Free-living Ciliates of River Tisa and its tributaries

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Introduction

The largest left-side tributaries of River Danube, being the largest ones anyway, are River Tisa (966 km) and River Prut (926 km). The former proceeds on the territory of Ukraine, Romania, Slovakia, Hungary and Serbia, while the latter in Ukraine, Moldova and Romania. Despite the great value of these water courses, literature devoted to the study of protozoans inhabiting them is poor. Some of these papers (Pujin, Stanojevic 1979; Josa 1981; Kovalchuk, Kovalchuk 1984) deal with the ciliates of River Tisa. Data on ciliates of River Prut have been published recently (Kovalchuk 1993). More comprehensive data on the species composition of free-living ciliates of occasional eco-groups (Kovalchuk 1997, 1997a) have not been published in any paper, instead they were presented at two international conferences held in 1997 in Transcarpathia.

Keywords: free-living ciliates, species, abundance, biomass, saprobity

Material and methods

Time and location of the examinations: The seasonal expeditions on River Tisa and basins in its region were undertaken in 1991-92. When allocating the basic sampling sites it was recognized that River Tisa flows alternately in Ukraine, Romania and Hungary, under the conditions of a mountainous terrain, on lowland and in hilly lands. Accordingly, three sampling sites in the lower, middle and upper reaches of the river were defined initially: above the village Vilok (area typical of the hilly land of Berehovo), between the towns Hust and Tiachiv (at the village Veliatin: area typical of that adjoining River Tisa lowland) and on River Stohovets' above the village Luhi in the Rahiv region (a typically mountainous area). Taking into consideration the fact that River Tisa is characterised by an extreme hydrological regime, three complex study journeys were made to these sites: the first one was dated for a freshet, the second took place in a stabilisation period after high water, and the third in a period of low water level.

In addition to the 15 basic sites on River Tisa (in its reach in Ukraine's Transcarpathian area), samplings were carried out on all of the basic tributaries of

River Tisa (excluding the rivers Uzh and Latoritsa that had been investigated earlier: Kovalchuk 1993), on the Tereble-Rikske reservoir, and on lake Sinevir (Figure 1.).

During the summer and autumn journeys the network of sites at which the sampling was done was extended. When analysing the results, the sites were grouped in conditional zones (see below).

Collecting method

The planktonic samples were taken in 70-100 mm capacities at depths of 10-15 cm. With respect to the small depths of the investigated basins, the vertical distribution of ciliates was not studied. Benthic samples were taken using a microbenthos sampler of the type MB - TE (Babko 1989) with a 3,2 cm^2 area of encroachment or throat banks by an area up to 6 cm^2. The samples of periphyton were derived from overgrown stones by washing off.

During the research a total of 143 samples were taken and processed, with the following distribution: 45 planktonic, 46 benthic and 52 periphytonic.

Further methods

Sample processing was carried out in accordance with the procedure published earlier (Kovalchuk 1990; 1990a, 1993).

The identification of ciliate species was carried out based on the taxonomic work of Kahl (1930-1935). In a number of cases complementary references were used. The taxonomical system of Corliss (1977), with an independent Colpodea class (Foissner 1985), was applied.

Saprobity was assessed with the help of ciliate bioindicators and was calculated using the method of Toderash (1980):

$$\mathbf{S} = \frac{\sum \mathbf{N_i} * \mathbf{G_i} * \mathbf{\breve{S}_i}}{\sum \mathbf{N_i} * \mathbf{G_i}}$$

where N_i, G_i and $\breve{S}_i$, respectively, are the value describing the amount of specimens, an indicator value, and the mean index of saprobity of *i* species.

The essential source of information about saprobic valency and the indicator value of ciliates were works by Bick (1972), Moravceva (1977), Ausgewahlte Methoden... (1979) and Foissner (1988).

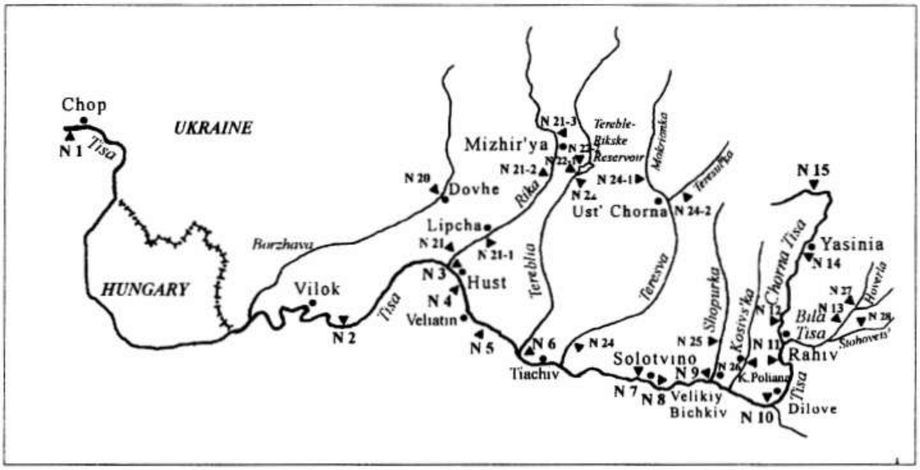

Figure1. The map of sampling sites in the Upper Tisa region in 1991-1992

Results and Discussion

In the region of River Prut 111 species and varieties of ciliates had been revealed from the benthos, plankton and periphyton (Kovalchuk 1993). Considerably more species are now ascertained for basins and water courses of the region of River Tisa. A total of 254 species and varieties of ciliates were found with the following distribution: 113 species and varieties in the Kinetofragminophora class, 72 in the Oligohymenophora class, 63 in the Polyhymenophora class, and 6 Colpodea (Table 1.). As regards the taxonomic composition of ciliates in River Tisa, the richest was the benthos with 187 species, followed by periphyton with 138, and plankton with 85 species.

Formed cilioplankton was found to be practically absent from the water courses of the Prut and River Tisa. Euplanktonic species of ciliates occurred in the plankton only at the site at the town Chop.

The greatest diversity of ciliates was found in the summer (166 species), and in the autumn (164 species). One-hundred-and-six species occurred in the spring, while only 30 in the winter. Among different water courses it was River Uzh (115 species) that appeared to be the richest in the taxonomical structure of ciliates. Thirty-four species of ciliates were found in the high-mountainous lake Sinevir. The total number of ciliate species discovered in River Tisa was 255. This figure testifies that species structure was sufficiently revealed. In the well-investigated River Kura (Azerbaidjan) 45 species of ciliates were revealed (Aliev 1986), and 54 were found in River Biala Pshemsha (Poland) (Czapic 1982). However, the true species-richness of ciliates can be well over the revealed values in the investigated rivers. For example, in the

Hungarian area of River Tisa 80 species of ciliates (Josa 1981) were found, many of which are absent from our list.

