Protozoological investigations in the side-arm system Szigetköz of the River Danube (1991—1992)

By

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Abstract. The development of heterotroph Protozoa communities was investigated for two years in the greatest Hungarian side-arm system of the Danube. The aim of the investigations were to establish the species composition, the abundance relation, the feeding spectrum, and the saprobity conditions of the planktonic Protozoa communities in five different biotops within the side arm system. Water exchange and current velocity depends on the water level fluctuations in the main arm. The species composition was diversified and rich. With the recessing water level they become more and more unique with characteristic species appearing. The feeding spectrums reflect the changes in food resources due to the changes in light, temperature, dissolved oxygen conditions caused by the water regime alterations. Between the feeding groups and saprobity groups several significant correlations have been found.

Few studies have yet been published of those Protozoa which live in larger or smaller side-branches, side-branch systems along a large or small river. Our knowledge of them are poor not only in cenological or ecological sense, but also in faunistic one. We have previous data from some side-branches of the Danube (BERECZKY & GULYÁS, 1985, BERECZKY, 1991), but we began to perform systematic multipurpose investigation in the branch system of Szigetköz in 1989. The very first task was to reveal the Ciliata community of one of the branch systems of Szigetköz undisturbed so far.

This area of 300 km^2 of these part of the Danube, which owed its hydrological conditions to the river control of the end of the preceding century. This side-arm system consists of five subsystems with arms of different length and width. These are partly separated from each other and from the main arm by cross barriages of different crest height, so the flow regime, water exchange and current velocity depends on the water level fluctuations in the main arm. From the middle of the sixties modernization took place, a number of new dams, diverting and lifting systems were built. As the result of these regularizations the side-branches, side-branch systems got into touch with the main branch only at a waterstand above the average at 440 cm (measured at Dunaremete 1824 riv. km), discharge 2800 m^3/sec. The actuality of the task was given by the building operations of a reservoir at Dunakiliti (1842 riv. km) and an hydro-electric power-plant at Bős/Gabčikovo (1819 riv. km)

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in the main branch of the Danube. Results of the investigations of several years prove the adaptibility of heterotroph Protozoa to the seasonal changes of climatic zones similarly to higher organisms. This is the reason why we can evaluate as aspect changing the seasonal arrangements of Ciliata communities emerging one after the other.

The composition of the protozoan fauna that lives in the main branch of River Danube significantly differs two times yearly not only with respect to species but in changing their density. They reach the maximum of the individual number of their water occurrence in spring and autumn, generally in May and at the end of October, sometimes at the beginning of November. Several ecological factors, eg. water regime or alteration of nutrition basis can modify the time of changes of the aspect. Hundreds of data prove that a developing Protozoa community truly reflects the actual biological waterquality.

As it is well-known, the rate of the decomposition of organic matters is faster in summer than in winter, therefore in summer the mesosaprobic character, but in winter the alfamesosaprobic one is dominant. With full knowledge of the precedings we think our aim was realistic, namely to gather sample series in a given time and to get informations about the emergence of the protozoan community and about the actual waterquality after examining these sample-series.

In this paper we report on the results of our two years' investigations, carried out just before when the water of the main branch of the Danube was turn to Slovakia.

Material and method

In 1991 and 1992 samples were taken seasonally according to the characteristic water regime changes (at raising and/or recessing water levels) filtering 20—100 l water through a net of 10—20 μm mesh size. Protozoological analysis was carried out from the filtrate, partly under living and partly under fixed conditions by protargol impregnation modified by Wilbert (1974) and by the staining method by Bereczky (1985) for counting. Simultaneously with planktonic samplings we carried out chemical measurings on the spot by the instrument model " 6D in situ Water Quality Analizer (Surveyor) Type II". We measured WT, pH, DO, COND and ORP (Tab. 1). The biomass (biovolumen) of species (if unknown yet) were calculated by the Simpson-formula. Minimum, maximum and averages of species numbers and individual numbers can be found in Table 2, 3.

The nutrition quality was analized by "in situ food vacuola content" method (Schönborn, 1981). We distinguished algaevorous, alga-bacteriovorous, bacteriovorous, omnivorous, carnivorous and detritusvorous species. Their percent abundance is shown by pie-diagram on the basis of evaluating different samples. Enlisting the saprobionts we took for a basis Foissener's (1988) modifications and the results of our own. The number of the collected samples was 108.

