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Distribution and coenotic composition of benthic testaceans (Protozoa, Rhizopoda) in the abandoned main channel of River Danube at Szigetköz (NW-Hungary)

By

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Abstract. Sediment inhabiting testaceans were examined from five sampling sites in the abandoned main channel of River Danube from the 1845.5th rkm to the 1813th rkm in three subsequent seasons (October 1995, April and August 1996). The main fields of interest were as follows: detecting the faunistic as well as the coenotic composition making qualitative and quantitative experiments and establishing the spatial distribution along the vertical core samples. The faunistic composition was characteristic to the aquatic sediment habitat. The sediment inhabitants were of low abundance, especially the active testaceans. Only 29 of the 70 identified species were seen alive. The mean proportion of the active cells was no more than 8% of the total. The testaceans inhabited the upper some centimeters, the majority was confined to the topmost 1-2 centimeters. Since this layer is being removed during floods, only temporary communities can be observed.

The main channel of River Danube at side river arm system Szigetköz has suffered considerable hydrological changes, which had serious effects on the riverbed. Presumably, the changes have also influenced the protozoan fauna of the sediment, though, due to the lack of former protozoological investigations in the River's sediment till 1995, the only objective of the author remained to detect and follow the changes after the establishment of the bottom sill. This task was made more difficult owing to the sparse amount of literature referring to the benthic protozoans in running waters, with special regard to the really large rivers, like the Danube.

Generally, documentation of sediment inhabiting testaceans is plentyful (eg. PENARD, 1902; SCHÖNBORN, 1965, 1966, 1967; GOLEMANSKY, 1968; LAMINGER, 1971). Hungarian experts have studied the benthic testate amoebae of Lake Balaton (BERECZKY, 1973) and River Tisza (GÁL, 1961, 1970). Numerous studies on the subject have been carried out in the neighbouring countries (STEPANEK, 1967; OPRAVILOVA, 1980, 1993; ZIVKOVIC, 1975). GURVITS and DZJUBAN (1966) observed the microbenthos in the estuaries of Rivers Danube and Dnjeper, concluding that the species compositions in both rivers are fairly similar.

Quantitative researches into the microbenthos have been made by several authors (eg. BALDOCK and SLEIGH, 1988; FOISSNER, 1994; SCHMID-ARAYA, 1994). In general, quantitative investigations have been focused on the microbenthos of standing waters or narrow mountain streams of low water discharge. However, the qualitative and quantitative relations of the benthic testaceans in the lower reaches of a large river's main channel have remained still unknown.

My recent job was to observe the qualitative and quantitative composition of the sediment inhabiting testacean communities in the main channel of River Danube

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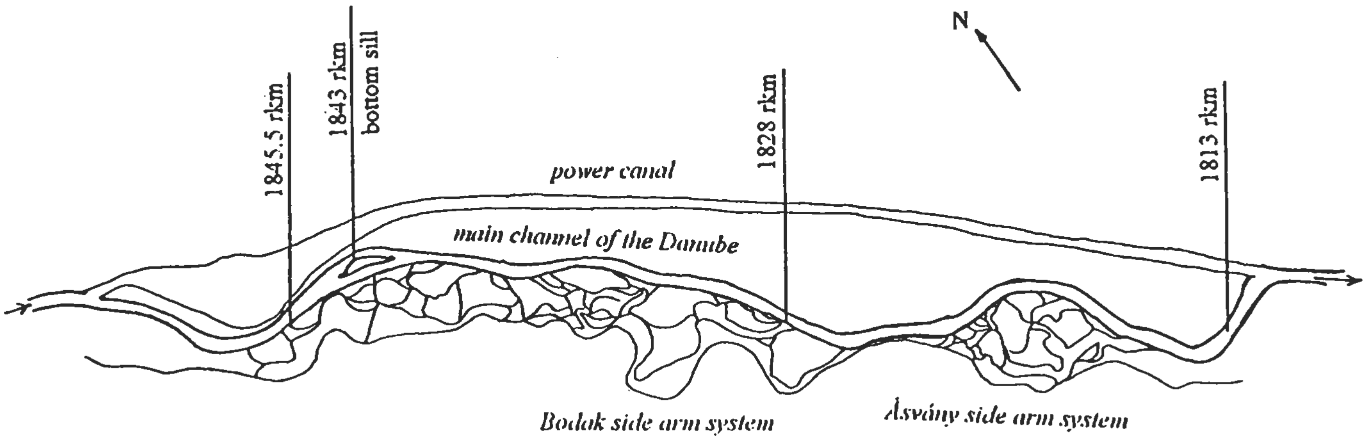

