 1998–1999 (Derka 2003, Krno 2003). According to this, the Gidra river basin represents a significant gene pool of rare species and communities of running waters not only in Slovakia but also Europe, even though the lower stream is under anthropogenic influence (Halgoš 2003).

The aims of our study were to:
1. Identify taxa composition of Ephemeroptera and Plecoptera communities of the Gidra river basin;
2. Calculate metrics using software Asterics;
3. Assess the ecological quality class for all sample sites and compare it to the situation in 1998–1999;

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4. Evaluate the influence of measured factors on Ephemeroptera and Plecoptera taxa composition.

MATERIAL AND METHODS

The Gidra river rises as a stream in the central part of Malé Karpaty Mts and flows into the Dudváh river in the Malá Mača village. The bedrock consists mainly of biotic granodiorites and quartz diorites in the headwater area; in the middle reaches coloured slates and quartzites are predominant, whilst in the lower section Quarternary alluvial sediments are dominant. In the surrounding landscape there is loess and loess-like loam (Fusán et al. 1980). According to the stable typology of the AQEM project the Gidra river belongs to small (basin area 10–100 km^2) streams of the Carpathian ecoregion (code: C02), with flysch foothills of altitude 200–500 m (Hering et al. 2004). Samples were taken at five sites (see the map – Figure 1) adapted according to Rodriguez & Derka (2003) and photographs of the sites – Figures 2–6). The first two – site 1 and 2 were located on the most natural tributary, Kamenný potok, which flows through an almost undisturbed beechwood area. A small dam above site 2 represents the only human intervention. Other three – site 3 – Píla, site 4 – Budmerice and site 5 – Voderady were situated along the Gidra river. The anthropogenic impact, especially in the lower part of river, is obvious (reinforced banks, river regulation, intensive agricultural land use). Physiographi-

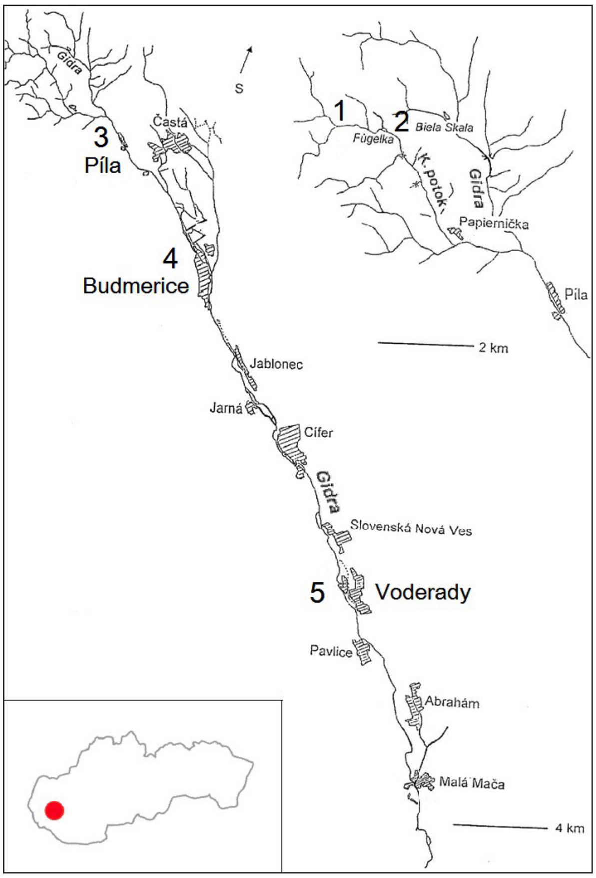

Figure 1. Map of sampling sites of the Gidra river basin (the Malé Karpaty Mts) (adapted according to Rodriguez & Derka 2003).

Figure2. Sampling site 1 – Pod prameňom.

Figure 3. Sampling site 2 – Pod nádržou.

cal characteristics and physicochemical parameters of water are shown in Table 1 and 2.