Description of the study sites

We fixed our choice on the branch-system of Cikolasziget, the greatest branch-system of the upper reach of the Danube, because the smaller or larger waterbodies of the area are of various evolution and also their morphology and watersupply differs. In Cikolasziget branch system which is composed of the most branches consists of 18 smaller units of different siltation stages. We investigated such units which were separated from the main branch to a different extent, seasonally. These units were as follows :

1. Csákány branch, through which the direct watersupply gets into the system.
2. Forrásos branch. It is in the earliest stage of detachment. Topographically it is the nearest to the main branch.
3. Schisler backwater. Connection develops with the main branch only at extraordinary high waterstands.
4. Disznós branch. The farthest side branch with the greatest level fluctuation. We collected samples from different sites in every side branches. These sites are marked in Fig. 1.

Result and conclusions

The aim of our investigation was to track the Ciliata community which developed in consequence of the disjunction from the main branch to get to know the community forming species, their density and feeding structure. We followed with attention the seasonal aspect-changes considering the changes of saprobity relations.

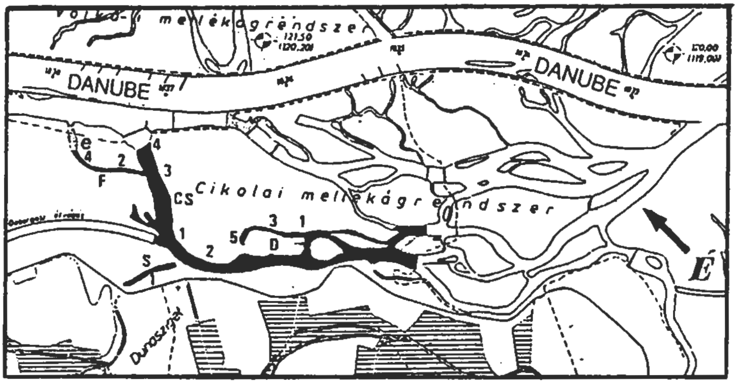
From our material (1991, 1992) collected from the four side branches we identified 193 Ciliata species. In 1967 a book was published titled Limnologie der Donau. In this book DUDICH gave a list of Protozoa found up to that time in nine countries. Their number from head to mouth was less than 250. From 1965 to 1995 we have found nearly 700 planktonic and sedentary protozoan species from the main arm of the Hungarian Danube section (417 riv.km long).

Table 1. Minimum and maximum and mean values of water temperatures and water chemistry parameters

Date		WT loc.	WT val.	pH loc.	pH val.	DO loc.	DO val.	COND loc.	COND val.	ORP loc.	ORP val.
1991											
JUNE	Min.	c5/4	11.4	c2/5	6.2	c5/4	6.6	c1/6	352	c5/2	254
	Max.	c1/6	18.2	c1/6	7.9	c2/1	15.3	c2/5	598	c2/5	355
	Mean		15.3		7.2		10.6		461		302
JULY	Min.	c5/4	17.3	c1/6	6.9	c1/7	7.0	cs/4	331	c5/4	208
	Max.	c2/3	22.4	c2/5	8.0	c2/5	17.5	c2/5	403	cs/4	306
	Mean		20.8		7.5		9.4		355		261
OCT.	Min.	c1/6	15.6	c1/6	6.6	c1/7	7.1	c1/6	385	cs/2	263
	Max.	cs/2	16.2	cs/1	7.7	cs/1	11.0	cs/1	482	c1/6	356
	Mean		15.9		7.3		9.3		449		300
1992											
JUNE	Min.	c5/2	15.6	c1/10	7.1	m/6	4.6	cs/3	307	cs/3	108
	Max.	c1/10	19.6	cs/3	7.5	cs/3	9.6	c5/4	422	c2/5	225
	Mean		17.6		7.2		6.7		337		173
AUG.	Min.	c5/4	17.1	m/6	6.9	m/1	2.4	c1/1	311	m/6	-83
	Max.	c1/10	30.8	c1/1	7.6	c2/3	9.4	m/4	651	cs/3	274
	Mean		26.3		7.6		8.1		376		137
OCT.	Min.	c1/10	9.0	m/6	6.9	m/6	6.3	m/6	172	c1/5	217
	Max.	cs/2	12.8	cs/2	7.7	cs/3	11.4	cs/3	451	m/4	578
	Mean		11.2		7.3		8.8		366		331

loc.= location, val.= values

In these sampling sites we have found some new taxa for the Hungarian Ciliata fauna, these: *Paradileptus caducus* KAHL, *Holosticha naviculatum* KAHL, *Prorodon nucleolatus* PENARD, *Coleps trichotus* SAVI, *Spathidioides excavata* KAHL, *Acaryophrya collaris* (KAHL), *Halteria chlorelligera* (KAHL), *Plagiopyla nasuta* STEIN, *Monodinium balbiani* v. *nanum* KAHL and *Monodinium balbiani* v. *rostratum* KAHL. (The complete fauna list of the collected materials can be found in the databasis of the Hungarian Danube Research Station.)