Among sections of River Tisa and water courses of its region, the middle reaches of River Tisa appeared to be the richest where 122 species of ciliates were ascertained. Accordingly, in the upper and lower reaches of River Tisa (in Ukraine) 85 and 86 species were revealed, respectively.

Among the tributaries of River Tisa, River Rika is the most investigated. Thirty-nine species of ciliates were found here, 31 species were discovered in River Kosivs'ka, and 26 were found in River Teresva. In the rivers Mokrianka and Borzhava 23 and 24 species of ciliates, respectively, were ascertained.

Planktonic ciliates

The strong flow of the rivers has an effect on the development of planktonic ciliates. However, the availability of organic substances is also important. The abundance of ciliates in the plankton depends primarily on the level of organic pollution. It is distinctly observable at sites along a flow (Kovalchuk 1993). In the presence of large areas inhabited by humans such increase can be very sharp. Without them it is less appreciable.

On River Hoverla we investigated a «standard» ecosystem in a Carpathian reserve area characterised by the lack of human economic activity. At this site ciliates were completely absent from the plankton, which was probably caused by the high velocity of the flow. The adverse influence of fast flow on ciliates has been known for a long time (Chorik 1968). The negative effect of this factor especially applies to planktonic ciliates. For River Kuban' the velocity of which is 0.2-1.7 m/sec, Kornienko (1972) reported not more than 14 species of planktonic ciliates. In slow rivers the species-richness of this eco-group is much higher. For example, 29 species of ciliates with a biomass of 0.1-3.4 mg/l were found in the plankton of the quiet river Berezina (Belarus) (Rassashko, Markelova 1982). Values obtained by us at the majority of sites in the mountain rivers are remarkably above those reported in both of the above examples.

In spring, during the first trip, the mean abundance of planktonic ciliates naturally decreased towards the upper reaches. Abundance values there were by two orders less even during the second as well as the third (by two-three orders) sampling sessions (Table 2.). It is associated with the fact that ciliates are washed away from benthic depositions during high water.

Water course	Abundance	Biomass	Destruction	Production
	thous. specim.	mg	cal/day	cal/day
PLANKTON per m^3				
Stohovets'	30 (0 - 142)	0.5(0- 2.3)	0.1(0 -0.9)	0.0(0 -0.5)
Tisa near Veliatin	858(14-4000)	44(0.3-305)	25(0.3-4.3)	8.2(0.2-41)
Tisa before Vilok	2263(0-10700)	16 (0 - 69)	18 (0 - 79)	8 (0- 27)
PERIPHYTON per m^2				
Stohovets'	500(200-5000)	6 (2- 20)	3 (1 -10)	2 (0.5- 6)
Tisa near Veliatin	9611(1200-34476)	61 (3- 202)	49 (3 -167)	30 (2-102)
Tisa before Vilok	7000(2000-12000)	38 (8- 69)	50 (10- 88)	30 (6- 54)
BENTHOS per m^2				
Stohovets'	1500(1000–800)	12 (10-23)	3 (1 - 6)	2 (0.5- 4)
Tisa near Veliatin	20200(5000-33500)	310(40-570)	240(35-450)	95 (21-243)
Tisa before Vilok	7368(68-13500)	85 (9 -100)	87 (2 -120)	25 (1 - 53)

Table 2. General characteristics of ciliates of the Upper Tisa region (April 1991)
Notes: Figures outside parentheses are geometric means, inside parentheses are minimum and maximum values.

The summer period was characterised by the maximal development of planktonic ciliates at the middle reaches of River Tisa (Table 3.), where the values of abundance approached those shown for the small rivers of the Dnieper, and biomass was also considerably more.

In contrast with the middle reaches, the levels of the quantities of ciliates in the lower reaches did not vary sharply from spring to summer, with biomass remaining on a low level.

The sharp decrease of the quantitative parameters of planktonic ciliates was observed in the autumn (Table 4.). It appeared that the level of cilioplankton quantities was more in the winter (Table 5.), than in late autumn.

Benthic ciliates

In comparison with the significant oscillations of all parameters of planktonic ciliates, large density was characteristic for benthic ciliates (Table 2.). The average abundance of bottom-dwelling ciliates at the investigated basins (including all) was 5.8 mln spec./m^2, and biomass was 58.5 mg/m^2 (disregarding results from 1991). The variation of parameters from basin to basin was quite insignificant; even the remarkable diversity of biotopes which ranged from peat sludge to sand did not cause sharp differences in the quantities of these protozoans.

The average parameters for benthic ciliates of River Prut, obtained in 1987 by Kovalchuk (1993), are close to those for River Uzh in 1989, which accordance testifies the correctness of the indicated average parameters for this group obtained for the middle rivers and occasional satellite basins in June 1989. The 1987 data from River Uzh should not be taken into consideration, for these samples were taken at highly

Water courses	Para-meter	Periphyton (on m^2)	Benthos (on m^2)	Plankton (on m^3)
Upper Tisa	N	6653(8.8±1.4)	-	2249(7.7±2.3)
	B	149.6(5.0±1.2)	-	51.9(4.0±1.6)
	R	137.2(4.9±1.2)	-	64.2(4.2±1.6)
	P	103.8(4.7±1.3)	-	39.4(3.7±1.6)
	n	3	-	2
Middle Tisa	N	5474(8.6±1.1)	5115(8.5±0.4)	12530(9.4±2.9)
	B	98.7(4.6±1.0)	80.0(4.4±0.9)	107.7(4.7±2.1)
	R	132.2(4.9±0.9)	106.9(4.7±0.7)	166.8(5.1±2.2)
	P	78.6(4.4±0.9)	64.0(4.2±0.7)	89.1(4.5±2.3)
	n	6	6	2
Lower Tisa	N	2815(7.9±0.5)	2843(8.0±0.3)	1414(7.3±3.4)
	B	56.3(4.1±0.5)	45.1(3.8±0.8)	19.1(3.0±3.5)
	R	82.5(4.4±0.3)	68.8(4.3±0.4)	37.4(3.4±3.5)
	P	46.9(3.9±0.2)	39.2(3.7±0.3)	24.4(3.2±3.4)
	n	3	3	2
Stohovets', Hoverla, Black Tisza	N	4192(8.3±0.4)	5554(8.6±0.1)	-
	B	38.0(3.7±0.2)	58.7(4.1±0.6)	-
	R	23.8(3.2±0.5)	50.0(3.9±0.5)	-
	P	13.3(2.7±0.3)	27.8(3.4±0.6)	-
	n	3	2	-
Mokrianka, Teresul'ka	N	10568(9.3±0.3)	-	-
	B	111.5(4.7±0.8)	-	-
	R	94.6(4.6±0.6)	-	-
	P	19.0(3.0±1.0)	-	-
	n	2	-	-
Teresva, Borzhava Rika, Kosivs'ka	N	28715(10.3±0.2)	54790(10.9±0.2)	-
	B	297.3(5.7±0.5)	1731.2(7.5±0.6)	-
	R	287.3(5.7±0.1)	1167.4(7.1±0.1)	-
	P	132.9(4.9±0.5)	707.4(6.6±0.1)	-
Sinevir	N	-	16787(9.7±0.1)	-
	B	-	668.8(6.5±0.3)	-
	R	-	352.0(5.9±0.1)	-
	P	-	201.0(5.3±0.2)	-
	n	-	2	-