In 2007–2008 quantitative samples of benthos were collected at the sites using "kicking technique" method (Hynes 1961). One sample was obtained from each substrate present within the site. Samples were fixed with 4% formaldehyde solution. Using the software package ASTERICS 3.01, which calculated 146 metrics, we scored the ecological quality at the sites according to the classification 5 = high, 4 = good, 3 = moderate, 2 = poor, 1 = bad. Stream typology was applied from the type which has been created for the Czech Republic, where the main stressor was organic pollution. Similarity of sample sites was analysed using software PAST 0.45. The influence of physicochemical and microbial factors was assessed with statistical analysis based upon Canonical Correspondence Analysis (Ter Braak & Šmilauer 1998).

Figure 4. Sampling site 3 – Píla.

Figure 5. Sampling site 4 – Budmerice.

Figure 6. Sampling site 5 – Voderady.

RESULTS AND DISCUSSION

We found out 17 mayfly and 20 stonefly taxa at the study sites. Their dominance is shown in Tab. 3. The river flow can be divided into two sections, based on the taxa composition:

1. Upper part (sites 1–3) – the number of Plecoptera taxa slightly prevails (site 1 and 2) or is approximately equal (site 3) as the number of Ephemeroptera taxa. Presence of species with a certain degree of preference to crenal or xenosaprobic zone is typical. Plecoptera species are represented mainly by *Leuctra braueri, L. nigra*, *L. albida*, *L. prima, Protonemura praecox*, *P. intricata, Diura bicaudata*, *Siphonoperla neglecta, Brachyptera risi.* Characteristic Ephemeroptera species belong to the family Heptageniidae (*Rhithrogena semicolorata*, *Ecdyonurus* spp., *Electrogena ujhelyi, Epeorus sylvicola*), less to the family Leptophlebiidae (*Paraleptophlebia submarginata, Habroleptoides confusa, Habrophlebia fusca*). However, euryecious species *Baetis rhodani* from the family Baetidae is predominant.

2. Lower part (sites 4–5) – the number of Ephemeroptera taxa significantly exceeds number of Plecoptera taxa (site 4). Plecoptera are not present at site 5. *Baetis vernus* prevails over *Baetis rhodani* (only low number of *B. vernus* was found at site 5).

The results of cluster analysis are shown in Figure 7. On the basis of the species spectrum, core metrics were calculated (Table 4). Saprobic index (Zelinka & Marvan 1961) and oligo (%) (scored taxa = 100 %) indicate organic pollution. The Rhithron Typie Index, Index of Biocoenotic Region and Aka+Lit+Psa (scored taxa = 100 %) indicate organic pollution and river morphology degradation. The diversity (Shannon–Wiener Index) and BMWP (Biological Monitoring Working Party) indicate organic pollution, river morphology degradation and general degradation. The saprobic index value increases as a result of organic pollution, other metric values decrease as a result of stressor, except for the Index of Biocoenotic Region, the values of which are variable. Table 5 shows metrics which are basic for ecological quality assessment for given stream type. The Czech saprobic index increases as a result of ecological stress, and the number of Ephemeroptera and Plecoptera taxa decrease. According to the metric values we can state that upper section of the

Table 1. Selected abiotic parameters of the sampling sites.
(DFS and stream order according to Rodriguez & Derka 2003)

Parameter	Site number				
	1	2	3	4	5
DFS	7569	7569	7670	7670	7771
Latitude	48°24’13”N	48°24’24”N	48°23’05”N	48°21’59”N	48°16’26”N
Longitude	17°14’56”E	17°16’10”E	17°20’36”E	17°23’58”E	17°33’16”E
Water width (m)	0.8	2.3	5	3.2	3
Bankfull width (m)	3.6	5.8	7	5	5
Left banktop height (m)	0.1	6	0.3	2	1.8
Right banktop height (m)	0.3	4	0.3	2	2
Water depth (m)	0.1	0.1	0.15	0.2	0.3
Stream order	2	3	4	4	4

Table 2. Average values of selected physicochemical parameters of water calculated from data from autumn 2007, spring 2008 and summer 2008.