F=Forrásos arm Cs=Csákányi arm S=Schisler arm D=Disznós arm

1, 2, 3, 4, 5, e = sampling sites

Fig. 1. Locations and marks of study sites (riv. km 1834—1838)

While in 1991 we found the Cikola branch system totally disconnected only in autumn (Fig. 1), in 1992, just after the sampling, water supply ceased in June, later on when the so called "C"- variant was finished, when water was conducted from the main branch to a side-channel, then not only the side-branch but also the main one remained badly watered (Fig. 2). On the occasion of the flood in November feed water got into the side-branch not through the overflow weirs, but by seepage, because connection can be effected through the Csákányi branch only at 440 cm waterstand.

The Csákányi branch even with such watersupply is similar to the main branch. Mainly algaevorous species dominate in 1991 and similarly to recent years in the quantitative conditions mosaic arrangement is characteristic. In 1992, however, as a result of the changed circumstances the bacterivorous species dominated.

The Forrásos old branch receives its feedwater from Csákányi branch. Topographically it is the nearest to the main branch. The Ciliata plankton found here is poorish in every aspect. Though in spring (1991) we could identify 30 species, their abundance comparing those can be found also in other biotops is smaller. Simultaneously remarkably much Flagellata could be observed and we found also cysts and *Vorticella* in telotroche state very often. In the second years of our investigations changes were drastical also here. Now the bacterivorous, now the algaevorous, but by autumn the omnivorous species became numerous (Fig. 4, 5).

Disznós branch has three sampling sites, where the quality and quantity of Protozoa shows differences in June. On the so called C2/5-field both the species and the individual number shows the decrease of community (Table 2). Of the hydrochemical parameters also pH and dissolved oxygen are different from that of the two other sites. pH (6.2) was remarkably low as compared to the usual values

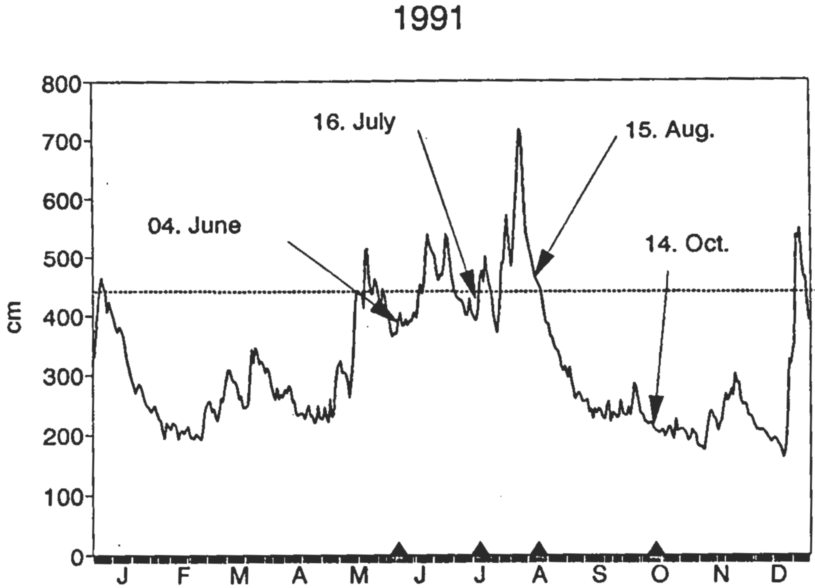


Fig. 2. Water level and time of sampling (1991)