Table 3. Average hydrobiological parameters describing communities of ciliates from various eco-groups of the River Tisa region in the summer season and the summer-autumn period (August - September) in 1991

Notes: N - abundance (thousand specimens); B - biomass (mg); R and P: breakdown and production (cal/day)

Water courses	Para-meter	Periphyton (on m^2)	Benthos (on m^2)	Plankton (on m^3)
On all massif data	N	–	–	25(3.3±3.2)
	B	–	–	2.0(1.1±1.3)
	R	–	–	0.8(0.6±0.7)
	P	–	–	0.5(0.4±0.6)
	n	–	–	5
Upper Tisa	N	904(6.8±0.6)	520(6.3±0.2)	-
	B	5.4(1.9±0.3)	2.1(1.3±0.1)	-
	R	1.8(1.0±0.3)	0.9(0.6±0.1)	-
	P	1.1(0.8±0.2)	0.6(0.4±0.1)	-
	n	3	2	-
Middle Tisa	N	1853(7.5±1.2)	255(5.5±2.1)	-
	B	9.7(2.4±0.4)	6.7(2.0±1.5)	-
	R	4.0(1.6±0.6)	2.0(1.1±1.0)	-
	P	2.5(1.3±0.5)	1.4(0.9±0.9)	-
	n	5	4	-
Lower Tisa	N	2046(7.6±0.5)	-	-
	B	10.2(2.4±1.0)	-	-
	R	4.5(1.7±0.7)	-	-
	P	2.7(1.3±0.6)	-	-
	n	2	-	-
Shopurka, Rika, Teresva	N	340(5.8±2.4)	884(6.8±0.8)	-
	B	4.4(1.7±1.5)	4.3(1.7±0.4)	-
	R	1.9(1.1±1.0)	1.7(1.0±0.2)	-
	P	1.0(0.7±0.8)	0.7(0.6±0.5)	-
	n	3	3	-
Hoverla, Stohovets', Chorna Tisa	N	356(5.9±1.2)	-	-
	B	3.0(1.4±0.6)	-	-
	R	0.9(0.7±0.4)	-	-
	P	0.4(0.3±0.1)	-	-
	n	3	-	-

Table 4. Average hydrobiological parameters describing communities of ciliates from various ecogroups of River Tisa region in an autumn period (November) 1991
For abbreviations see Table 3.

antropogenic sites (in places of sewage disposal). It also has resulted in very low mean abundance (about 60 mln spec./m^2) and biomass (0.8-0.9 g/m^2) parameters.

The seasonal study of benthic ciliates was carried out in 1991. The distinct rise of the abundance and biomass of ciliates from the upper reaches to the middle section (Table 2.), and the subsequent decrease towards the lower reach (Table 3.) was observed.

Water courses	Para-meter	Periphyton (on m^2)	Benthos (on m^2)	Plankton (on m^3)
On all massif data	N	2278(7.8±1.7)	5833	1750
	B	49.2(3.9±1.5)	310.7	52.2
	R	11.0(2.5±1.5)	42.5	9.0
	P	6.7(2.0±1.5)	19.4	4.1
	n	5	1	1

Table 5. Average hydrobiological parameters describing communities of ciliates from various ecogroups of River Tisa region in a winter period (Fabruary) 1991
For abbreviations see Table 3, n - sampling.

The repeated samplings executed in April before freshet, at the time of the freshet and after freshet allowed to ascertain the influence of a short-term high water on benthic ciliates.

At the same time, a lasting flood has a sharp negative effect on the ciliates of this eco-group. An example can be late autumn (November), when the average abundance of benthic ciliates of River Tisa and its tributaries was 200-900 th. sp./m^2, and the biomass was 2-7 mg/m^2 (Table 4.). This is essentially beneath the values both of the other seasons. Apparently, probably related to the stabilisation of the regime, the abundance of ciliates in the benthos was higher even in the winter (Table 5.).

It is essential to note that, although the seasonal abundance of benthic ciliates of River Tisa and its tributaries did not exceed $2\text{-}6 \cdot 10^6$ sp./m^2 as a mass average, extremely high values were observed in occasional watercourses. Accordingly, the mean summer abundance of bottom-dwelling ciliates for occasional tributaries of the middle reach was $50\text{-}60 \cdot 10^6$ sp./m^2, which completely corresponds to the data obtained for Uzh in 1987 (Table 3, Kovalchuk 1993).

Significant deviation (by 2-3 ranges) from the above-mentioned quantitative data of benthic ciliates were found in the mountain tributaries of River Danube (Kovalchuk 1993). The extremely unstable regime caused low values of ciliate abundance and biomass (Table 2.). During the process of seasonal vegetation fluctuation in these rivers, a sharp summer decrease in the quantities of benthic ciliates was pointed out. Autumn parameters were found to be by 2 orders higher.

The functional activity of benthic ciliates at various reaches of the River Tisa region is determined by a complex of hydrophysical factors the cardinal ones of which are the velocity and the temperature of the flow. Fairly essential is the presence or absence of everyday sewage. By virtue of the above stated reasons, the maximal parameters of the transformation of organic substances (OS) by benthic ciliates are conventionally observed in the summer. On a site below Mizhir'ia the level of breakdown was 1265 cal/(m^2*day). Very high values 1076 cal/(m^2*day) were reported from the river Kosivs'ka inside the village Kosivs'ka Poliana. These confirm the high level of mineralisation of OS by ciliates at mountain anthropogenic areas.