Fig. 1. Location of the sampling sites along the main channel of the Danube in Szigetköz

Table 1. The sampling sites. Upper: Characterization of the sites. Lower: Date of collectings and type of samples. (A_0: water/sediment interface; A,B: sediment layaers below A_0)

	Sampling site	Characteristics of the sampling site	Sediment type	Water depth
I.	1845.5 rkm	right side, directly below the beginning of the supply-channel	fine sand	2.5 m
II.	1843 rkm	right side, from the side of the bottom sill	gravel, sand	0.8 m
III.	1828 rkm "lake "	right side, "lake", isolated from the main channel	black sand	2 m
IV.	1828 rkm main channel	right side, main channel, close to a shallow	partially black, sand and mud	1 m
V.	1813 rkm	natural conditions, right and left sides	sand	1 m

		Date of collection	Type of vertical subsample
1	II	October 1995	no vertical subsamples
2	IV		- " -
3	I	April 1996	A_0, A, B
4	II		A_0, A, B
5	III		A_0
6	IV		A_0, A, B
7	V		A, B
8	I	August 1996	A_0, A, B
9	II		A_0, A, B
10	III		B
11	IV		A_0, A, B
12	V		A_0, A

river kilometers (rkms) 1845.5 and 1813. This section of the Danube was severely affected by the changes, through the dramatic fall of water discharge after the construction of the upstreams nearby beginning power canal of the Bős/Gabcikovo power plant in 1992, moreover, the establishment of the submerged dam at the 1843rd rkm in 1995 resulted in further decrease. There had been no information about the quality of the sediment in the area, whether it was suitable for the testate amoebae to inhabit it. Also the vertical and seasonal distribution of the testaceans were of great interest. Having all of these data may contribute to understand how the microbenthic fauna makes up after the significant hydrological changes. The present study introduces the results of the first three samplings.

Materials and methods

During the choice of the sampling areas the most important point of view was to follow the dynamics of the qualitative and quantitative changes in the testacean fauna.

In October 1995 preliminary study was carried out in order to mark out the proper sampling sites. Two of these sites proved to be suitable for further investigations, therefore the collected data are already involved in the article. Sampling took place at five different areas, for topological view see Fig. 1. The characteristics of the sites and the samples are given in Table 1.

Width of the main channel of the Danube between rkms 1846 and 1813 streches to 100-200 meters, respectively. Most parts of this river section represent the Hungarian-Slovakian border. Until 1992 mean water discharge fluctuated between 2000-3000 m^3/sec. The present mean water discharge is no more than 200-300 m^3/sec. In recent years explosive increase in the waterdischarge happened irregularly, resulting in a flood caused by the human regulation of the waterlevel of the power canal in the Slovakian side. In the latter case high waters of 1000-2000 m^3/sec maximum discharge flowed across the main channel, in order to exempt the power canal of the Bős/Gabcikovo power-plant (RÁKÓCZI, SASS, 1995). The main channel of the Danube at the investigated section was free from macrovegetation.