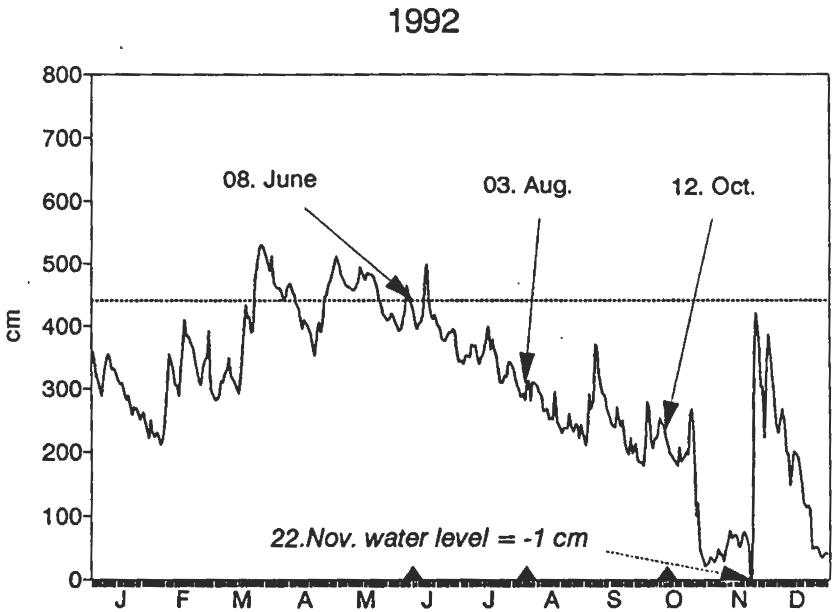


Fig. 3. Water level and time of sampling (1992)

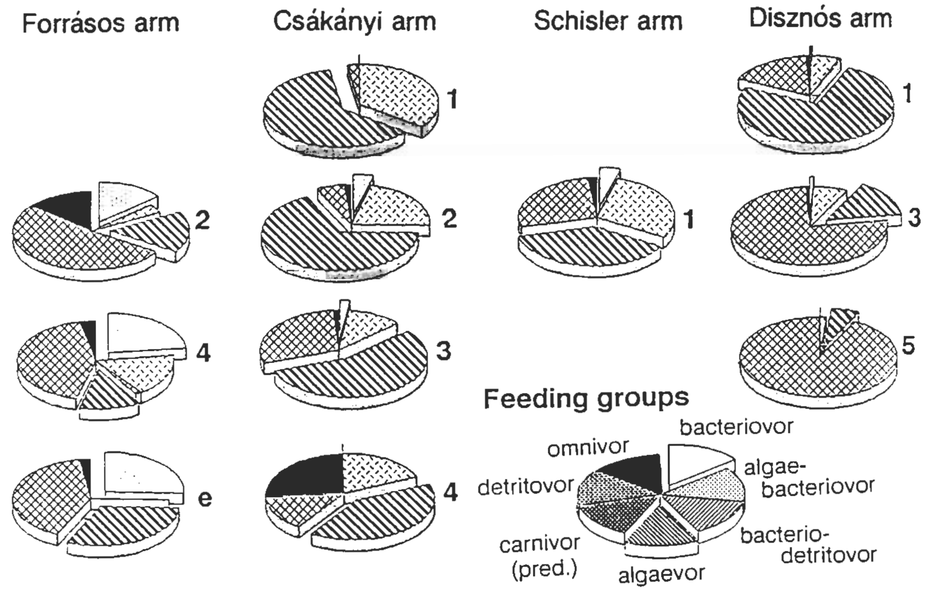


Fig. 4. Changes in feeding spectrum of Ciliata communities based on percental abundance (04. 06. 1991)

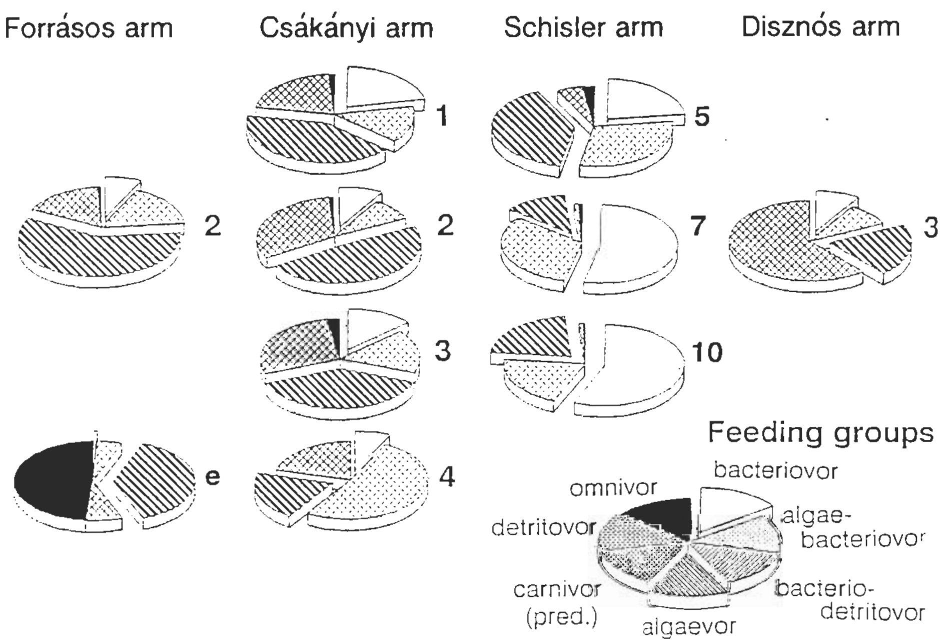


Fig. 5. Changes of feeding spectrum (12. 10. 1992)

