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MAYFLIES (EPHEMEROPTERA) OF THE GIDRA RIVER BASIN

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Abstract: Changes in the mayflies communities of the stream Gidra (Malé Karpaty Mts.) have been studied at 11 localities beginning with the spring area towards the mouth in the Dudváh River. 35 species have been recorded forming 4 types of communities according to the position of the studied localities in the river continuum. As it was expected, crenophilic and rhithrophilic species dominate in the upper reaches flowing through beech forests of Malé Karpaty Mts. The α-diversity values are increasing from the spring. In the lower reaches flowing through intensively exploited agricultural landscape the occurrence of ubiquist and potamal species increases and α-diversity decreases. The middle section has been found the most valuable because it shows the highest values of species richness and the mayfly communities show the highest degree of ecological integrity. In spite of a considerable human impact several rare species have been recorded in the lower reaches. It is the evidence of the fact that such negative factors like eutrophication are suppressed by preservation of the natural bottom of the stream and riparian vegetation. The impact of the small dam in the upper section as well as that of the streambed regulation in the middle section is discussed in the study.

Keywords: Ephemeroptera, mayflies, community, species composition, Malé Karpaty Mts.

INTRODUCTION

The study of mayflies in relation to natural and anthropogenic environmental factors was the aim of many works originating from the territory of Slovakia. Several of them were realised also in the area of Malé Karpaty Mts. HUSÁROVÁ-DUDÍKOVÁ (1960) presented data about the benthic fauna in the stream Bystrica. KRNO & HULLOVÁ (1988) studied the influence of pollution on the structure and dynamics of benthos in the stream Vydrica. LANDA & SOLDÁN (1989) included to their comprehensive publication several localities of Malé Karpaty Mts. The study of KRNO (1993) includes the lower part of the tributary from Malé Karpaty Mts. to the National Nature Reserve Jurský Šúr. The study of KRNO et al. (1994a) refers to the SW part of Malé Karpaty Mts. DEVÁN (1995) studied fauna mayflies of the south part of Malé Karpaty Mts. The work of KRNO et al. (1994b) studied temporal fauna of the upper reaches of the Gidra stream. The presented work deals with the study of changes in the communities of mayflies in the longitudinal profile of the Gidra stream in relation to changes in natural and anthropogenic environmental factors.

CHARACTERISTICS OF THE STUDY AREA

The Gidra stream rises in the central part of Malé Karpaty Mts. at the altitude of 500 m. In the upper section the stream Kamenný potok was studied. It is the more preserved right-side tributary of

Gidra (localities 1-6). It originates approximately at the same altitude. Near Sládkovičovo it flows into Dudváh River. The bedrock consists mostly of biotic granodiorites and quartz granodiorites in the area where the spring is situated. Somewhat lower there are varicoloured slates and quartzites prevailing. In the lower section quarternary alluvial sediments are found. In the surroundings there are loesses and loess-like loams (FUSÁN et al. 1980).

Samples were taken at 11 localities. More or less natural stream, flowing through beech forests, has been preserved at localities 1-4. A smaller dam between localities 3-4 and local interventions into the stand represent the only human influences. At localities 6, 7 the stream is affected by settlements. An increase in eutrophication is evident especially at the locality 7. Leaving the massif of Malé Karpaty Mts. (loc. 8) Gidra flows through agriculturally exploited and deforested lowlands to the mouth into Dudváh. In the lower reaches regulated and unregulated sections alternate. More detailed description of the area as well as the study localities is presented in the work of RODRIGUEZ & DERKA (2003).

MATERIAL AND METHODS

Qualitative and quantitative samples of benthos were collected at the study localities. Quantitative samples were obtained using the "kicking technique" method HYNES 1961. A hydrobiological net is placed at the bottom of the stream while the substrate upstream is disturbed with collector's feet. Imagoes were occasionally caught in the net. Quantitative samples were taken using Kubíček's folding benthometer HELAN et al. 1973 0.1 m^2 in area. Samples were always taken 3 times in order to catch an adequate area of a representative sample. Qualitative and quantitative samples were fixed with 4% formaldehyde. Water temperature, stream width and depth were measured, too. Some additional samples were taken at the localities 3, 4, 7, 9 and 10. Mayflies were separated in the laboratory. The saprobity index values were calculated according to KRNO (1996). Biological quality of biotope and mayfly community integrity were evaluated using the method of BUFFAGNI (1997) adapted to Slovak conditions by KRNO (2000).

