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SPATIO-TEMPORAL VARIATIONS OF MACROINVERTEBRATE COMMUNITY IN THE TISZA RIVER (NE HUNGARY)

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Investigations were carried out on spatial and temporal distribution of benthic macroinvertebrate assemblages at a cross-section of the River Tisza. The macrozoobenthos showed significant spatial and seasonal changes in number of individuals and taxa, and Margalef's species richness. The spatial and temporal differences were shown by discriminant analysis (DA) too. These variations were most pronounced in chironomids. When all macroinvertebrate groups were taken into consideration, the identification of chironomids to genus and species level increased the sensitivity of DA in characterization of spatial distribution. However, the chironomids themselves less showed the spatial differences along the cross-section. In contrast with spatial distribution, the temporal variations in the benthic community were most remarkable by DA when the chironomids were identified to family level, and the sensitivity of DA decreased according to genus and species level identification of chironomids. The same situation was detected if only the chironomids were taken into account. Present results suggest that species level identification can be important in characterizing habitat-dependent variations of benthic community. In contrast, the family level identification of chironomids is enough for characterization of temporal distribution of benthic macroinvertebrates.

Key words: Chironomidae, discriminant analysis, spatial and temporal distribution, identification level

INTRODUCTION

Benthic macroinvertebrates are widely used for the biological monitoring programmes of water quality in rivers. These surveys are generally designed to describe the spatial and temporal distribution of these organisms (MORRIS & BROOKER 1980). The family Chironomidae often is the dominant group of benthic macroinvertebrate fauna both in their abundance and species richness (e.g., AAGAARD *et al*. 2004, COIMBRA *et al*. 1996, DAVIS 1997, GÍSLASON *et al*. 2000, GRZYBKOWSKA & WITCZAK 1990, HUMPHRIES *et al*. 1998, MUÑOZ & PRAT 1994). As a result of their abundance and known sensitivity to differences in water quality, chironomids have long been used as ecological indicators (e.g. BAZERQUE *et al*. 1989,

RUSE 2000, RUSE & WILSON 1984, WILSON & MCGILL 1977). Unfortunately, the use of Chironomidae in bioassessment is often problematic, because of the time-demanding and laborious identification of species. Due to these difficulties and despite their known utility as biological indicators, in many surveys, e.g., BMWP system (ARMITAGE *et al.* 1983), the chironomids are only identified at genus or family level, which may lead to loss of important information (BEAVAN *et al.* 2001, MORRIS & BROOKER 1980, TOKESHI 1991). The species-level ecological knowledge is important, because the linkage between genera and the ecology of their constituent species is tenuous (CRANSTON 1990). On top of that the significance of species-level identification of chironomids was confirmed in many cases (e.g. BUTLER *et al.* 2000, KOWNACKI 1989, WAITE *et al.* 2004). In contrast, RABENI and WANG (2001) concluded that the elimination of Chironomidae did not decrease the sensitivity of bioassessment when metrics such as a biotic index, total taxa, or a diversity index were used.

The aim of this study was to detect the differences in the description of spatial and temporal variations in benthic macroinvertebrate assemblages when the chironomids are identified to different taxonomic levels.

MATERIALS AND METHODS

Studies were carried out at a cross-section of the Hungarian reach of Upper Tisza between Tiszamogyorós and Lónya, NE Hungary (651 km, 48°19'03"N, 22°15'03"E). At the cross-section the riverbed is asymmetric (Fig. 1): the main current is close to the right bank, and water depth and velocity gradually decrease from the right to the left bank. The riverbed is characterized by different sediment granulometry: silty/sandy at the left bank, sandy at the mid-bed and coarser sandy at the main flow.

Benthic samples were taken six times from March to November 2003 (02 March, 23 April, 03 June, 14 July, 08 September and 17 November). Three sampling sites were assigned within the cross-section based on the water depth and water velocity conditions (Fig. 1): (1) at the main flow (right bank), (2) at mid-bed (at half distance between the right and the left bank) and (3) close to the left bank. Triplicate benthic samples were taken at each site with the help of a Petersen grab (sampling area 558 cm^2). Samples were washed through a net (mesh size 250 µm), then macroinvertebrates were sorted and put directly into 70% ethyl-alcohol. Oligochaeta were identified to subclass level, while Diptera: Tipulidae, Limoniidae and Ceratopogonidae were identified to family level. Mollusca, Ephemeroptera, Odonata, Trichoptera and Diptera: Chironomidae were identified to species level and only these taxa were included for discriminant analyses.