The first sampling site was situated at rkm 1845.5 right side of the river, just downstream to the beginning of the water recharge channel - opened by an artificial break through in 1993 - which supplies the side arm system with water since closing the main channel with the Dunacsún river barrage in 1992. The current velocity was relatively high, the bank was steep, the sediment probes were obtained from the crevices at about 0.8 m depth among the large stones supporting the bank. The second site was at rkm 1843, directly above the submerged dam, where the current velocity was significantly diminished by the latter. (The submerged dam was constructed in 1995 to increase the water discharge in the side arm system, which resulted in even less water in the main channel downstreams.) The current velocity in the 15 m region near to the right bank was quite low, the bottom was covered in sandy and to a lesser extent gravel sediment, generally exceeding 20 cm thickness. The bank was gently sloping towards the water. The next place was located at the 1828 rkm, comprising rather diverse conditions. Formerly the Kisbodak side branch flowed into the main channel at this point, but the mouth was closed in 1992. Three spur dikes were situated at the right bank, which caused the increased sedimentation among them especially after the fall of the water discharge. The final result was a small "lake" between two of the spur dikes having about 500 m^2 area, which became totally separated from the main channel by the large scale sediment deposition. This was the third sampling site. The lake had lost all connections with the main channel apart from the great floods, therefore the sediment made up from sand and mud became

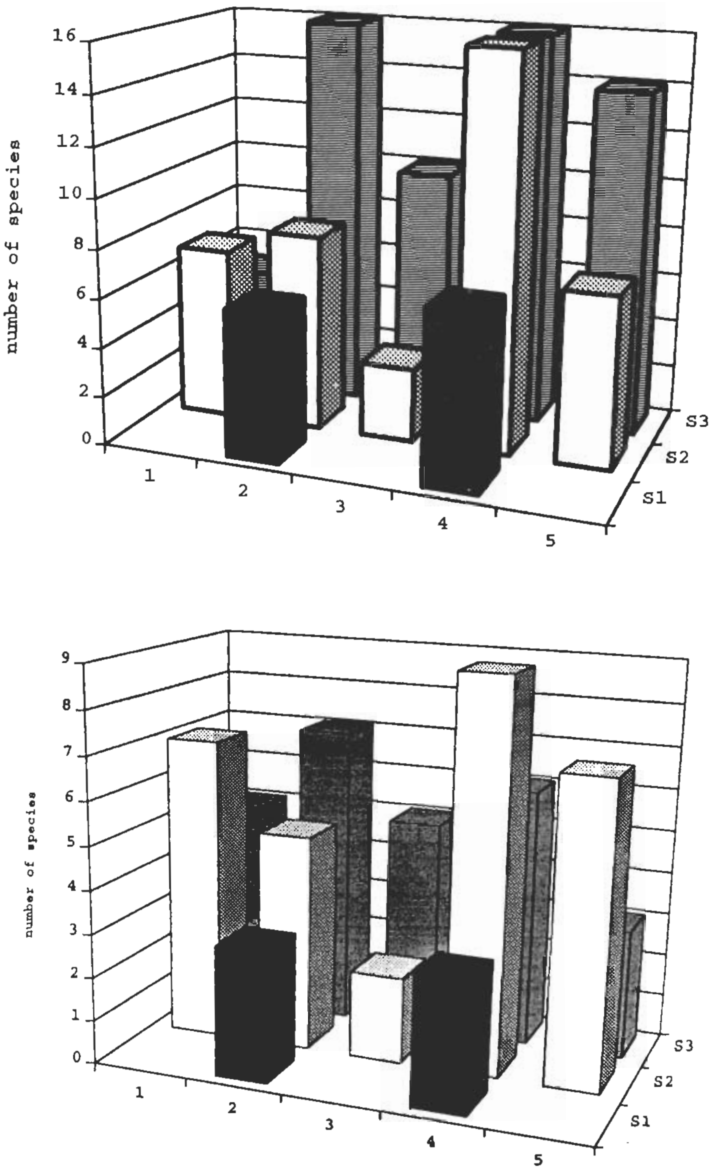

Fig. 2. Distribution of a) *Difflugia* spp., b) *Centropyxis* spp. according to the location and the date of sampling. (S_1, S_2 and S_3 correspond to the sampling times in October, April and August)

strongly anoxic if compared to the main channels sediment. The riverbed of the main channel has shrunk to almost half of the original (before 1992). Recently the originally coarse gravel bottom is being covered by muddy sediment along the right side. The fourth sample site was located here. The fifth site at the 1813rd rkm near the Ásvány branch comprised a so called "living" part of the main channel. This region had a higher waterlevel and discharge due to the reimpoundment caused by the vicinity of the outlet of the power canal, as well as upstreams the mouth of the Ásványi side branch meeting the main channel.