of the Danube. On sampling sites C2/1 and C2/3 we found a Ciliata community which was more abundant in comparison with the main branch. The dominance of predators was unequivocal. By October we could not find such abundant, variegated taxocoenozis which was characteristic to this biotop in 1991 spring. In 1992 community showed a varying face. In autumn there were nearly no water in the waterbed and again predator species were characteristic.

Table 2. Minimum, maximum values of species and individual numbers of Ciliate

1991						1992					
Date		**Species number**		**Individuals number**		**Date**		**Species number**		**Individuals number**	
		loc.	**val.**	**loc.**	**val.**			**loc.**	**val.**	**loc.**	**val.**
JUNE	**Min.**	cs/1	15	c5/2	148	**JUNE**	**Min.**	m/1	7	m/1	42
	Max.	c1/6	39	c2/1	2406		**Max.**	c1/1	37	c5/4	2896
JULY	**Min.**	c1/7	9	c5/2	210	**AUG.**	**Min.**	c5/e	8	c5/e	66
	Max.	c2/3	36	c1/7	2379		**Max.**	cs/1	39	c5/2	4744
OCT.	**Min.**	c5/e	11	c5/e	480	**OCT.**	**Min.**	c2/3	6	cs/4	480
	Max.	c1/6	33	c1/6	1988		**Max.**	m/6	29	c2/5	2296

loc.= location, val.= values

Schisler as a waterbody differs from other biotops not only topographically, but considering its Protozoa community, too. In the period of our investigations we found a taxocoenozis of the greatest diversity (39 species) and one of the greatest individual number (2439.10^3 ind/m^3) here. In June (1991) the Ciliata community of rich individual number, though only of 9 species, was characteristic to the open water. An absolutely dominant species, the predatory *Prorodon viridis* (882.10^3 ind/m^3) dominated a third of the community. In October it was characterized by a rich, variegated aspect with the dominance of carnivorous and microalgaevorous species. Last year we investigated the planktonic samples of 3 sites of Schisler. The Ciliata coenozis which in spring was of relatively balanced nutrition type, in August and October was stocked by predators and bacterivorous species of alternativ dominance.

Investigating the different biotops of the Cikola branch system we found that the planktonic Protozoa community was very protean and abundant. There were characteristic species in the biotops (e.g. *Prorodon viridis* in Schisler branch or *Acaryophrya* sp. in Forrásos branch), but at the same time they were characterized as units by the predator *Coleps* community, by the species of the really planktonic *Strobilidium, Strombidium, Tintinnidium* genus. The favourable conditions, the good oxygen supply, the appropriate food supply implies a rich community. Those species which get in from the main branch multiply when it is rising, so they make the rich Protozoa coenozis more variegated.

On different nutrition bases develop different communities and knowing their composition biotops can be characterized, mainly when they are totally separated from the main branch. The presence of Ciliata in the biotops of the side-branches was always determined by nutrition. They can tolerate the modification of other environmental factors rather than the change of nutritive conditions. Density may change on the effect of such factors like temperature or any other limiting factor in the menu. In the Danube the main source are diatomas, but it may be completed with bacteria due to the seasonal change in winter.

It is proved by results, that in rivers the rate of decomposition is four times so great than in lakes (SCHÖNBORN, 1992). So it was not entirely without interest to examine how this process is carried on in the Cikola branch system, which becomes practically a lake, later on a puddle, while at the end it dries up. The rate of elimination of organic matters can be determined mostly by chemical measuring, but we can get informations about the changes by the species/individual ratio number of KÖHLER (1982). We believe that a Protozoa community of high density and rich in species is apt to demonstrate this proportion by itself. Proportion supposes that the little species number together with a high individual number refers to a high organic matter content, while a great species number and a low individual number relates to a low one.

With the exception of Forrásos branch the increase of organic matter content can be showed at every site. It is the less characteristic to the Csákányi branch, but is the most expressive for the Disznós branch. The lake character of the Schisler could be seen in recent years already and we could draw a curve, which is characteristic to lakes and is in accordance with seasonal rythms. As we formentioned, the proportion values of the Forrásos branch are different than the values of all other sites of investigation and they demonstrate the uniqueness in October, while its condition in spring and summer is the same as that of the others (BERECZKY & NOSEK, 1994).