Sampling sites and dates were classified by discriminant analysis (DA) (PODANI 1997). The DA is useful in order to build a predictive model of group membership based on observed characteristics of each case. DA generates discriminant functions based on linear combinations of the predictor variables that provide the best discrimination between the groups. Five different DA analysis were performed, including log-transformed [log(x+1)] number of individuals of: (1) all macroinvertebrate groups identified to species, (2) all macroinvertebrate groups identified to species, but chironomids to genus, (3) all macroinvertebrate groups identified to species, but chironomids to family level, (4) only chironomids identified to species, (5) only chironomids identified to genus.

RESULTS

On the basis of the number of species and individuals, family Chironomidae was the most dominant taxon among the collected animal groups (63% and 95% respectively). Two other important benthic groups, Oligochaeta and Bivalvia, were strikingly found in very low number of specimens. Some other groups, such as Trichoptera and other Diptera were also found in larger number of individuals.

The macrozoobenthos showed significant or marginally significant spatial and seasonal changes in number of individuals of certain species, total number of individuals, total number of taxa and species richness (Margalef's index) (Table 1). Differences between the sampling sites and dates could be presented by discriminant analysis too. Sampling site at close to the left bank could be separated from the other two sites (Fig. 2). Spring samples (March, April and early June) were very similar, while summer and autumn samples were different from earlier samples and also from each other (Fig. 3).

The total benthic community (chironomids and non-chironomids together) showed the same situation when the chironomids were identified to species and ge-

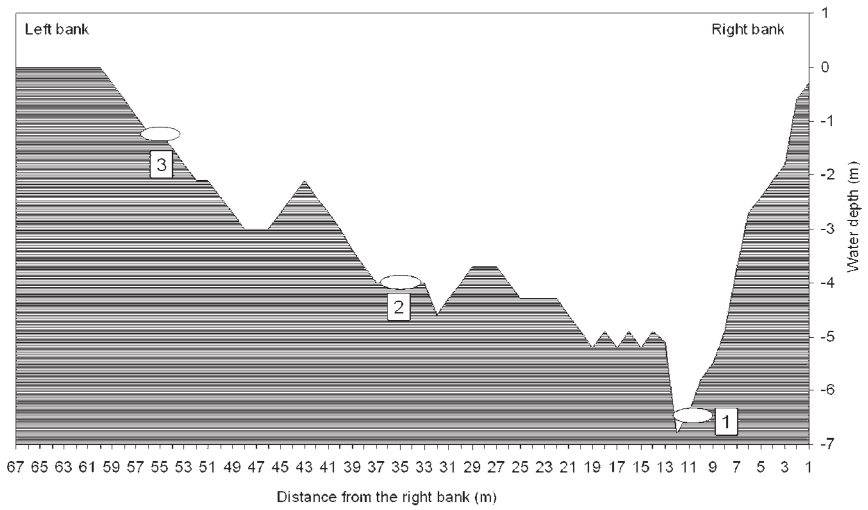

Fig. 1. Cross-section of the Tisza riverbed between Tiszamogyorós and Lónya at low water level. Abbreviations: 1 = main flow (right bank), 2 = mid-bed (at half distance between the right and the left bank), 3 = left bank

Table 1. Results of ANOVA for comparison the sampling sites and dates on the basis of number of individuals of the different taxa, total number of individuals, total number of taxa, species richness (significant (bold) and marginally significant (italics) differences are marked)

	between sampling sites				between sampling dates			
	F	df1	df2	p	F	df1	df2	p
OLIGOCHAETA	1.000	2	15	0.391	1.000	5	12	0.458
MOLLUSCA								
Unio crassus PHILIPSSON, 1788	1.000	2	15	0.391	1.000	5	12	0.458
Lymnaea peregra (MÜLLER, 1774)	5.000	2	15	**0.022**	0.600	5	12	0.701
EPHEMEROPTERA								
Caenis pseudorivulorum KEFFERMÜLLER, 1960	1.000	2	15	0.391	1.000	5	12	0.458
Ametropus fragilis ALBARDA, 1878	1.000	2	15	0.391	1.000	5	12	0.458
ODONATA								
Gomphus flavipes (CHARPENTIER, 1825)	4.519	2	15	**0.029**	0.630	5	12	0.681
TRICHOPTERA								
Hydropsyche contubernalis MCLACHLAN, 1865	1.000	2	15	0.391	1.000	5	12	0.458
Neureclipsis bimaculata (LINNAEUS, 1758)	1.000	2	15	0.391	1.000	5	12	0.458
Oecetis notata (RAMBUR, 1842)	1.000	2	15	0.391	1.000	5	12	0.458
DIPTERA								
Tipulidae	0.691	2	15	0.516	0.537	5	12	0.745
Limoniidae	0.217	2	15	0.807	1.754	5	12	0.197
Ceratopogonidae	0.369	2	15	0.697	5.893	5	12	**0.006**
Chironomidae	2.373	2	15	0.127	4.583	5	12	**0.014**
Procladius sp.	2.500	2	15	0.116	0.800	5	12	0.571
Telopelopia fascigera (VERNEAUX, 1970)	1.000	2	15	0.391	1.000	5	12	0.458
Psectrocladius sp.	1.000	2	15	0.391	1.000	5	12	0.458
Beckidia zabolotzskyi (GOETGHEBUER, 1938)	1.492	2	15	0.256	1.705	5	12	0.208
Chironomus spp.	2.802	2	15	*0.092*	1.034	5	12	0.441
Cladotanytarsus cf. *mancus*	1.000	2	15	0.391	1.000	5	12	0.458
Cryptochironomus sp.	4.370	2	15	**0.032**	0.640	5	12	0.674
Cryptotendipes sp.	1.000	2	15	0.391	1.000	5	12	0.458
Stictochironomus sp.	1.000	2	15	0.391	1.000	5	12	0.458
Harnischia fuscimana KIEFFER, 1921	4.000	2	15	**0.041**	0.667	5	12	0.656
Lipiniella moderata KALUGINA, 1970	6.595	2	15	**0.009**	0.957	5	12	0.481
Paralauterborniella nigrohalteralis (MALLOCH, 1915)	1.000	2	15	0.391	1.000	5	12	0.458