The samples were taken from the first four sites near the right side by snorkelling (for water depths see Table 1). At the last site, 1813 rkm, we used a boat to obtain samples, since otherwise we could not get to the area, furthermore the discharge and current velocity were too high. By means of this boat it was possible to take samples from a cross-section at the selected point.

A core-sampler modified after KAJAK was used to take samples. This equipment consisted of a 20x3.8 cm plastic tube which was inserted into a metall sampler. When taking samples from the boat, a long metallic rod of necessary length was fixed to the sampler. Afterwards the tubes were put into a cold chamber. In the laboratory the contens of the plastic tubes was cut into several vertical layers in order to establish the vertical distribution of the testaceans in the sediment. The thin 1-2 mm layer of the water/sediment interface (A_0) containing mainly detritus was pipetted from above. The rest of the sediment was separated letting out the sediment downwards, and getting the desired fractions, which were as follows (started from above): a 1-2 cm layer directly below the A_0 layer (called A), below 1-3 cm B layer, and the rest C layer. One part of the samples was observed alive, the other was fixed and stained after BERECZKY (1985).

The microscopic examination was carried out by direct observation and counting. This method seemed to be the most reliable. Other authors used dilution procedures at quantitative examination (FOISSNER, 1994; SCHMID-ARAYA, 1994). In the present study we assumed that dilution methods would serve misleading results on account of the extremely low abundance of specimens in the sediment.

Dominance and costancy values were calculated for each sampling series, the latter were clustered on the basis of the detected testacean species using the NCLAS program (PODANI, SYN-TAX, 1988; clustering method: simple average, distance function: Jaccard-formula), the result was represented on a dendrogram. Diversity of the sites was calculated using the Shannon-Weawer function.

Results

The metazoan fauna in the samples was made up of a low number of chironomid larvae, amphipods, rotifers, nematodes, tardigrades and bryozoan sporoblasts. The protozoan fauna consisted of flagellates, amoebae, testaceans, heliozoans and ciliates. Altogether 70 testacean species were identified (Table 2). First records in the Hungarian fauna were as follows: *Difflugia achlora*, *D. bicornis*, *D. bicruris*, *D. gassowskyi*, *D. minuta*, *D. urceolata olla* (Fig. 3). Majority of the species are considered to be aquatic, many of them consisting of xenosomes (eg. *Difflugia* and *Pontigulasia* spp.). The most numerous genus was *Difflugia* with 34 taxa, the following was *Centropyxis* with 12 ones. The distribution of *Difflugia* and *Centropyxis* species on the different sampling sites and periods are described in Fig. 2. 17 species occurred merely at one site, 14 of them were represented with only 1 specimen, two species were first records in the Hungarian fauna.