Parameter	Site number				
	1	2	3	4	5
Temperature (°C)	8.83	11.00	10.13	12.97	12.93
pH	7.17	7.35	7.85	7.93	7.96
Conductivity (μScm^{-1})	16.26	19.70	31.93	36.80	53.67
O_2 ($mg.l^{-1}$)	10.13	9.97	10.57	9.60	8.47
O_2 (%)	90.67	93.00	94.67	90.33	78.67

Gidra river basin is in better ecological state than lower section.

Charts in Figure 8 and 9 compare our metric values with those reported in 1998–1999. The saprobic index increased and the number of mayfly and stonefly taxa decreased at almost all the sites. We observed a significant decline of ecological quality at the last site (from class 4 to class 2), while at sites 1, 2 and 4 the ecological quality declined slightly (one class decline); no change was observed at site 3 (class 5) (Table 6). This is in relationship with changed taxa list found at the sample sites. Three new species – *Protonemura aestiva*, *Isoperla difformis* and *Caenis luctuosa* were recorded in the Gidra river basin for the first time in very low numbers. *Perla burmeisteriana* was not found here in 1998–1999, however, it is described from site 3 by Krno et al. (1994). On the contrary, our research did not confirm the occurence of genera *Centroptilum* and *Heptagenia* (Ephemeroptera) and *Nemurella, Capnia* and *Perlodes* (Plecoptera) reported by Krno (2003) and Derka (2003). As some of these genera were not recorded in high numbers even at that time, their absence could be a random factor (e.g. *Centroptilum luteolum*). Other reasons could be the different number of samples (three in the present study comparing to seven in 1998–1999) and different date of sampling. As for absent species of recorded genera the reason could be the fact that not all the larvae of given genus were determinable to species level. However, reduction in taxa number and decline in ecological quality, especially at site 5 is therefore probably caused by certain environmental factors. From five tested physicochemical factors (water temperature, pH, O_2 ($mg.l^{-1}$), O_2 (%) and conductivity) conductivity showed to have a significant effect on Ephemeroptera and Plecoptera communities (Figure 10). Raise of conductivity is caused by increased eutrophication, which naturally increases downstream. Thus, the values of faecal enterococci increased along the flow (Vrbická 2009). This parameter showed to be a statistically significant microbial factor (from five tested microbial parameters) (Figure 11). The presence and abundance of species in the lower reaches (sites 4 and 5) positively correlate with these factors. *Baetis vernus* which was found at high abundance at site 4 and the only species found at site 5 can be stated as good indicator of anthropogenic influence. Other authors (e.g. Krno et al. 1994a, Pastuchová 2006) also confirm the occurrence of *Baetis nexus* (former *B. pentaphlebodes* Ujhelyi, 1966), *Serratel-*

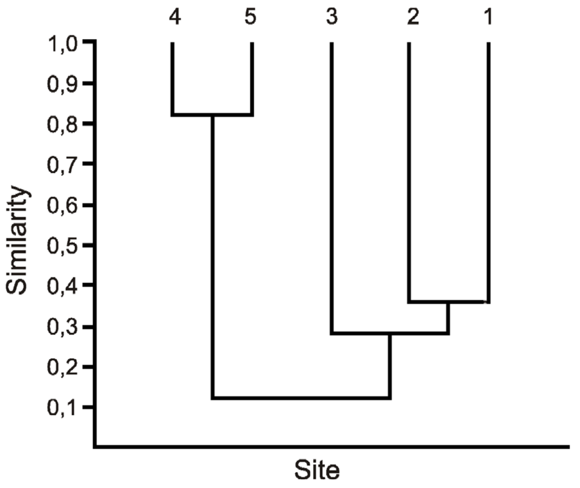

Figure 7. Tree diagram of similarity of five sites, Paired group, Correlation.

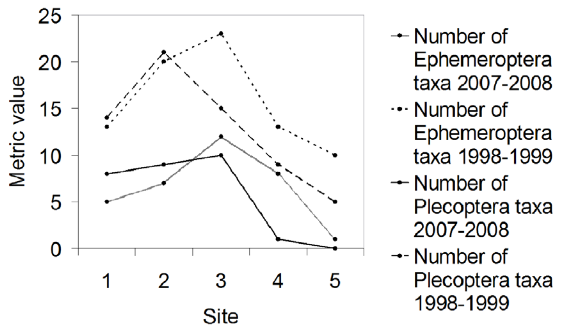

Figure 8. Comparison of Ephemeroptera and Plecoptera taxa number at the sampling sites of Gidra in 2007–2008 and 1998–1999.