RESULTS AND DISCUSSION

35 species of mayflies were found at the studied localities (Tab.1). It represents approximately 25% of mayfly fauna of Slovakia. As it was expected, mayfly communities respond to natural changes of environmental factors as well as to human impacts alongside the Gidra stream. The α-diversity is increasing from the spring towards the middle section where it culminates at loc. 7. Downstream its values considerably decrease under the influence of regulation and pollution (Fig. 2). An annual average of species dominance values was used for calculating of a dendrogram of similarity of mayfly communities at studied localities (Weighted pair-group average, Euclidean distances). As it was expected, there is a significant difference between communities of the upper or middle stream (the massif of Malé Karpaty Mts. – loc.1-8) and the lowland section as far as the mouth. These two basic groups should be further divided into four types of communities (Fig.1):

1. **The spring stream** – loc. 1. It is a cascade-like stream containing a large amount of the coarse organic matter (leaves and debris). Water temperature is low (4-10 ˚C) through the whole year. The community is naturally poor, crenophilic species prevail (Fig. 4). Six species have been recorded there. However, only 3 species of them occur regularly. *Baetis rhodani* and *Electrogena ujhelyi* are dominant ones. *B. rhodani* is the ubiquist species, one of the most common mayfly species in Central Europe. *E. ujhelyi* is a typical species of spring areas. It is less abundant in shallow metarhithral streams. It was described from small tributaries of the Balaton Lake. It has been found in several Slovak mountain ranges. *Baetis alpinus* is the typi-

cal mountain species, abundant in streams of the high Slovak mountains. It also occurs in springs and spring streams in lower mountains. According to SOLDÁN et al. (1994) it tolerates a large scale of lotic biotopes in nearly all altitudinal zones. DEVÁN (1995) found *E. ujhelyi* in all spring streams (under the name *E. samalorum*). Apart from one exception, *B. rhodani* has been also recorded in the springs. This author did not find *B. alpinus* at all. KRNO et al. (1994a) found this species in the stream with higher discharge. In the study of KRNO et al. (1994b) the occurrence of *B. alpinus* is also mentioned at the lower locality. However, we did not find any individual there. KRNO et al. (1994a) recorded a similar number of species in the spring stream. *E. ujhelyi* and *B. rhodani* were the most abundant here, too. Other accessory species mentioned in this article correspond to our results only partially. KRNO (1997) indicates similar communities in the spring streams of the Slovak Karst. Mayfly communities in the springs of Malé Karpaty Mts. are characterised by the codominance of *B. rhodani* and *E. ujhelyi* according to previous results. Apart from it, several accessory species abundant in lower sections of the streams may occur there. The absence of species belonging to the group *Ecdyonurus helveticus* that inhabit spring streams in other Slovak mountains is characteristic. They are replaced by *E. ujhelyi* in Malé Karpaty Mts.

2. **The submontane stream** – loc. 2–8. The saprobity index value is not changing significantly down the stream (Fig. 3). The lowest one (1.19) is at loc.2, the highest one (1.36) at loc. 4. Loc. 8 with the value of 1.7 is the exception. It may be due to higher abundance of ubiquist species in the regulated stream channel and not due to decreasing water