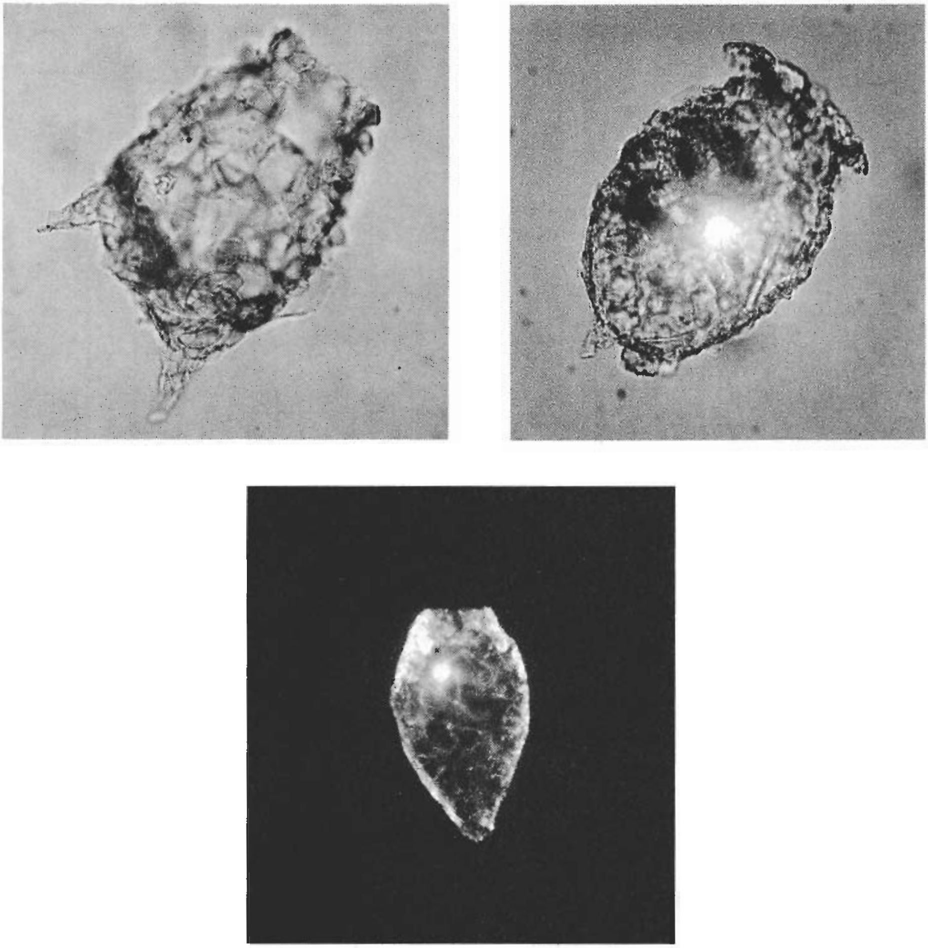

Fig. 3. a) *Difflugia bicornis* PENARD, first record in Hungary, b) *Difflugia urceolata olla* PENARD, first record in Hungary, c) *Difflugia mammillaris* PENARD, a fairly frequent species

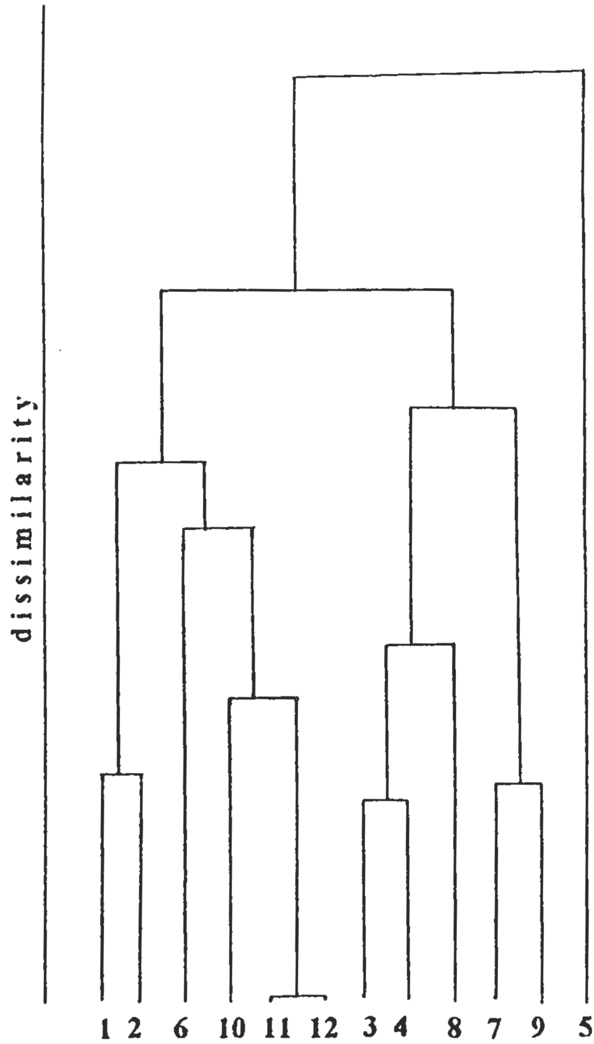

Fig. 4. Similarity of the units of the sample series on the basis of the faunistic composition