The average coefficient of net production efficiency for the communities of benthic ciliates of the investigated rivers was about 0.35, based on which we can assume an insignificant predatory component (niliovorous).

Periphytic ciliates

Periphyton on stones is an important eco-group under the conditions of the upper reaches of River Tisa. As regards the quantities of ciliates, figures obtained for periphyton approximated the values for benthos. In particular, we note the spring and autumn increase of ciliate numbers in periphyton as well as in benthos, in transition from the upper to the middle reaches. Such difference between reaches was not observed in the summer (Tables. 2-5.).

In the process of the seasonal fluctuation of cilioperiphyton an autumn quantitative minimum is noted conventionally. The mean abundance parameters for the reaches of River Tisa varied between $1 \cdot 10^6$ - $9 \cdot 10^6$ sp./m^2, and biomass between 30 - 150 mg/m^2. The biomass of cilioperiphyton of River Tisa, its value being more than in autumn (November), did not exceed 5-10 mg/m^2, which fact refers to the fine size of ciliates in this period of the year.

The average value of cilioperiphyton quantities in the tributaries of River Tisa is dependent on their geographical altitude. For the tributaries of the upper sections in the Ukrainian reach (i.e. rivers Stohovets', Hoverla, Chorna Tisa) lower parameters of periphytonic ciliates were characteristic than those mentioned above for River Tisa. Much higher values of abundance and biomass were observed in the tributaries of the middle and lower reaches (i.e. rivers Teresva, Borzhava, Rika) which is possibly caused by the more favourable trophic conditions of these rivers. The importance of the influence of this factor on bottom-dwelling populations in small watercourses was emphasised by Baldock and Sleigh (1988). It is noted that the abundance of ciliates falls sharply only in case of the combined influence of catarobic water and high velocity of the flow.

Estimation of the degree of organic pollution on ciliates as bioindicators

Attempts to evaluate the degree of organic pollution on ciliate bioindicators has been formerly made by us on materials from 1987-1989 (Kovalchuk, 1993). The findings included indications of the gradual improvement of the saprobiological situation of River Uzh, the largest tributary of River Tisa, serving as the water supply of Uzhgorod. The considerable amount of material on ciliates of River Tisa and it tributaries, which accumulated during a series of expeditions in 1991-1992, allowed the seasonal evaluation of the level of pollution on ciliate bioindicators. Recommendations to use such approach in various types of basins were also made. The influence of freshets on the saprobiological situation of the water was evaluated as well. Intense freshets were fairly frequent on the inspected rivers.

It is necessary to note that it is practically impossible to apply certain indices of saprobity for plankton. The reason is the negative influence of a fast flow on ciliates, due to which fact no formed cilioplankton were found at the majority of the sampling sites (except for site 1). The second reason for the low efficiency of water quality estimation from planktonic organisms was the insufficient number of indicator species. For example, neither of the three samples taken in the period of low water level at the site N 2 on 29 April 1991 yielded any ciliate bioindicators. A similar situation was observed on 25 April at site N 28 (River Stohovets'). As opposed to this, saprobiological estimation from benthic and periphytic organisms in the spring turned out to be impossible only in one instance, namely at site N 27.

In April, as a result of three journeys, data from sites N 2, N 5 and N 28 were obtained. As estimations specified, each sample appeared to indicate an alpha-mesosaprobic range of organic pollution (Table 6.). In the presence of parallel samples, indices obtained by estimating from cilioperiphyton were higher than those calculated from benthos. The period of freshet was characterised by fairly similar saprobity indices (Figure 2.). The reason is the proportional increase of water volume and contaminants which, as experience has shown, are the most actively dumped in the rivers just in the period of freshets.

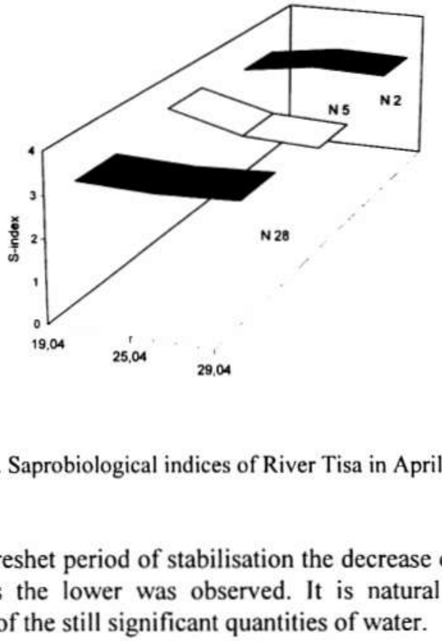

Figure 2. Saprobiological indices of River Tisa in April 1991

During an after-freshet period of stabilisation the decrease of the index from the upper course towards the lower was observed. It is natural if we consider the OS-attenuating effect of the still significant quantities of water.

During a period of low water level the indices of saprobity were characterised by a low alpha-mesosaprobic range on sites N 28 and N 5, and by an even lower alpha-mesosaprobic range at site N 2 (Table 6.). Consequently, in a lower flow of River Tisa the processes of the self-purification of water under normal conditions take place intensively enough. This allows the river to cope with pollution, despite the presence of large cities and other inhabited sites.

Site	Ecogroup	S-index	n	S-index	n	S-index	n
		19-20.04		25.04		29.04	
N 28	Plank.	3,00	1	—		3,48	1
	Benth.	—		—		2,94±0,11	2
	Peryph.	2,88±0,04	2	3,18±0,53	3	3,21	1
N 5	Plank.	2,51±0,31	3	3,10±0,42	2	3,00±0,00	2
	Benth.	2,81±0,08	3	—	3	—	
	Peryph.	—		2,69±0,14	3	3,21	1
N 2	Plank.	2,65±0,11	3	2,00	1	—	
	Benth.	2,90±0,98	3	2,52	1	2,43±0,61	2
	Peryph.	—		2,61±0,21	2	3,15	1

Table 6. Saprobiological characteristic of occasional sites on River Tisa in spring 1991

In the summer much attention was paid to the influence of inhabited areas on the saprobiological condition of River Tisa and its tributaries. At occasional points samples were taken repeatedly, which confirmed a disastrous state of the water ecosystem below large cities. The largest contaminator with ordinary sewage is the city Rahiv. Water quality, as suggested by ciliate bioindicators, was estimated here to be constantly upper alpha-mesosaprobic to polysaprobic (Table 7.). If we take into account the possibility of the breakdown of any of the sewage treatment systems, we can quite obviously predict the increase of saprobity indices in a cold season, as is observed in real life (Table 7.).