Table 1 (continued)

	between sampling sites				between sampling dates			
	F	df1	df2	p	F	df1	df2	p
Paratendipes KIEFFER, 1911	0.121	2	15	0.887	6.867	5	12	**0.003**
Paratendipes "*connectens*" LIPINA, 1926	0.127	2	15	0.882	3.908	5	12	**0.025**
Paratendipes nubilus (MEIGEN, 1830)	0.296	2	15	0.748	3.520	5	12	**0.034**
Phaenopsectra flavipes (MEIGEN, 1818)	1.000	2	15	0.391	1.000	5	12	0.458
Polypedilum KIEFFER, 1912	5.274	2	15	**0.018**	0.527	5	12	0.752
Polypedilum cultellatum GOETGHEBUER, 1931	0.946	2	15	0.410	2.785	5	12	*0.068*
Polypedilum nubeculosum (MEIGEN, 1804)	1.000	2	15	0.391	1.000	5	12	0.458
Polypedilum scalaeneum-gr.	4.025	2	15	**0.040**	0.665	5	12	0.657
Tanytarsus VAN DER WULP, 1874	2.048	2	15	0.163	0.851	5	12	0.540
Tanytarsus curticornis KIEFFER, 1911	1.000	2	15	0.391	1.000	5	12	0.458
Tanytarsus ejuncidus (WALKER, 1856)	1.000	2	15	0.391	1.000	5	12	0.458
Tanytarsus heusdensis GOETGHEBUER, 1923	1.000	2	15	0.391	1.000	5	12	0.458
Tanytarsus sp.	1.000	2	15	0.391	1.000	5	12	0.458
Total number of individuals	2.451	2	15	0.120	3.686	5	12	**0.030**
Total number of taxa	3.291	2	15	0.065	2.447	5	12	*0.095*
Species richness (Margalef's index)	3.269	2	15	*0.066*	0.983	5	12	0.467
Shannon diversity	0.575	2	15	0.574	2.058	5	12	0.142

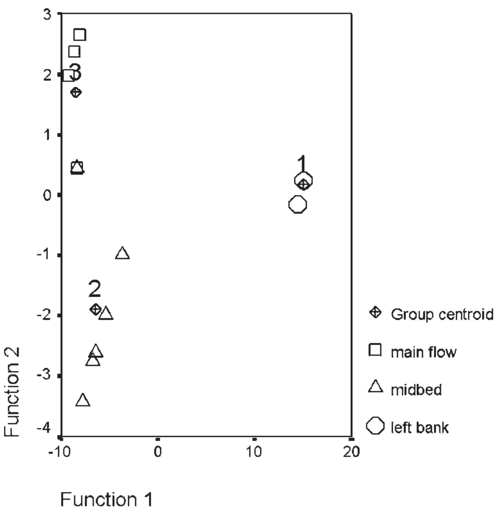

Fig. 2. Classification of sampling sites along the cross-section of River Tisza between Lónya and Tiszamogyorós. All taxa were taken into consideration with chironomids identified to species level. Groups are as follows: 1: left bank, 2: mid-bed, 3. main flow

Table 2. The results of discriminant analyses showing the ratios of correctly grouped cases for sampling sites and dates

	sites %	dates %
total benthic community (with chironomid species)	94.4	83.3
total benthic community (with chironomid genera)	94.4	88.9
total benthic community (with chironomids at family level)	88.9	94.4
chironomid species	72.2	83.3
chironomid genera	72.2	88.9

nus levels (94.4% of original grouped cases were correctly classified). When chironomids were identified only to family level, the differences were less pronounced (88.9% of original grouped cases were correctly classified). While only the chironomids were taken into consideration, the same results were detected with both species and genus levels identification but only 72.2% of original grouped cases were correctly classified (Table 2).