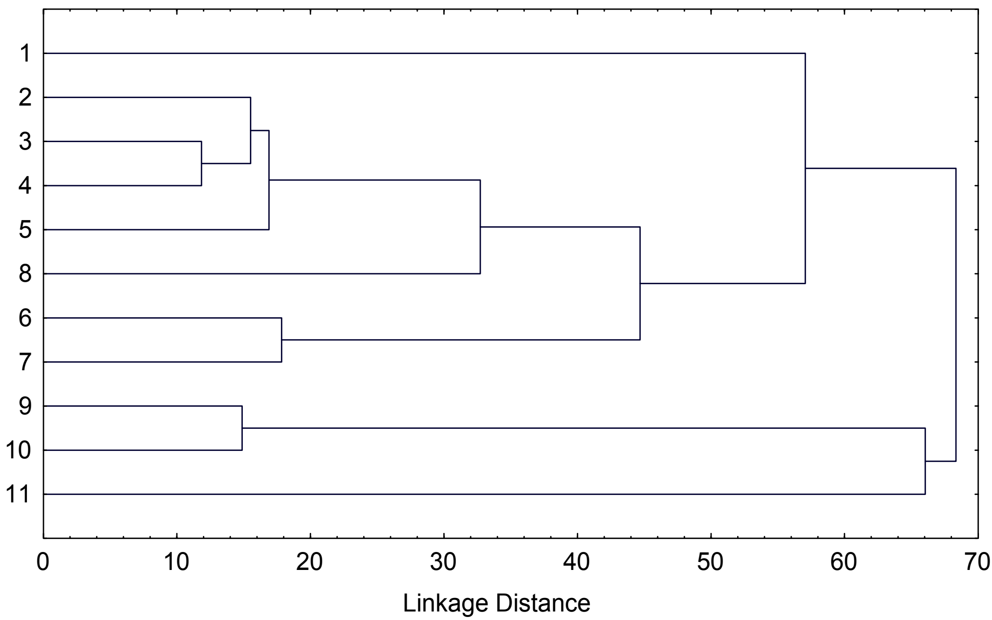

Fig. 1. Tree diagram for 11 study sites, Weighted pair-group average, Euclidean distances.

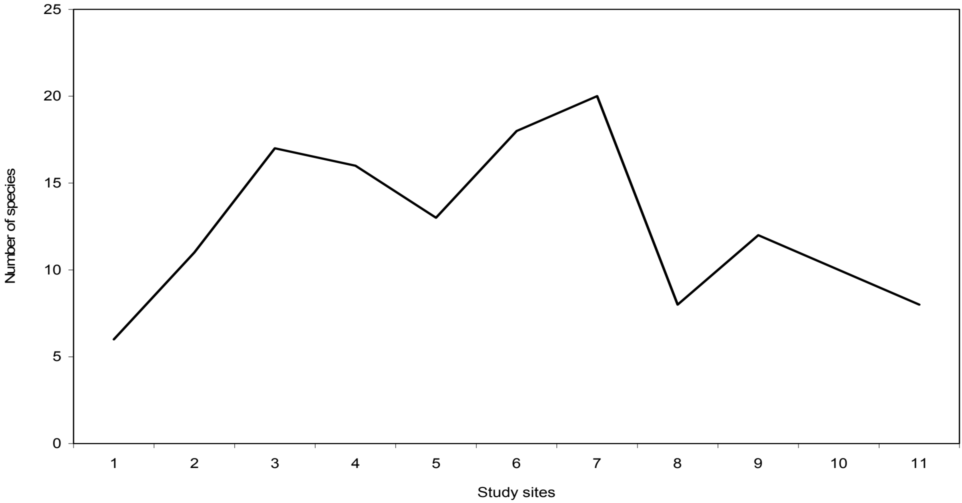

Fig. 2. Changes in α-diversity of mayfly communities along the Gidra river.