It is well known that the functional activity of hydrobionts falls with a decrease in temperature, which is reflected in their reduced ability to mineralise organic substances. Truly enough, when River Tisa is occasionally polluted on its reach above the cities, the effect is stronger in autumn than in summer.

Unexpectedly, there was an indication of pollution even in a state wildlife area, namely the high-mountainous lake Sinevir. While the main water body was oligotrophic and oligosaprobic, the beach showed mesosaprobic pollution. It is associated not only with the increase of poorly supervised tourism, but also with the activity of breeding domestic ducks by the local inspectors.

Site	Summer S-index				Early Autumn S-index				Late Autumn S-index				Winter	
	Pl.	Be.	Pe.	Ad.	Pl.	Be.	Pe.	Ad.	Pl.	Be.	Pe.	Ad.	S-in.	Ad.
N 1	2,84					3,09			2,80					
N 2	2,98		3,03				2,40				2,76			
N 2a											2,89	Upper to N2		
N 3			2,88							3,30				
N 4											2,37			
N 5	2,80		2,41	20.08				20.08	2,90		3,00		2,64	Pl.
		2,47	2,27	27.08				27.08					2,88	Pe.
													2,27	Pe. on Carex
N 6							2,87			2,94	3,11			
N 7		2,85	2,68								3,70			
N 8		3,00									2,75			
N 9		2,70												
N 10	2,80	2,60							3,00	4,00				
N 11	3,78		3,04	18.08				18.08					3,33	Pe.
	3,24			19.08				19.08			3,54		2,89	Be.
N 12			2,79								3,51		2,66	Pe.
N 14			2,79								2,51			
N 15		2,86								3,00	2,73			
Tributaries														
N 20							2.95							
N 21													3,40	Pe.
N 21-1							2,98				2,50			
N 21-2						2,92				3,07				
N 21-3							3,01				3,59			
N 22					2,95									
N 22–1					3,00									
N 22–2									2,80					
N 23						3,16	2,54							
N 23-1						3,04								
N 24							3,03			2,28				
N 24-1							2,66							
N 24-2							2,63							
N 25											2,80			
N 26	2,84													
N 27		2,50	2,82								2,84			
N 28							2,57	1.09			3,97			
							2,34	3.09						

Table 7. Saprobiological characteristic of occasional sites on River Tisa in the summer (19 Aug. - 30 Aug.), early autumn (1 Sept. -13 Sept.), late autumn (2 Nov. -14 Nov. 1991), and winter (14 Feb. - 15 Feb. 1992)

Notes: Pl. - plankton, Be. - benthos, Pe. - periphyton, Ad. - additional information,
S-index - index of saprobity

The classification of sampling sites on River Tisa and basins in its region, based on occasional structurally functional parameters of ciliate communities

The growing anthropogenic influence on basins and watercourses, and the need for eco-monitoring aquatic ecosystems call for fast methods of assessing their conditions. One stage of such assesment is their classification.

Can the quantitative and functional parameters characterising different groups of hydrobionts be criteria for such classification?

Using data from water courses and basins of the River Tisa region I lead the classification along 7 parameters: quantity of ciliate species, aggregate number, total breakdown of organic substances, ratios of algae-, bacterio- and ciliovores, saprobity on bioindicator ciliates. Evaluation was done by means of three types of cluster analysis: agglomerate-hierarchical, K-average and combined RQ-analysis. We received valid results for benthos and periphyton. The number of significant clusters for the spring and summer-autumn periods varied between 3 and 4.

N	Date, 1991	The name of the site (river zone)	Agglomerative - hierarchical	RQ	K-average	Mean
1.	18.08	Hoverla	1	1	1	1
2.	16.08	Tisa after Yasinia	1	1	1	1
3.	19.08	Tisa before Rahiv	1	1	1	1
4.	18.08	Tisa after Rahiv	3	3	3	3
5.	20.08	Tisa after Hust	1	1	1	1
6.	20.08	Tisa before Hust	2	2	2	2
7.	28.08	Tisa before Vilok	1	1	1	1
8.	27.08	Tisa before Hust	3	3	3	3
9.	29.08	Tisa after Solotvino	2	2	1	2
10.	1.09	Stohovets'	2	2	2	2
11.	5.09	Tisa before Vilok	2	2	2	2
12.	3.09	Stohovets'	2	2	2	2
13.	9.09	Tisa after Tiachiv	1	1	1	1
14.	9.09	Borzhava	3	3	3	3
15.	9.09	Rika near Lipcha	1	2	3	2
16.	10.09	Rika near Mizhir'ia	3	3	3	3
17.	13.09	Lake Sinevir	1	2	2	2
18.	13.09	Teresva	3	3	3	3
19.	12.09	Teresul'ka	2	2	1	2
20.	12.09	Mokrianka	2	2	1	2

Table 8. Results of cluster analysis of summer cilioperiphyton of sites on River Tisa and basins of its region, on seven variables

In practice, results of classification of ciliobenthos are not assessed together with hydrological conditions and the characters of the biotope. The occasional results of the classification of sampling sites are presented in Table 8. The results of clusterisation using various parameters of bioindication coincide with findings from the complex evaluation of water quality with the help of hydrochemical parameters (dissolved OS, heavy metals, biogenes, etc.). Polluted are River Rika in Mizhir'ia, River Tisa below Rahiv, River Teresva in the lower region and River Borzhava near the village Dovhe. River Hoverla and lake Sinevir (though not at all sites) are considered to be completely catarobic. Moderately polluted are River Stohovets', River Rika near the village Lipcha, River Tisa below the mouth of River Vişeu. The rest of the sampling sites with data from different periods appeared in neighbouring clusters. The same was observed when various procedures of cluster analysis were used.

Accordingly, the complex use of a number of parameters that characterise groups of ciliates appears a good perspective for the purposes of classifying aquatic objects based on their degree of influence on hydrobionts. Even the classification of basins using parameters of quantities and functional activity of ciliates is possible.

Summary

In the plankton, benthos and periphyton of the Upper Tisza region (in Ukraine) 85, 187 and 138 species of free-living ciliates, respectively, were found. The total amount of discovered species was 254. The distribution of ciliates in different seasons and biotopes, changes in their quantities, biomass, and their production characteristics are ascertained.