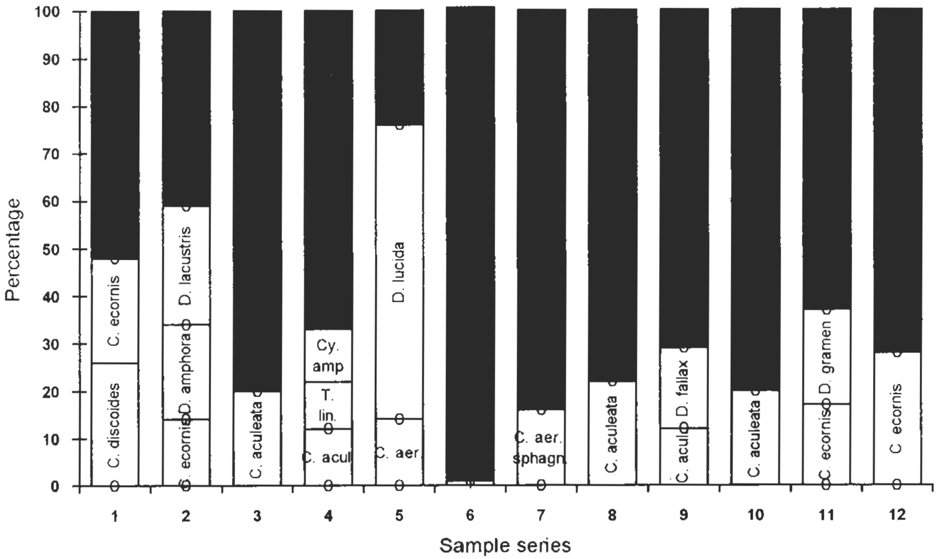

Fig. 5. Dominant species in the sample series

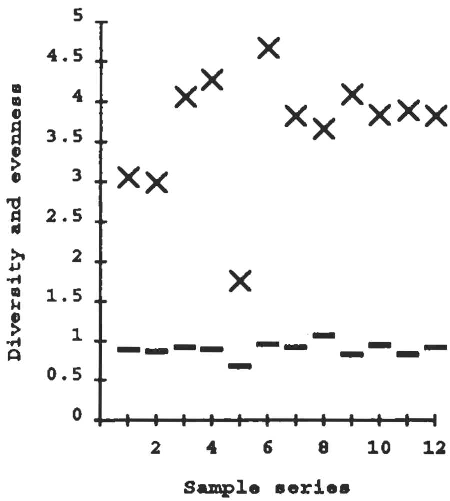

Fig. 6. Diversity and evenness values in the sample series

Fig. 4 shows the dendrogram of the sampling sites calculated on the basis of the resident testacean population.

Euconstant species present in at least 10 of the 12 sample series were as follows: *Centropyxis aculeata*, *C. discoides*, *C. ecornis*. Constant species, occurring at minimum 7 sites were *Arcella hemisphaerica*, *Difflugia amphora*, *D. elegans*, *D. mammilaris*. Distribution of dominant species - those comprising at least 10% of a community - are displayed on Fig. 5. *Centropyxis ecornis* and *C. aculeata* proved to be dominant in four sample series. The bulk of species of high dominance value were members of the genera *Difflugia* and *Centropyxis*. Numbers of dominant species per sample series fluctuated between 1 and 3. Fig. 6 shows the diversity and evenness values given for each sample series.

Proportion of active cells to empty shells was extremely low. All in all 29 species of the total 70 were observed alive, the living individuals made up only 8% of the total abundance. Occurrence of cysts was sparse. The three sample series, taken in autumn, spring and summer were slightly different regarding the presence of active cells: the number of species represented with living specimens was 18 in summer, 11 in autumn and 10 in spring.

The A_0 and A vertical layers were the richest regarding the number of active cells. The B layers were poorly inhabited, although empty shells were accumulated there in a large number. As a whole, A_0 and A layers provided the 77 % of the active cells, while the B only 23 % . The C layers did not contain any living specimens and the occurrence of empty shells was scattered.