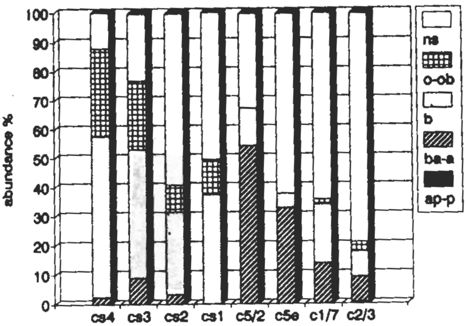
Relations show that changes in a Protozoa community reflects the environmental conditions and indicate that saprobity increases while watersupply decreases and organic matters, which are able to decompose, accumulate. This is an undesirable phenomenon from the view of valuing the quality of surface waters, mainly if they would serve as a drinking-water base later on. A typical state of saprobity in spring and typical one in autumn is shown in Fig. 6—7.

We evaluated biomass simultaneously with the examinations of food spectra on every occasion. We should like only to mention, that e.g. while in 1991, in the Disznós branch maximum value hardly exceeded the 2 mg/m^3 value, in 1992 just here it exceeded it more times, moreover it reached up to 5 mg/m^3. The increase runs to 150 % (Tab. 3). Like other researchers (e.g. LAYBOURN-PARRY, 1992), neither we did not find any relationship between the individual number and the biomass.

We learned from the saprobiological analysis of the Ciliata community, that the mass of species of unknown saprobic indicator classification is significant. We thought we should find any correlation between feeding types and different saprobic categories. So we made correlation analyzis to establish the relation between the feeding character and saprobity grouping of the species.

The linear correlation coefficient was calculated between the number of individuals belonging to the different feeding and saprobity groups, as well as the physico-chemical parameters of the water. The number of pooled samples (the number of pairs) was 90 in the case of feeding groups versus saprobity groups and 54 in the case of feeding and saprobity groups versus physico-chemical parameters (water temperature, pH, dissolved oxygen content, conductivity and oxydoreduction potential). Regarding the physico-chemical parameters we have not found any significant correlations. The explanation of this fact may be the following: the changes of the environmental conditions — caused by the alterations in the water regime via current velocity — may alter the species composition of the planktonic Ciliata community, but these changes do not alter significantly the distribution of the feeding and saprobity spectrum. In other words the algaevorous or beta-mesosaprobic species

1991 spring



1992 autumn

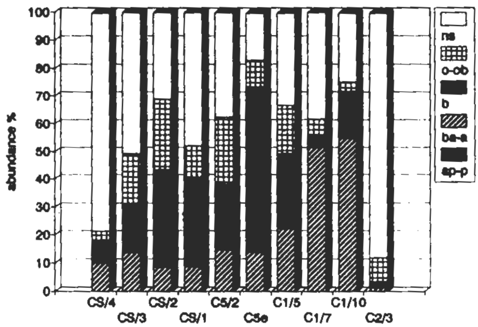


Fig. 6. Fig. 7. Percental distribution of ciliata species indicating different waterqualities within a population in spring 1991 and 1992 (ns=unknown indikative species, o-ob=oligo-oligobeta-mesosaprob sp., b=beta-mesosaprob sp., ba-a=beta-alfa-mesosaprob sp., ap-p=alfapoly-polysaprob sp.)

Table 3. Changes of the biomass (mg/m^3 wet weight) in the side-arm system at Cikola in the study period

Sampling sites	Time of sampling					
	1991			1992		
	JUNE	JULY	OCT.	JUNE	AUG.	OCT.
Main branch (1837 riv.km)	n.m.	n.m.	n.m.	1.7203	n.m.	1.9468
Csákányi side-branch (CS)						
CS4	0.7444	0.1820	n.m.	1.1151	0.2504	0.0794
CS3	0.2880	0.7085	n.m.	0.2622	0.3835	0.2418
CS2	0.4484	0.1984	2.6679	1.0884	1.4699	0.6085
CS1	0.1597	0.2371	0.0882	0.2322	1.6213	0.2069
Forrásos branch (C5)						
C5/2	0.0359	0.4917	0.7702	3.2404	1.2172	1.0012
C5/4	0.1580	0.9515	n.m.	1.8000	0.2913	n.m.
C5/at the end	0.0239	n.m.	0.0983	0.9707	0.0111	0.2592
Schisler branch (C1)						
C1/1	n.m.	n.m.	n.m.	3.0630	0.2616	n.m.
C1/5	n.m.	n.m.	n.m.	1.2848	0.4948	0.1165
C1/7	1.2884	0.1693	0.3139	7.9146	0.4737	0.0933
C1/8	n.m.	n.m.	n.m.	2.3422	0.1829	n.m.
C1/10	n.m.	n.m.	n.m.	2.2755	0.1376	0.2307
Disznós branch (C2)						
C2/1	0.5604	0.4790	n.m.	2.9902	1.7194	n.m.
C2/3	1.9997	0.0742	0.3405	5.2752	3.1552	0.8723
C2/5	0.5610	1.2929	n.m.	1.1674	2.0826	n.m.