The saprobiological situation of ciliates as bioindicators was evaluated and it appeared to be extremely unfavourable: alfa-mesosaprobic and polysaprobic range of pollution were revealed. The worst water quality was observed below the city of Rahiv. The use of cluster analysis allowed the classification of sampling sites.

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N	Species	Pl	B	Pr	W	Sp	Su	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Class Kinetofragminophora																							
1	Acaryophrya mamillata Kahl	+					+	+	+															
2	Actinobolina vorax Wenrich		+				+																+	
3	Amphileptus pleurosigma (Stokes)		+				+																+	
4	Chaenea teres Duj.	+	+	+		+	+	+	+	+	+												+	
5	Chilodonella labiata Stokes		+								+											+		
6	C. uncinata Ehr.	+	+	+	+	+	+	+	+	+	+		+										+	
7	C. piscatoris Bloch.			+			+																+	
8	Chilodontopsis depressa Perty	+	+	+		+	+	+	+	+									+				+	
9	Chilophrya labiata Edm.		+																				+	
10	Coleps hirtus Nitzsch.	+	+	+		+	+	+	+				+		+								+	+
11	C. hirtus var. minor Kahl	+	+	+			+	+		+													+	+
12	C. elongatus Ehr.		+				+																	+
13	Dileptus bivacuolatus da Cunha	+	+			+			+	+														
14	D. margaritifer(Ehr.)Ding.	+	+	+	+	+	+	+		+	+												+	
15	D. monilatus Stokes		+	+		+	+	+		+	+												+	
16	D. mucronatus Pen.		+				+	+	+															
17	D. singularis Vux.		+					+				+												
18	D. gracilis Kahl			+				+			+													
19	Drepanomonas revoluta Pen.		+				+																+	
20	Enchelyodon nataliae Kovalch.		+				+																+	
21	Enchelys gasterosteus Kahl			+			+	+		+														
22	Enchelys sp.					+								+										
23	Gastronauta membranacea Buetschli		+			+		+		+						+		+						
24	Holophrya atra Svec.		+	+		+				+														
25	H. simplex Schew.			+			+	+			+													
26	H. oviformis Vux.		+				+																+	
27	Holophrya sp.		+					+					+											
28	Homalozoon vermiculare Stokes		+	+		+	+	+	+	+													+	
29	H. caudatum Kahl		+			+			+															
30	Lacrymaria filiformis Maskell		+	+			+	+	+											+			+	
31	L. olor O.F.M.		+	+		+	+	+		+	+												+	
32	L. olor var.pusilla Vux.		+	+		+	+	+	+		+												+	+
33	Lagynophrya ovalis v.Gelei	+		+			+	+	+	+	+									+				
34	L. mutans Kahl			+				+			+													
35	L. simplex Kahl	+					+	+		+														
36	Lagynophrya sp.			+		+					+													
37	Leptopharynx sphagnetorum (Lev.)		+	+		+	+			+				+									+	
38	Litonotus anguilla Kahl	+				+			+															
39	L. lamella (O.F.M.)		+	+			+	+	+												+		+	
40	L. l. var.armatum Vux.		+				+																+	
41	L. fusidens (Kahl)	+	+	+	+	+	+	+		+	+	+												
42	L. crystallinus Vux.			+			+	+		+														
43	L. cygnus O.F.M.		+			+			+															

Table 1. Species list and the distribution of free-living ciliates of River Tisa

	Species	Pl	B	Pr	W	Sp	Su	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
44	L. fasciola O.F.M.		+	+			+	+		+					+	+							+	
45	L. triqueter Pen.		+				+	+											+					
46	L. nanus Vux.	+	+			+	+		+														+	
47	L. uninucleatus Fois.		+	+		+	+	+		+	+									+				
48	Litonotus sp.	+	+	+		+		+		+	+	+	+	+		+	+	+		+				
49	L. sp.		+							+														
50	Longifragma obliqua Kahl	+					+	+	+															
51	Loxodes striatus Pen.		+				+	+					+										+	
52	Loxophyllum helus (Stokes)		+				+	+		+														
53	L. lionotiforme Vux.		+	+			+	+	+														+	
54	Mesodinium acarus Stein	+	+	+		+	+	+	+	+			+	+		+		+						+
55	Metacystis tesselata Kahl		+	+				+			+		+											
56	Monodinium balbianii Fab.-Dom.		+				+	+	+														+	
57	Nassula tumida Maskell			+			+	+		+	+									+				
58	N. rotunda Gelei			+			+	+		+														
59	Nassulopsis elegans (Ehr.)			+			+	+		+													+	
60	N. vorax (Stokes)	+	+	+			+	+		+	+												+	
61	Paraenchelis wenzeli Foiss.		+	+			+	+		+													+	
62	P. terricola Foiss.		+	+		+	+				+											+		
63	Paraurotricha discolor (Kahl)		+				+																+	
64	Penardiella crassa (?) Pen.		+					+											+					
65	Phascolodon vorticella Stein	+					+	+	+															
66	Phialina jankowskii Foiss.		+	+	+	+	+	+		+	+			+				+		+	+			
67	Ph. minima Kahl		+					+					+											
68	Ph. pupula O.F.M.		+			+	+	+	+						+								+	
69	Phialina sp.		+					+											+					
70	Phialina sp.1		+					+					+											
71	Pithothorax sp.		+				+												+					
72	Placus ovum Kahl		+	+		+		+		+	+													
73	Plagiocampa mutabilis Shew.		+	+		+	+	+	+	+	+								+				+	
74	P. metabolica Kahl		+				+																+	
75	P. nistroviensis Kahl		+	+		+	+	+		+			+	+					+				+	
76	P. rouxi Kahl	+	+	+		+	+	+	+	+	+	+	+		+				+			+	+	
77	P. longis Kahl		+	+			+																+	
78	P. sassykensis Kovalch.	+	+	+		+	+	+	+	+														
79	Plagiocampa sp.		+						+															
80	Prorodon ovum (Ehr.)		+				+																+	
81	Prorodon teres Ehr.		+				+	+	+		+												+	
82	Pseudochilodonopsis caudata(Perty)		+	+			+	+											+		+		+	+
83	P. algivora (Kahl)	+		+		+		+		+	+			+	+									
84	Pseudomicrothorax dubius (Maupas)		+				+																+	
85	Pseudoprorodon sp.		+					+					+										+	
86	Rhagadostoma completum Kahl		+			+	+	+	+										+				+	
87	Spathidioides sp.		+				+																+	
88	Spathidium brunneum Kahl		+			+				+														