Discussion

The species composition agrees well with those found by other authors. Majority of the species have already been found in other inland waters, such as Balaton and Tisza (BERECZKY 1973, GÁL, 1961). The numbers of species at the different sites were not really high: the mean number was 19, whereas STEPANEK (1967) found on the average 36 species in one sample site in the Vranov storage lake.

The detected Testacea fauna was unanimously aquatic. On the contrary, the composition of testacean fauna found by FOISSNER (1994) in Bavarian streams was similar in many features to that of wet mosses or soils. In case of the Danube there was no remarkable communication between the aquatic and terrestrial testacean fauna.

The sampling took place close to the river bank, where sediment deposition happened on the surface of the river gravel. The quality of the sediment was sandy or muddy. The present bank comprised a former part of the waterbed, the previous littoral zone being totally above the waterlevel today. The main channel of the Danube, as a wide river of great discharge and high current velocity, cannot be characterized by intensive sediment deposition as a rule. However, along the investigated length considerable sediment layer has formed. This phenomenon was a result of the decreased discharge, causing lower waterlevel, latter resulting in the loss of connections with the side arm system (RÁKÓCZI & SASS, 1995, 1997). The sediment load increased, in the vicinity of the bank in a 1 - 2.5 meters deep water more 10 cm thick sediment layer could be found. Where the streamline lied close to one of the banks, the reduced velocity on the other side forced the river to deposit its load forming shallows (eg. rkm 1828). These areas were rather of pool than riffle types. Only the streamline region preserved its original character, with the coarse gravel on the bottom, therefore core samples could not have been taken from that area (rkm 1813). Consequently, proper conditions were given to the testaceans to colonize the benthos in the investigated region.

Table 2. List of species in the different sample series. (1: one specimen only; 2: 1-3 individuals; 3: 4-9 individuals; 4: 10-20 individuals; 5: more than 20 individuals)

Species	1	2	3	4	5	6	7	8	9	10	11	12
Arcella discoides Ehr.								1				
A. excavata Cunningham								1				
A. hemisphaerica Perty			3	2		2	2	3	2	2		
A. vulgaris Ehr.			2									
Centropyxis aculeata Penard		2	3	3	3	3	3	4	3	3	4	3
C. aculeata oblonga Deflandre				2	2	3					3	
C. aërophila Deflandre			4	3	3			3		2	4	
C. aërophila sphagnicola Defl.			2	2		3	3	2	2			
C. constricta Deflandre						2	3	3	2		2	
C. discoides Deflandre	3	2		2		2	2		2	2	3	3
C. ecornis Leidy	3	3	3	2		2	2	2	2	2	3	3
C. elongata (Pen.) Thomas			1					2		2		
C. gibba Deflandre						2						
C. marsupiformis Deflandre	2					2						
C. orbicularis Deflandre							2	2				
C. platystoma (Pen.) Deflandre				2		3						
Cyclopyxis sp.					2			2				
C. arcelloides Deflandre			2	2			2					
Plagiopyxis intermedia Bonnet			2	2								
P. declivis Penard			3	2			2	3				
Difflugia achlora Ogden						2		2		2		
D. acuminata Ehr.											2	2
D. amphora Leidy	2	4		2	2	2					2	2
D. avellana Penard							2				2	2
D. bicornis Penard	2							2			3	2
D. bicruris Gauthier-L. & Thomas								1				
D. bryophila (Pen.) Jung							1					
D. corona Wallich	2	2				2				2	3	2
D. curvicaulis Penard	2	2				2		3			2	
D. curvicaulis inflata Decloitre							2			2	2	3
D. distenda Ogden	2		2					2	2	2		2
D. elegans Penard		2	2	2		2		3		2	3	2
D. elegans teres Penard								2			2	
D. fallax Penard			3					4				
D. gassowskyi Ogden		2				2	2					
D. gramen Penard				2		3		3			5	
D. lacustris Penard		2				2						2
D. lebes Penard						2				2	2	2
D. lemani Blanc							2		2		2	2
D. limnetica Levander						2				2	2	
D. linearis Gauthier-L.&Thomas										1		
D. lobostoma Leidy			2							2		2
D. lucida Penard					5			2				
D. mammillaris Penard			2	2		2	2	2	2		3	
D. manicata Penard						2			2			
D. microclaviformis Kourov						1						
D. oblonga Ehr.				2				2		2	2	
D. pristis Penard			2	2				2	2			
D. pulex Penard			1									
D. rubescens Penard								1				
D. scalpellum Penard							2	2			2	2
D. urceolata Carter	2	3	2			2						
D. urceolata olla Penard						2						2
Pontigulasia bigibbosa Penard		2									2	2
P. spectabilis Penard						2	2			2	3	
D. minuta Rampi				2	2	2		2				
Lesquereusia modesta Rhumbler											1	
Netzelia oviformis (Cash)						1						
Nebela dentistoma Penard			2					2				
N. retorta (Leidy) Stepánek				1								
Schoenbornia viscicula (Schönborn)			2									
Euglypha acanthophora Perty			3			2		2				
E. laevis Ehr.			2	2								
E. rotunda Wailes			1									
Trinema enchelys Leidy	2		2									
T. lineare Penard			4	2		2						
Cyphoderia ampulla Leidy	2		4	2				3				
C. laevis Penard			3									
Paulinella chromathophora Lauterborn			1									
Pseudodifflugia sp.								1				