loc.= location, val.= values

for example may be replaced, but the relative abundance of individuals feeding on algae or beta-mesosaprobic indicators may remain almost the same.

Between the feeding groups and saprobity groups correlations have been found. The beta-mesosaprobic condition is characterized by the presence of the algaevorous species (r=0.784) (Fig. 8). Similarly the carnivorous species indicate a transitional beta—alpha mesosaprobic situation (r=0.7683) (Fig. 9). Remarkable is the correlation (r=0.751) between the bacteriovor and non-indicator species (species without saprobity classification) (Fig. 10). Bacteria are present in every type of water and the species feed on them may occur under different saprobity conditions and therefore they have no indicative value.

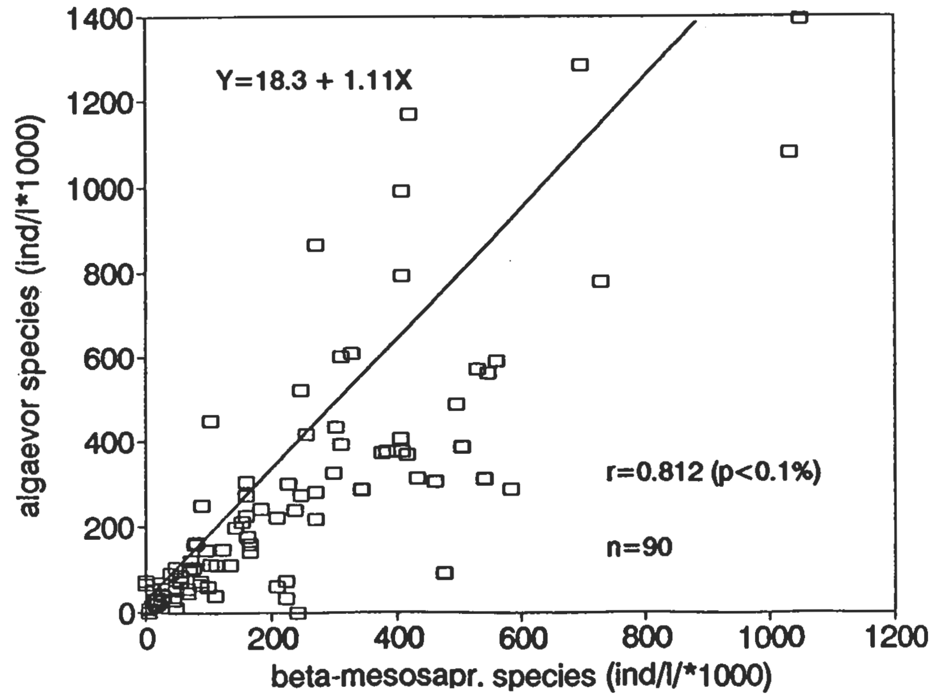


Fig. 8. Correlation between beta-mesosaprobic species and algaevorous Ciliata species

Summary

Side-branches are organic parts of the ecological system of River Danube, in them the decreasing flow velocity creates new ecological environments, which drastically differs from that of the main branch. (We have already reported on the main branch in many cases, so now we do not go into details; Bereczky, 1977, 1985, 1993, 1994a). This environment gradually looses its species stock characteristic of lotic waters, and species, which are specifically characteristic of dammed waters and lakes become dominant. These side-branches enrich the aquatic fauna and flora of the main branch and help the decomposition of organic pollution when they are scoured. At low waterlevels this connection diminishes, perhaps it ceases and simultaneously independent, smaller biotops emerge. The main branch differs from