Table 1. continue

	Species	Pl	B	Pr	W	Sp	Su	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
89	Sp. chlorelligerum Kahl		+					+	+															
90	Sp. latum Kahl		+	+			+	+		+														
91	Sp. spathula O.F.M.	+	+			+	+	+		+	+												+	
92	Sp. faurei Kahl		+				+																+	
93	Sp. peniculatum Kahl		+				+																+	
94	Sp. muscicola Kahl		+				+																+	
95	Spathidium sp.		+					+		+														
96	Spathidium sp.1			+				+			+													
97	Spathidioides sp.			+		+				+														
98	Supraspathidium multistriatum Foiss. et Didier		+				+																+	
99	Trachelius ovum Ehr.			+			+																+	
100	Supraspathidium sp.		+					+				+												
101	Trachelophyllum apiculatum Per.	+	+	+		+	+	+	+		+												+	
102	Tr. attenuatum Foiss.		+	+			+													+			+	
103	Trithigmostoma cucullus(O.F.M.)	+	+	+	+	+	+	+	+	+	+				+								+	+
104	T. hyalina Sramek-Husek			+				+		+														
105	T. steini (Blochman)		+	+		+	+	+		+	+							+	+			+		
106	Trochilia minuta (Roux)	+	+	+	+			+		+	+													
107	Trochilioides fimbriatus Foiss.			+				+							+									
108	Urotricha armata Kahl		+	+		+	+	+		+								+						
109	Ur. farcta Clap.-Lach.	+	+	+		+	+	+	+	+	+		+									+	+	+
110	Ur. furcata Clap.-Lach.	+	+	+		+	+	+	+	+	+													
111	Ur. ovata Kahl	+	+	+		+	+	+		+	+		+										+	
112	Ur. pelagica Kahl	+				+	+	+	+															+
113	Vasicola ovum Kahl		+			+	+	+	+	+									+		+		+	
	Class Oligohymenophora																							
114	Astylozoon faurei Kahl			+			+	+		+														
115	Cinetochilum margaritaceum Perty	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	
116	Colpidium colpoda (Losana)			+				+								+								
117	C. kleini Foiss.			+				+							+									
118	Cohnilembus fusiformis Kahl	+	+	+	+	+	+	+	+	+	+				+		+		+			+		
119	Cohn. vexillarius Kahl		+				+																+	+
120	Cristigera setosa Kahl	+		+	+	+	+	+	+	+	+				+					+			+	
121	Cr. phoenix Pen.		+				+																+	
122	Ctedostema acanthocrypta Stokes		+	+			+	+	+	+	+		+	+	+			+						
123	Cyclidium bonnetti Groliere			+				+							+									
124	C. flagellatum Kahl		+					+					+										+	
125	C. glaucoma O.F.M.	+	+	+	+	+	+	+	+	+	+			+	+			+		+			+	+
126	C. g. var. elongatum Schew.	+	+	+		+	+	+	+	+	+					+	+	+	+				+	
127	C. g. var. minuta Vux.		+			+		+							+								+	
128	C. heptatrichum Schew.		+	+		+	+	+		+	+								+	+				
129	C. lanuginosum Pen.		+	+			+	+		+	+													
130	C. libellus Kahl		+	+			+	+		+	+													
131	C. oligotrichum Kahl	+	+	+		+		+		+	+											+		

Table 1. continue

	Species	Pl	B	Pr	W	Sp	Su	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
132	C. putrinum Vux.			+			+	+		+														
133	C. sapropellicum Vux.		+	+			+	+		+								+	+					
134	C. sphagnetorum Sramek-Husek		+					+					+											
135	C. singulare Kahl		+	+			+	+	+	+			+		+				+				+	+
136	C. versatile (?) Pen.		+			+				+													+	
137	C. simulans Kahl			+				+													+			
138	C. gracile Vux.		+			+																	+	
139	Cyclidium sp.	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+		+	+	
140	Cyclidium sp.1		+	+		+		+	+	+	+				+									
141	Cyclidium (?) sp.	+	+	+		+		+	+	+	+	+		+	+									
142	Dexyostoma campyla (Jank.)		+	+	+	+	+	+	+	+	+													
143	Dexiotricha colpidiopsis (Kahl)		+				+																+	
144	Dexiotrichides centralis (Stokes)			+		+		+		+	+											+		
145	Disematostoma invallatum v.Gelei			+				+		+														
146	Epistylis plicatilis Ehr.	+		+			+	+		+	+													
147	E. rotans Svec	+		+		+			+	+														
148	Frontonia elliptica Beard.		+	+		+	+	+	+	+	+				+			+		+			+	
149	F. leucas Ehr.	+	+			+		+		+			+						+					
150	F. roquei Drag.	+	+	+		+	+	+	+	+	+			+				+					+	
151	F. depressa (?) Stokes	+					+		+															
152	F. sp.		+						+	+														
153	Frontoniella complanata Wetzel		+	+			+	+					+		+		+	+					+	
154	Glaucoma myriophylli Pen.		+				+																+	
155	Glaucoma sp.			+		+				+														
156	Monochilum elongatum Mermod.		+			+				+														
157	Ophryoglena flava Ehr.		+			+	+	+	+				+										+	
158	O. utriculariae Kahl			+				+		+					+									
159	Paramecium bursaria (Ehr.)		+	+	+		+	+			+				+			+					+	
160	P. caudatum Ehr.	+	+	+		+	+	+	+	+							+	+					+	
161	P. putrinum Cl.et L.	+	+			+	+		+														+	
162	P. calkinsi Woodruff		+	+	+					+	+													
163	Philasterides armata (Kahl)	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+					
164	Platynematum sociale Penard		+	+		+	+	+	+						+								+	+
165	P. solivagum Kahl	+	+			+	+	+	+	+			+											
166	Pleuronema coronatum Kent	+	+	+		+	+	+	+	+	+		+	+	+	+		+					+	
167	P. crassum Duj.		+				+												+					
168	Pseudocochnilembus putrinus(Quen.)		+			+			+															
169	Stegochilum fusiforme Schew.		+	+			+	+		+	+									+			+	
170	Spirozona caudata Kahl	+	+			+	+	+	+	+	+								+			+	+	
171	Tetrahymena pyriformis (Ehr.)	+	+	+	+	+	+	+		+	+				+							+	+	
172	Turaniella vitrea Brodsky	+				+				+														
173	Urocentrum turbo O.F.M.	+	+	+			+	+		+													+	+
174	Uronema halophila (Kahl)	+	+	+		+	+	+	+	+	+	+	+	+	+		+		+				+	
175	Ur. marinum (Duj.)	+		+		+	+	+	+	+	+												+	
176	Ur. sp.			+				+			+													