quality. Potamophilic species are absent at all. Number of crenophilic species decreases down the stream. They completely disappeared at loc. 8 (Fig. 4). Number of rhithrophilic and ubiquist species is not changing significantly up to loc. 7. Numbers of rhithrophilic and ubiquist species at loc. 8 is the same (Fig. 4). The α-diversity moderately increases downstream. The decrease was observed at loc. 5. However, it may be due to the lower number of samples. The α-diversity culminates at loc. 7 (Fig. 2). It forms the independent cluster (Fig.1) with loc. 6. α-diversity is reduced by more than a half at loc. 8 as a result of the stream channel regulation. The decrease of diversity and mayfly community integrity was recorded at this locality (Fig. 3). The decrease of the community integrity is apparent with respect to almost twenty fold increase of the B/H index (the ratio of the number of Baetidae to Heptageniidae) in comparison with loc. 7. The dominant species (56%) is *B. rhodani.* The *Ecdyonurus* species absents at all and the occurrence of the *Rhithrogena* genus is considerably reduced. Many authors observed the increased dominance of baetids after regulation of the stream (see e. g. BRITTAIN & SALTVEIT 1989). DERKA (1998) found similar values of dominance for *B. rhodani* in a regulated stream in Biele Karpaty Mts. BRITTAIN & SALTVEIT (1989) include *B. rhodani* among species generally favoured by regulation. It is explained by plasticity of the developmental cycle with overlapping cohorts (CLIFFORD 1982). It enables the use of favourable conditions and maintenance of viable population in case when one cohort or generation is reduced because of unfavourable environmental conditions. As opposed to it the majority of Heptageniidae are reported as having univoltine winter life cycles, whereby they are present as nymphs throughout much of the year. Therefore, they are vulnerable in case of unfavourable conditions. SOLDÁN et. al. (1998) indicates that *B. rhodani* replaces numerous more sensitive species of mayflies occurring at the same localities earlier. Characteristic species are: *B. rhodani*, *Alainites muticus*, *Rhithrogena carpatoalpina*, *R. picteti*, *R. semicolorata*, *Epeorus sylvicola*, *Ecdyonurus macani*, *E. starmachi* and *Ephemerella mucronata.*

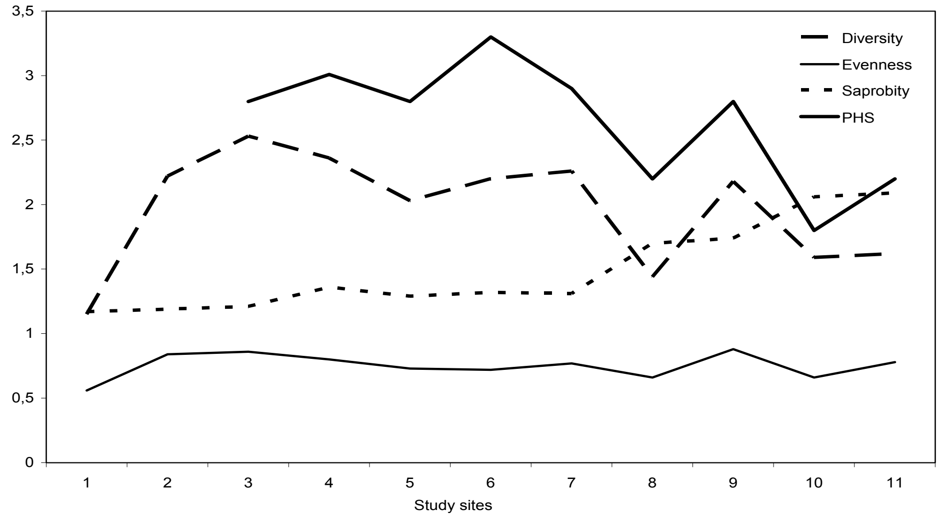

Fig. 3. Changes in diversity, evenness, saprobity and MAS along the Gidra river. Diversity and evenness were calculated as Shannon index of diversity, saprobity as Saprobic index. MAS (mayfly average score) i sused according to the BUFFAGNI (1977).

Although the analysis of similarity between communities showed the highest similarity between loc. 3 and 4 (Fig. 1), the influence of warmer water released from the dam epilimnion on dominance values of some species is evident (Tab. 1). The dominance value of *Baetis melanonyx* decreases under the dam but increases again at loc. 5. According to SOLDÁN et al. (1998), larvae mostly occurred together with *B. alpinus* but their ecological range was lower. However, in comparison with that species *B. melanonyx* generally prefers lower altitudes. The same pattern was observed in the Gidra river. DEVÁN (1995) found it on two localities in Malé Karpaty Mts. In contrast, the dominance value of *R. semicolorata* increases below the dam. It is more abundant only in the lower reaches of the stream (loc. 6, 7). The dominance value of ubiquist species *S. ignita* considerably increases below the dam. Under normal conditions *S. ignita* is abundant in lowlands and lower coline zone and in such localities it is an accessory species only. It is the clear influence of released warmer water in summer season when the zone of the stream is shifting downwards. *C. luteolum* was recorded below the dam only. The dam may also cause the occurrence of *H. lauta* at loc. 4. According to SOLDÁN et al. (1998) *H. fusca* is the winter univoltine species living in deeper still water with debris and a minimum current. *H. lauta* has very similar developmental cycle and ecological requirements as *H. fusca.* However, this species is more abundant and distributed at higher altitudes. They often occur together at the same locality but abundance of *H. lauta* increases with increasing altitude. *H. fusca* was recorded at loc. 10 and 11 and surprisingly also at loc. 3. We can speculate that *H. lauta* was favoured by colder water released in winter months from the epilimnion of the dam. It means that in this season of the year this locality shifts upwards in the river continuum.