In contrast to spatial distribution, temporal differences could be detected most clearly when the total benthic community was taken into consideration and chironomids were identified only to family level (94.4% of original grouped cases were correctly classified). With identification of chironomids to genus or species level temporal differences were less obvious (88.9% and 83.3% of original

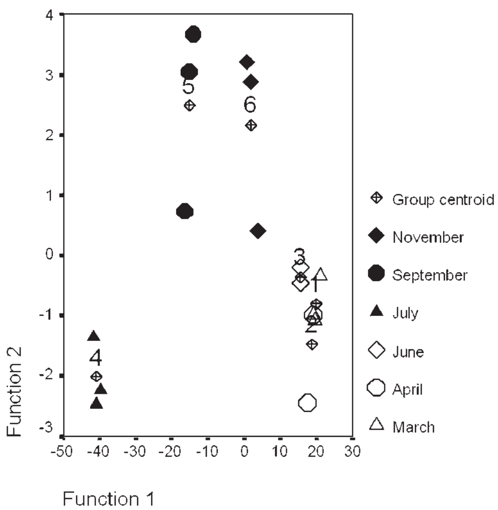

Fig. 3. Classification of samples from the cross-section of River Tisza between Lónya and Tiszamogyorós by dates. All taxa were taken into consideration with chironomids identified to family level. Groups are as follows: 1: March, 2: April, 3: June, 4: July, 5: September, 6: November

grouped cases were correctly classified respectively). On the basis of chironomids the differences were more detectable when the chironomids were identified to genus level than to species level (88.9% and 83.3% of original grouped cases were correctly classified respectively) (Table 2).

DISCUSSION

Habitats near the bank represent special and important places to the macroinvertebrates, respectively it has been shown by the prominently high species richness and number of individuals found there compared with the other parts of the riverbed. It was detected in case of River Tisza (MÓRA *et al*. 2005), and also in case of other European rivers (COGERINO *et al*. 1995, FESL 2002, FRANQUET & PONT 1996). These works also mentioned that family Chironomidae is one of the most important groups in larger lowland rivers.

According to our results spatial differences were most prononunced when all benthic macroinvertebrate groups were taken into consideration and the chironomids were identified to genus or species level. Although many chironomid species were found at all three sampling sites, their spatial distribution showed significant differences which were partly lost when the chironomids were identified only to family level. It should be pointed out that most of the found chironomid genera included only one species, so the number of genera and species were nearly the same. Both chironomid and non-chironomid taxa were found in highest number of species and individuals at close to the left bank, but the results show that the spatial differences are mainly arising from the variations of non-chironomid taxa. Species-level identification of chironomids can be important in the characterization of spatial distribution, but it is no definitely necessary in all cases (MORRIS & BROOKER 1980). In the present study the chironomid community showed only little spatial differences along the cross-section, accordingly they were less useful than total benthic community for characterization of spatial distribution.

The non-chironomid taxa were less important in the characterization of temporal distribution. These taxa could be found mainly during spring, and to a much less extent in the remainder of the year when chironomids were dominant by far. Abundances of chironomids differed between sampling dates, while their species composition did not remarkably vary, resulted in that seasonal differences were more detectable when the chironomids were taken into consideration at family level. However, the same situation was detected on the basis of both total benthic community and chironomids. Although the seasonal distribution can also be recorded by the chironomid community alone, it is enough to identify them to family level when other benthic animal groups are also taken into consideration.

In view of whole benthic macroinvertebrate community, we detected a decrease or an increase of sensitivity of DA when chironomids were identified to different level, while WRIGHT *et al*. (1995) observed similar patterns using univariate (ANOVA) and multivariate (NMDS) techniques at both species and family levels. Our results suggest that a species-level identification of chironomids could be not necessary for routine and rapid bioassessment techniques and protocols, which incorporate them as part of an analysis, e.g., AQEM assessment system (HERING *et al*. 2004), Hierarchical Diversity Index (HDI) analysis (OSBORNE *et al*. 1980), or other techniques in community level biomonitoring (ROSENBERG & RESH 1993). However, if the goal is to explore the exact ecological relationships in a river ecosystem, Chironomidae should anyhow be identified to species level, and elimination of this may cause loss of information (BEAVAN *et al*. 2001, MORRIS & BROOKER 1980). Especially it is more important when chironomids are the dominant organisms both in their abundance and species richness.

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