Table 1. continue

	Species	Pl	B	Pr	W	Sp	Su	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
177	Urozona buetschli Schew.		+	+		+		+		+	+											+		
178	Vorticella campanula Ehr.	+	+	+	+	+	+	+	+	+	+		+	+			+	+						
179	V. gracilis Duj.	+		+		+		+		+		+		+										
180	V. microstoma Ehr.	+		+	+	+	+	+	+	+	+													
181	V. mutans (?)(O.F.M.)	+						+		+														
182	V. venusta Nenninger	+				+				+														
183	Vorticella sp.		+						+															
184	Vorticella sp.1			+				+								+		+						
185	Zoothamnium sp.	+						+	+															
	Class Polyhymenophora																							
186	Aspidisca cicada (O.F.M.)	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+				+	+	+
187	Asp. lynceus Ehr.	+	+	+	+	+	+	+	+	+	+			+		+		+		+				+
188	Asp. herbicola Kahl		+				+																+	
189	Balladyna fusiformis Kahl	+	+	+	+	+	+	+	+	+	+												+	
190	B. similis Kahl	+	+	+			+	+	+	+	+		+		+								+	
191	Blepharisma steini Kahl		+				+																+	
192	Brachonella campanula Kahl		+				+																+	
193	Caenomorpha medusula var. dentata Wetzel		+				+	+		+														
194	Climacostomum virens (Ehr.)	+	+				+																+	
195	Codonella cratera (Leidy)	+					+	+	+															
196	Condylostoma tardum Penard			+				+	+															
197	C. vorticella (Ehr.)	+	+	+			+																+	
198	Hypotrichidium tisiae (Gelei)	+				+				+														
199	Keronopsis spectabilis Kahl			+				+		+														
200	Metopus es (O.F.M.)		+	+		+	+	+											+				+	
201	M. es var. rectus Kahl		+				+												+				+	
202	M. hasei Sond.		+				+	+							+				+					
203	M. tortus Kahl		+				+																+	
204	M. pulcher Kahl		+				+																+	
205	M. setifer Kahl		+			+	+		+														+	
206	Mylestoma cf. sp.		+			+			+															
207	Onichodromopsis flexilis Stokes	+			+					+														
208	Opistotricha crassistilata Kahl	+		+		+	+	+	+		+													
209	O. similis Engelmann			+	+					+														
210	Oxytricha furcata Smith		+	+			+	+	+	+	+											+		
211	O. agilis (Engelmann)			+			+	+		+														
212	O. granulifera Foiss. et Adam		+	+	+		+	+	+	+	+			+		+	+				+			
213	O. minor Kahl		+				+																+	
214	O. ludibunda Stokes	+	+	+			+	+	+	+														
215	O. similis Engelmann		+				+																+	
216	O. saprobia Kahl		+				+																+	
217	Oxytricha sp.		+					+		+														
218	Paruroleptus caudatus Stokes	+	+	+		+	+	+	+	+	+				+				+					
219	P. musculus(O.F.M.)			+				+					+											

Table 1. continue

	Species	Pl	B	Pr	W	Sp	Su	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
220	Paruroleptus sp.		+					+							+									
221	Paraurostyla weissei (Stein)		+	+		+		+			+											+	+	
222	Pelodinium reniforme Laut.		+				+	+					+		+				+				+	
223	Perisincirra gellerti Foiss.		+			+																+		
224	Saprodinium mimeticum (Penard)	+				+			+															
225	S. triangulum Kahl		+					+					+											
226	Spirostomum minus Roux		+				+	+					+										+	+
227	Spirostomum teres Cl. et L.	+	+				+	+							+								+	
228	Stentor coeruleus (Pallas)	+	+	+				+		+				+				+					+	
229	Str. velox F.-F.	+	+	+	+		+	+	+	+	+	+	+		+			+					+	
230	Str. pulex Galad.			+		+																+		
231	Str. lacustris Foiss.,Skog.et Pratt	+	+	+			+			+														+
232	Strombidinopsis gyrans Kent	+					+																	+
233	Strombidium mirabile Penard	+					+																	+
234	S. viride f. pelagica Kahl		+				+																+	
235	Strongylidium danubiensis Kovalch.		+				+																	+
236	Stylonychia pustulata Ehr.	+	+	+	+		+	+	+	+	+												+	
237	S. mytilus-lemnae complex	+	+	+		+	+	+		+				+	+								+	
238	S. fissiseta Cl. et L.		+		+						+													
239	Tachysoma pellionellum (O.F.M.)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+	
240	T. furcatum Kahl			+		+				+														
241	Tintinnidium fluviatile Stein	+					+																	+
242	Tintinnopsis cylindrata Kof.-Camp.	+	+				+																	+
243	Trichotaxis fossicola Kahl		+			+					+											+		
244	Uroleptus dispar Stokes			+				+			+													
245	Ur. piscis (O.F.M.)		+	+			+																+	+
246	Ur. violaceus (?) Stein		+				+																+	
247	Urosoma cienkowskii Kowalev.		+	+		+	+	+	+	+	+				+				+			+	+	
248	Urostyla grandis Ehr.	+	+	+	+		+			+	+												+	
	Class Colpodea																							
249	Bursaria truncatella O.F.M.		+				+																+	
250	Colpoda aspera Kahl			+				+			+													
251	Colpoda sp.			+		+					+													
252	Paracolpoda steini (Maupas)			+	+			+			+			+										
253	Platyophrya cf. sp.	+				+			+															
254	Semiplatyophrya sp.		+	+		+	+	+		+	+								+			+		

Table 1. continue

Notes: Pl - plankton, B - benthos, Pr - periphyton, W - winter, Sp - spring, Su - summer, A -autumn. 1, 2, 3 - lower, middle and upper reaches of River Tisa, respectively, 4 - Tereble-Rikske reservoir, 5 - lake Sinevir; Rivers: 6 - Borzhava, 7 - Rika, 8 - Mokrianka, 9 - Teresul'ka, 10 - Teresva, 11 - Kosivs'ka, 12 - Hoverla, 13 - Shopurka, 14 - Stogovets', 15 - Uzh, 16 - Latoritsa.