E. macani and *E. starmachi* showed certain tendency to the increase of dominance values below the dam. In this case, dominance values are similar to values at loc. 7. These are the only species of the genus *Ecdyonurus* regularly occurring in this section. Other species were recorded on one or two localities. Surprisingly, KRNO et al. (1994b) found only *E. starmachi* in Gidra. DEVÁN (1995) reported larvae of several species belonging to the genus *Ecdyonurus* in Vydrica only. However, he found more species of the *E. helveticus* group there.

Three species of the group *R. semicolorata* were recorded there. Differences in their distribution are evident along the stream. *R. picteti* was most abundant in upper reaches, *R. carpatoalpina* and *R. semicolorata* in lower parts. According to SOLDÁN et al. (1998) these two species are typically submontane while *R. iridina* is distributed at higher altitudes. BAUERNFEIND & MOOG (2000), observed similar pattern although vertical distribution of the genus *Rhithrogena* in the Alps partially differs from the Carpathians. Several authors (KRNO et al. 1994a,b, DEVÁN 1995) published records of the rare species *R. germanica* from Malé Karpaty Mts. Larvae of this species are similar to *R. semicolorata.* None of determined larvae corresponded completely to the description of *R. germanica*. Therefore, they are referred to as *R. semicolorata.* In order to resolve this problem satisfactorily the comparison of Malé Karpaty Mts. material with the material of *R. germanica* will be necessary. None of determined specimen corresponded to the description of *R. puytoraci*, published from this area by DEVÁN (1995). KRNO et al. (1994b) collected univoltine summer species *R. beskidensis* and *R. savoiensis* in Gidra. DEVÁN (1995) found *R. savoiensis* also in Vydrica stream. The rare occurrence of *R. beskidensis* was confirmed at loc. 6 and 7 but *R. savoiensis* has not been found. According to SOLDÁN et al. (1998) they can live together. The species probably lives in the studied localities in such a small abundance that it could not be recorded or it disappeared.

E. ujhelyi occurs up to loc. 7. Downstream its dominance decreases. Below the loc. 3 it is only accessory species. DEVÁN (1995) found also *E. lateralis* on several localities but we did not collect this species.

3. The lowland stream – Loc. 9 and 10. Gidra flows through agriculturally exploited lowlands. Regulated sections alternate with non-regulated ones and riparian stands are mostly preserved. Changes in Ephemeroptera communities happen as a result of the change of natural environmental factors related to the transition to the plain lowland and/or under the influence of human activities (pollution, deforestation of the river basin, regulation). It is difficult to determine exactly which of these factors have the main influence because an undisturbed lowland section of Gidra or a similar stream is not available and there is nothing to be compared with. The saprobity index value increases to 1.7 and 2.1 respectively. The α-diversity slightly increases (12 and 10 taxa) in comparison with loc. 8. However, the structure of the community is changing. Ubiquist (*B. rhodani*, *B. vernus*, *Seratella ignita*) and potamophilic (*B. buceratus*, *B. pentaphlebodes*, *B. tracheatus*) species prevail. *B. vernus* represents almost half of all individuals. Abundance of rhithrophilic species significantly decreases. The genus *Ecdyonurus* is absent. *E. sylvicola* and the genus *Rhithrogena* disappear at loc. 10. *Cloeon dipterum* is our most common inhabitant of various types of standing waters and most likely it was washed out at the locality from the adjacent pond. *B. buceratus*, *B. pentaphlebodes* and *B. tracheatus* were recorded on these localities only. Therefore, they can be considered characteristic for this biotope. According to IUCN criteria, *B. tracheatus* belongs to rare species of our fauna.