Figure 9. Comparison of Czech saprobic index at the sites of Gidra in 2007–2008 and 1998–1999.

la ignita and *Baetis buceratus* at polluted parts of other rivers. Rodriguez & Derka (2000) state that according to the microbial analyses eutrophication in lower section of the Gidra river is caused by adjacent settlements. Compared to previous studies (Valúchová & Rodriguez 2003) microbial pollution values have significantly increased, especially in lower reaches (Vrbická 2009), so we can presume this factor has contributed to the decline of ecological quality.

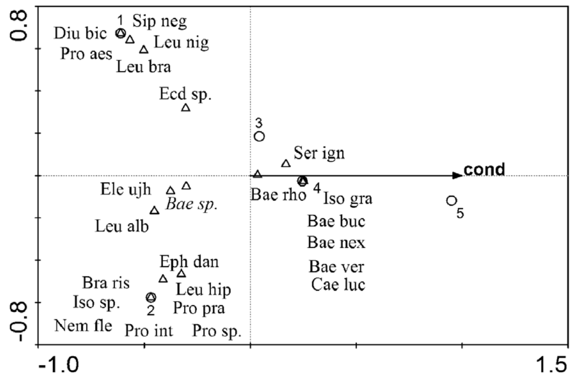

Figure 10. Species relation to the physicochemical characteristics of water (CCA) (cond = conductivity).

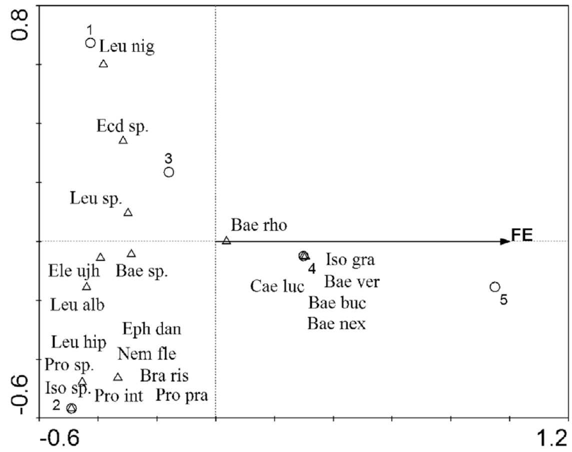

Figure 11. Species relation to the microbial parameters of water (CCA) (FE – faecal enterococci).

CONCLUSIONS

1. The Gidra river can be divided into two sections, based on the studied taxa composition: upper and middle section (sites 1–3) with approximately equal numbers of Ephemeroptera and Plecoptera taxa and a lower section (sites 4–5) where Plecoptera taxa are rare or absent. We recorded 2 new stonefly species (*Protonemura aestiva* and *Isoperla difformis*) and 1 new mayfly species (*Caenis luctuosa*) for the Gidra river basin.

2. The decline of metric values indicating organic pollution and river degradation and an increase in saprobic values in the lower reaches indicated decline of ecological quality in this section of the stream.

3. Sample sites 1–2 showed good ecological quality, site 3 very good, site 4 average and site 5 poor ecological quality, which represents minor change in the upper and middle sections, but marked decline of ecological quality in the lower section (from class 4 to 2 at site 5).

4. Conductivity was considered as a statistically significant physicochemical factor for influencing

Table 3. Dominance values (%) of mayfly and stonefly species collected at five sampling sites.