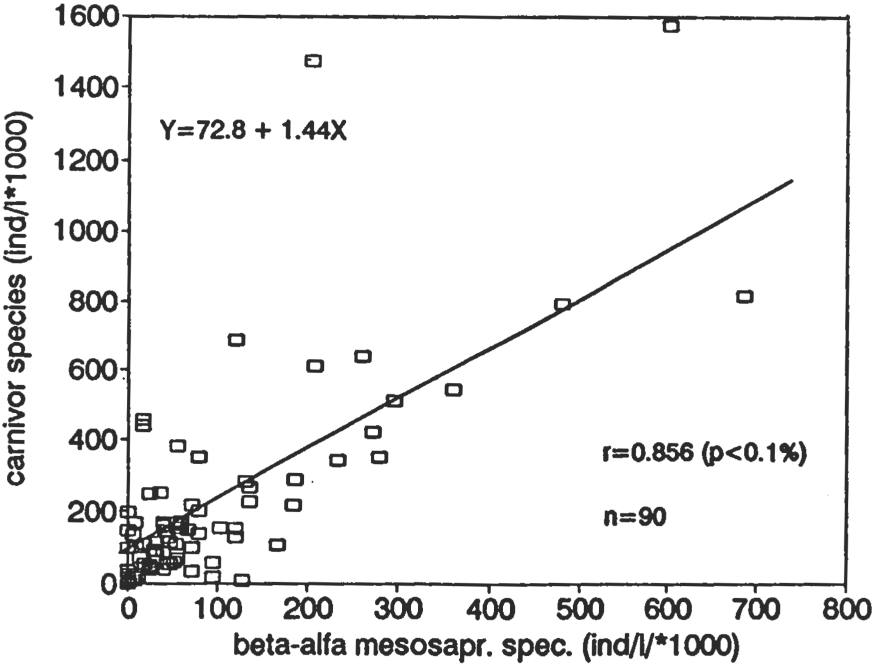


Fig. 9. Correlation between beta-alfa-mesosaprobic species and carnivorous Ciliata species

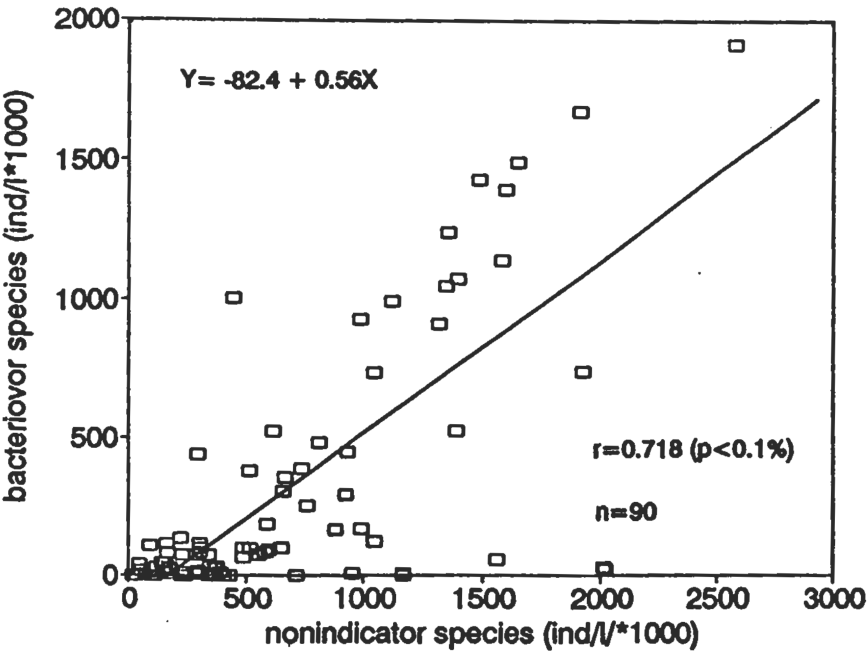


Fig. 10. Correlation between unknown indicative species and bacteriovorous Ciliata species

the detached side-branches also in that the main branch deepens and the side one silts, while the parameters characteristic of standing water become stronger both in abiotic and biotic respect.

— The Protozoa community which lives in the four kinds of biotops is rich both in species number and in individual one. Structures of the communities are different, their uniqueness is expressed in the composition of species and in the ratio of species abundance.

— Habitats can be characterized by species, according to their topographic distance from the main branch and to the duration of their flood periods.

— Floods rearrange the protozoan coenozis. Species that are frequent in the main branch become dominant fauna-forming ones of great density for a short time, later on fall into the background gradually as the standing water character becomes more marked.

— On different nutrition base proliferate different Ciliata species. The different abundances of common species of individual biotops can be attributed partly to this.

— We found the richest and most variegated community in Schisler branch water in late spring, while just then the Disznós arm could be characterized by predators of varied species composition, similar to Forrásos arm.

— More rare Ciliata species of the side-branch system was refugee.

Ceasing of the watersupply of a side-branch results in unfavourable changes also in the life of planktonic Ciliata community.

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