4. Locality 10. Similarly, as in the case of the previous group it is the lowland stream but there is an evident shift of the community towards the potamal type. Only one rhithrophilic species was recorded. Baetidae form about one third of the community. It is the significant shift in comparison with the previous group where they represented 83.9-93.5% of all individuals. *B. rhodani*, *B. buceratus*, *B. pentaphlebodes* and *B. tracheatus* completely disappeared, too. The significant growth of dominance values of *B. fuscatus* was recorded while number of *B. vernus* is decreased. It correspond to the results of SOLDÁN et al. (1998) according to which *B. rhodani* is mostly restricted to lotic erosional biotopes while *B. fuscatus* seems to be a typical potamal species although it occurs also in the zone of hyporhithral as well. With an increasing altitude it is replacing with other ubiquist species *B. vernus.* It was observed also on Gidra. Ubiquist (*Baetis fuscatus*, *B. vernus*, *Seratella ignita*) and potamal species (*Heptagenia flava, H. sulphurea* and *Caenis macrura.*) are dominant. The high dominance value of *C. macrura* was observed (42.3%). It is a typical ubiquist species inhabiting mostly large rivers in lowlands and lower coline zone (SOLDÁN et al. 1998).

The evaluation of dominance and number of crenophilic, rhithrophilic, potamophilic and ubiquist species lead to different results (Figs. 4, 5). Rhithrophilic species represent one third of species occurring at loc. 1, from loc. 2 up to loc. 6 more than one half of species. Number of ubiquists represented particularly by *B. rhodani* reaches 20%. Number of crenophilic species decreases while ubiquists increase at loc. 7. Ubiquists and rhithrophilic species represent 50% of species number at loc. 8. Number of rhithrophilic species is gradually decreasing at loc. 9-11 where they are replaced by ubiquists and potamophilic species. Potamophilic species represent about one third of the species recorded at these localities. The evaluation of dominance says more about the structure of the community. Dominance of rhithrophilic species at loc. 1 is negligible. Their dominance values gradually increase down the stream. At loc. 6 and 7 rhithrophilic species dominate the mayfly community. At loc. 4 the influence of warmer water released from the dam restricts crenophilic species but favours rhithrophilic ones. Slight increase in dominance of crenophilic species was observed at loc. 5. The influence of the dam is not clearly evident in the quantitative evaluation of communities. At loc. 8 affected by regulation dominance of ubiquist species (90%) is evident even though they represent only one half of the species collected. Ubiquists are significantly dominating at loc. 9 and 10. Potamal species appear here as well. Loc. 11 is characterised by co-dominance of potamal and ubiquist species.

The mayfly community integrity and the biological quality of stream can be evaluated by method proposed by BUFFAGNI (1997) which has been modified to Slovak conditions by KRNO (2000). Communities at loc. 1 and 2 are naturally poor and cannot be assessed by this method. Only loc. 4 and 6 (Fig. 3) can be included in the integrity class II witch means the nearly natural mayfly community. Loc. 3, 5 and 7 belong to the integrity class III characterised by disturbed biotope and altered community with notable loss of indicator taxa. It is evident that the higher α-diversity value as it is at loc. 7 may not mean more natural community with higher integrity class. Samplings at loc. 8 to 11 showed various results. In some cases very poor community was recorded here and biotope was considered as heavily altered (class V). In other cases communities belonged to class IV, rarely to III. Despite the fact that isolated rare species were recorded here, mayfly communities are heavily altered or very poor.

Tab. 1. Dominance values of mayfly species collected at 11 study sites.