Taxon / site	1	2	3	4	5
Ephemeroptera					
Baetis buceratus Eaton, 1870	–	–	–	1.41	–
Baetis nexus Navás, 1918	–	–	–	0.94	–
Baetis rhodani (Pictet, 1843)	20.24	20.15	23.56	27.00	–
Baetis vernus Curtis, 1834	–	–	–	48.36	100
Baetis sp.	15.48	16.42	4.60	2.11	–
Epeorus sylvicola (Pictet, 1865)	–	–	1.15	–	–
Rhithrogena semicolorata (Curtis, 1834)	–	0.75	5.17	0.23	–
Rhithrogena sp.	–	–	1.72	–	–
Ecdyonurus sp.	4.76	0.75	2.30	–	–
Electrogena ujhelyi (Sowa, 1981)	1.19	1.49	0.57	–	–
Paraleptophlebia submarginata (Stephens, 1835)	–	1.49	3.45	–	–
Habroleptoides confusa Sartori et Jacob, 1896	1.19	–	6.90	–	–
Habrophlebia fusca (Curtis, 1834)	–	–	1.15	–	–
Ephemera danica Linnaeus, 1758	–	2.99	–	0.23	–
Serratella ignita (Poda, 1761)	–	–	28.74	19.01	–
Ephemerella mucronata (Bengtsson, 1909)	–	–	3.45	–	–
Caenis luctuosa Burmeister, 1839	–	–	–	0.23	–
Plecoptera					
Brachyptera risi (Morton, 1896)	–	0.75	–	–	–
Nemoura flexuosa Aubert, 1949	–	3.73	–	–	–
Protonemura aestiva Kis, 1965	3.57	–	–	–	–
Protonemura intricata (Ris, 1902)	–	1.49	–	–	–
Protonemura praecox (Morton, 1894)	–	26.87	–	–	–
Protonemura sp.	–	5.22	–	–	–
Leuctra albida Kempny, 1899	5.95	8.96	1.15	–	–
Leuctra braueri Kempny, 1898	16.67	–	0.57	–	–
Leuctra hippopus Kempny, 1899	–	5.97	0.57	–	–
Leuctra nigra (Olivier, 1811)	23.81	–	2.30	–	–
Leuctra prima Kempny, 1894	1.19	–	3.45	–	–
Leuctra sp.	2.38	2.24	3.45	–	–
Diura bicaudata (Linnaeus, 1758)	1.19	–	–	–	–
Isoperla difformis (Klapálek, 1909)	–	–	0.57	–	–
Isoperla grammatica (Poda, 1761)	–	–	–	0.47	–
Isoperla sp.	–	0.75	–	–	–
Perla burmeisteriana Claassen, 1936	–	–	2.87	–	–
Perla sp.	–	–	0.57	–	–
Siphonoperla neglecta (Rostock, 1881)	2.38	–	–	–	–
Siphonoperla sp.	–	–	1.72	–	–

Table 4. Core metric values at the sampling sites.

Metric / Site	1	2	3	4	5
Saprobic index (Zelinka & Marvan 1961)	1.47	1.24	1.81	2.2	2.3
Diversity (Shannon–Wiener Index)	2.07	2.16	2.36	1.28	0
BMWP	61	71	74	59	4
Rhithron Typie Index	13.75	17.06	14.15	10.5	9
Index of Biocoenotic Region	3.37	3.4	4.4	4.55	4.5
Type Aka+Lit+Psa (scored taxa = 100%)	69.30	61.46	59.03	50.07	50
Oligo (%) (scored taxa = 100%)	38.87	57.5	30	19.79	20

Table 5. Metric values which are crucial for ecological quality class assessment.

Metric / Site	1	2	3	4	5
Czech saprobic index	0.861	1.055	1.396	1.938	2
Number of Ephemeroptera taxa	5	7	12	9	1
Number of Plecoptera taxa	8	9	10	1	0

Table 6. Comparison of ecological quality classes at sapling sites of Gidra in 2007–2008 and 1998–1999.

Season / Site	1	2	3	4	5
2007–2008	4	4	5	3	2
1998–1999	5	5	5	4	4

taxa composition. A rise in conductivity (which indicates increased eutrophication) especially at site 5 together with high values of faecal enterococci (statistically significant from five tested microbial parameters) are probably the main reasons for the reduction in taxa and a decline in ecological quality in the lower reaches of the Gidra river.

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