that area (rkm 1813). Consequently, proper conditions were given to the testaceans to colonize the benthos in the investigated region.

There were several surveys referring to the distribution pattern of the benthic microfauna, including testaceans both in standing and running waters, nevertheless there was no literature about any running water of Danube size. BRETSCHKO (1991) demonstrated, that the river zoobenthos is not confined to the water/sediment interface exclusively, but also penetrates into the sediment, unless the low oxigen level or the lack of interstitial space obstructs it. Bretschko`s examinations showed out that 95 % of the zoobenthos in a second order alpine gravel stream was distributed in the upper 40 cm of the sediment. SCHMID-ARAYA (1994), investigating the same stream, involved also the testate amoebae, concluding that in riffle type areas about 50 specimens were detected in the topmost 5 cm layer, 120 specimens by 25 cm depth, and 240 specimens by 40 cm depth per 1 litre sediment. Much reduced occurrence was detected in the pool type areas. The Danube served with much contrasting evidences. Its sediment was rather sandy, sometimes muddy throughout the investigated area. The interstitial spaces got plugged by the fine sediment particles and the colmatation prevented the testaceans from penetrating the lower sediment layers below 1-2 cm from the surface. Moreover, some of the cores were almost black in appearence, suggesting the inside prevailing low oxigen level, which is not tolerable for testate amoebae.

The dendrogram, describing the similarity of the sampling series does not allow to make clear conclusions. The sampling series taken in October and August, appeared to be closer to each other than the April series. Latter can be explained by the sudden high water supply let into the main channel in that month. The vertical distribution of testaceans in our sampling series was restricted to the topmost 4 centimeters. However, the floods occurring regularly in the Danube mobilize the upper sediment layers, removing almost the whole community from the original habitat. The new community must form from the beginning. Two hypotheses may be set up for the recolonization. On one hand, the Testacea fauna can regenerate after each flood from individuals which were not carried along, but remained in refugia, like crevices of large stones etc. This way was not supported by the results shown on the dendrogram, because in most cases no remarkable resemblance existed among the 2-3 samples on the same sites. On the other hand, active testaceans may arrive from the upstreams removed sediment, which settle down together with the sediment particles.

The diversity values calculated for each sampling series were quite high, fluctuating around 3 and 4. The only exception was estimated in one of the the "lake" samples (no. 5), which was a really particular habitat, due to the total isolation from the main channel and the dominating low oxygen level. Regarding the rest of the matter, the diversity values were of the same order of magnitude, like those measured by OPRAVILOVA (1983) in the sediment of River Jihlava. Since the numbers of individuals in the Danube were rather restricted, the calculated values are a bit high, comparing to the reflected relations.

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