Species	Site 1	2	3	4	5	6	7	8	9	10	11
Baetis alpinus (Pictet, 1843)	1.6		1.2								
B. buceratus Eaton, 1870									1.3	2.1	
B. fuscatus (Linnaeus, 1761)							2.5	2.8	1.3	0.5	21.1
B. melanonyx (Pictet, 1843)		5.3	4.9	0.4	7.1						
B. pentaphlebodes Ujhelyi, 1966									1.3	4.1	
B. rhodani (Pictet, 1843)	36.4	28.7	28.7	31.6	28.2	11.4	3.3	56.2	16	3.1	
B. scambus Eaton, 1870										2.1	
B. subalpinus Bengtsson, 1917								0.5			
B. tracheatus Keffermüller et Machel, 1967									1.3	2.1	
B. vernus Curtis, 1834			1.2			1.5	0.4	6.0	48	49.2	5.6
Baetis spp.	11.6	15.2	14.3	3.4	25.3	4.4	4.9	18.9	10.7	30.3	1.41
Alainites muticus (Linnaeus, 1758)		1.8	2.0	3.4	0.6	5.1	1.6				
Centroptilum luteolum (Müller, 1776)				0.4							
Cloeon dipterum (Linnaeus, 1761)									4		1.4
Epeorus sylvicola (Pictet, 1865)		1.8	5.7	4.9	14.7	2.6	6.6	0.5	2.7		
Rhithrogena beskidensis Alba-Tercedor et Sowa, 1987						1.1	1.6				
R. carpatoalpina Klonowska, Olechowska, Sartori et Weichselbaumer, 1984		8.8	0.8	1.9	1.2	0.4	1.2				
R. picteti (Sowa, 1971)	0.8	1.8	1.6	0.8		1.1					
R. semicolorata (Curtis, 1834)	0	8.2	4.9	11.3	2.4	12.1	18.5	2.8			
Rhithrogena spp.	0	11.1	12.3	6.4	8.8	23.9	9.5	0.5	5.3		
Ecdyonurus aurantiacus (Burmeister, 1839)						1.5	2.1				
E. macani Thomas et Sowa, 1970			0.4	3.4	1.2	0.4	2.5				
E. picteti (Meyer-Dür, 1864)						0.4					
E. starmachi Sowa, 1971			0.4	1.9	0.6	0.4	1.2				
E. submontanus Landa, 1970							0.8				
E. venosus (Fabricius, 1775)							1.2				
Ecdyonurus spp.		7.0	2.5	1.9	3.5	2.9	4.1				
Electrogena ujhelyi (Sowa, 1981)	48.0	7.0	0.8	1.5	1.8	0.4	0.4				
Heptagenia flava Rostock, 1877										1.5	4.2
H. sulphurea (Müller, 1776)											4.2
Paraleptophlebia submarginata (Stephens, 1835)			1.6			1.5	0.4		2.7		
Habroleptoides confusa Sartori et Jacob, 1986	0.8	1.2	4.5	7.1	1.8	3.7	1.6				
Habrophlebia fusca (Curtis, 1834)			0.8							2.1	2.8
H. lauta Eaton, 1884				2.6							
Ephemera danica Linnaeus, 1758				3.0	0.6	0.7	0.4				
Serratella ignita (Poda, 1761)			1.2	6.0	0.6	0.7	13.2	7.8	4	3.1	16.9
Ephemerella mucronata (Bengtsson, 1909)	0.8	2.3	9.8	8.3	1.8	23.9	21.4	4.1			
Caenis horaria (Linnaeus, 1758)									1.3		
C. macrura Stephens, 1835							0.4		1.3		42.3

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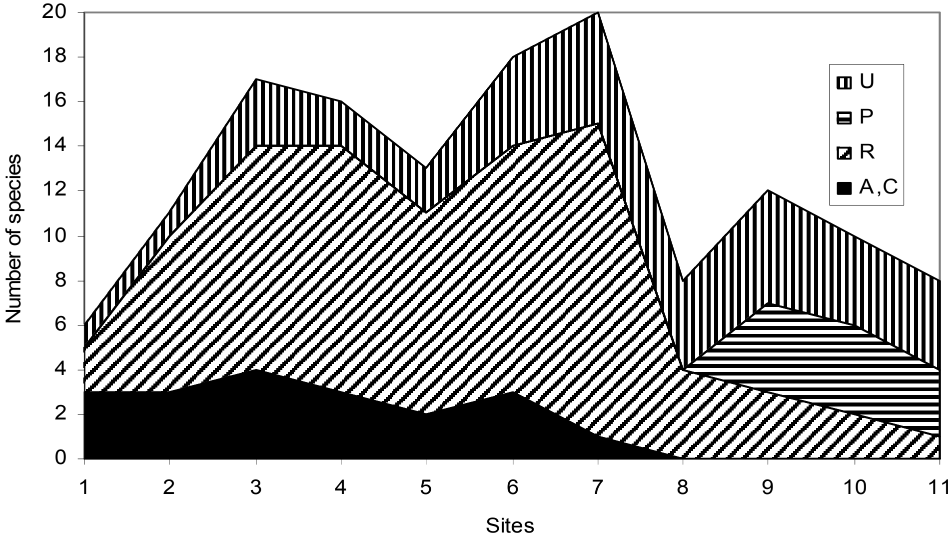

Fig. 4. Changes in the number of crenophilic (C), rhithrophilic (R), potamophilic (P) and ubiquist (U) species along the Gidra river. U – ubiquist species.

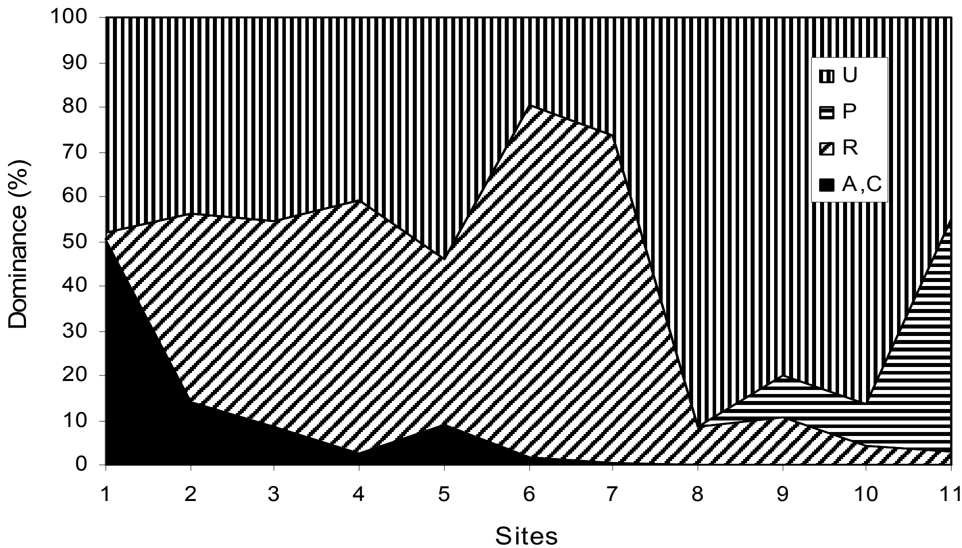

Fig. 5. Changes in the dominance of larvae of crenophilic (C), rhithrophilic (R), potamophilic (P) and ubiquist (U) species along the Gidra river. U – ubiquist species.

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SÚHRN

Podenky (Ephemeroptera) povodia Gidry

V práci sledujem zmeny spoločenstiev podeniek malokarpatského potoka Gidra na 11 lokalitách od pramenného toku k ústiu do Dudváhu. Zaznamenal som 35 druhov, ktoré vytvárajú 4 typy spoločenstiev podľa postavenia skúmaných lokalít v riečnom kontinuu. Podľa očakávania, v hornom úseku, pretekajúcom bukovými lesmi masívu Malých Karpát, prevládajú krenofilné a ritrofilné druhy, od prameňa stúpajú hodnoty α-diverzity. Tieto dosahujú maximá na relatívne nenarušených lokalitách v spodnej časti masívu Malých Karpát. V dolnom úseku, pretekajúcom intenzívne využívanou poľnohospodárskou krajinou, sa zvyšuje zastúpenie ubikvistných a potamálových druhov a klesá α-diverzita. Najcennejší sa javí stredný úsek, ktorý je druhovo najbohatší a spoločenstvá podeniek vykazujú najvyšší stupeň pôvodnosti. Aj napriek značnému antropickému vplyvu som aj v spodnom úseku zaznamenal niekoľko vzácnych druhov, čo svedčí o tom, že negatívne faktory ako eutrofizácia, sú tlmené zachovaním prirodzeného dna toku a brehovej vegetácie. V práci diskutujem vplyv malej priehrady v hornom úseku ako i vplyv regulácie koryta v strednom úseku.